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Smart tools for Central Asian Chinese learners

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Abstract. Beginning Chinese learners from Central Asia often show uneven development in classroom participation, online practice, and Chinese character writing. This study examined how smart teaching tools support formative assessment and process feedback in an elementary international Chinese classroom. A 12-week teaching practice was conducted with 17 students from Kyrgyzstan, Kazakhstan, and Russia, representing learners from Central Asia and neighbouring regions; 14 of them were Dungan students. Multi-source data collected through Chaoxing Learning Platform, the International Chinese Smart Teaching System, and a smart handwriting pen system were analysed with descriptive statistics and qualitative observation. The results showed that digital interaction was used 4.6 times per 50-minute class on average, increasing from 3.2 times per class in the first week to 5.1 times per class in the twelfth week, and the average participation rate in demanding tasks such as recitation and translation reached 94.1%. The average online practice score was 90.1, and each assignment was submitted 6.3 times on average, showing repeated corrective learning based on platform feedback. The average regular performance score was 90.12, the average final course grade was 76.94, and the passing rate was 100%. Handwriting trajectories revealed stroke order, stroke direction, starting position, and structural layout problems that were not fully visible in final written products, such as writing the vertical stroke before the horizontal stroke in simple characters like "十". Students showed positive acceptance of the tools, with an average satisfaction score of 4.19 out of 5; the point system received the highest score of 4.41. The findings show that smart teaching tools make the learning process of Central Asian Chinese learners more visible and provide practical evidence for classroom adjustment, writing feedback, and formative assessment

Keywords: learning analytics; Dungan learners; Chinese character writing; formative assessment; classroom interaction; process feedback

INTRODUCTION

International Chinese education has developed rapidly with the expansion of educational mobility, regional cooperation, and intercultural communication. In this context, Central Asian students constitute an important learner group in Chinese language education in China because of increasing academic mobility, regional cooperation, and cross-border communication. Students from Kyrgyzstan, Kazakhstan, Russia, Uzbekistan, and neighbouring regions often study Chinese for academic mobility, professional development, cross-border communication, and cultural exchange. Some students, particularly those with Dungan backgrounds, may have oral familiarity with Chinese-related speech varieties because of their community language background, but this familiarity does not necessarily translate into standard Chinese literacy skills, especially character reading and writing. This difference can be explained by the distinction between oral experience and literacy experience. The previous schooling of Dungan learners is based mainly on Cyrillic alphabetic literacy, which develops linear, letter-by-letter visual processing and left-to-right writing routines. Chinese characters, in contrast, require two-dimensional spatial analysis, stroke-based production, and attention to component arrangement and stroke order. The visual-spatial and motor skills developed through Cyrillic-based literacy are therefore not directly compatible with the stroke-based logic and structural principles of Chinese characters. As a result, oral familiarity with Chinese-related speech varieties does not by itself facilitate the acquisition of Chinese character reading and writing.

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Chinese character writing is one of the most difficult components for beginning learners whose previous literacy experience is based mainly on alphabetic writing systems. Learners must acquire not only the final visual form of a character but also stroke order, stroke direction, starting position, component arrangement, and spatial structure. If assessment focuses only on the final written product, teachers may overlook hidden procedural errors. For example, a character may look visually acceptable, while the learner may have written it with incorrect stroke sequence or reversed stroke direction. These process-level problems may influence later character learning and writing fluency. Addressing such process-level problems is also part of the broader transformation of international Chinese education in the new era, which has raised new requirements for teaching models, learner support, and educational technology (Li & Liu, 2021). Smart teaching tools provide new possibilities for addressing these problems. Recent reviews have identified intelligent technology, smart pedagogy, smart learning environments, smart learning, and smart learners as major pillars of smart education (Yang *et al.*, 2025). Smart education has also been discussed as a way to connect traditional classroom instruction with digital resources, interactive platforms, and adaptive learning opportunities (Chukwuemeka, 2025). In international Chinese education, smart teaching design has been used to support classroom interaction, task organisation, resource integration, and learning-process records (Wen & Liu, 2023). At the same time, research on online learning environments and learning analytics has shown that platform data can provide evidence of engagement, participation, and learning outcomes. J. Fan & M. Tian (2026) found that online learning environment factors influenced Chinese as a foreign language learning achievement among international students in China through student engagement. M. Hernández-Campos *et al.* (2025) reported that engagement and platform behaviour were frequently used indicators in learning analytics systems for evaluating higher education outcomes.

Recent Chinese language and character learning studies also provide important theoretical support. L. Yang & J. Lin (2026) examined writing development in Chinese as a foreign language and showed that writing development involves multiple textual and linguistic dimensions. H. Sun *et al.* (2026) found that computer-assisted stroke order learning influenced second language learners' Chinese character writing. J. Yu *et al.* (2026) analysed teachers' beliefs and practices in Chinese character teaching and highlighted the continuing importance of character instruction in Chinese as a foreign language education. Despite these developments, several gaps remain. First, many studies discuss smart education at a general level, while fewer studies examine how multiple smart tools can be integrated into formative assessment in a natural elementary Chinese classroom. Second, the learning characteristics of Central Asian Chinese learners, especially Dungan learners, have not received sufficient attention in classroom-based smart teaching research. Third, although digital handwriting technology has been used in Chinese character research, its pedagogical value in formative assessment and everyday classroom feedback remains underexplored.

Therefore, this study investigated how smart teaching tools supported formative assessment and process feedback for Central Asian beginning Chinese learners. The study addressed the following three research questions: 1. What patterns of classroom interaction, online practice, and handwriting behaviour emerged when smart tools were integrated into formative assessment for beginning Central Asian Chinese learners? 2. What learning-process evidence can be obtained from classroom interaction, online practice, and handwriting trajectory data? 3. How do Central Asian students perceive these smart tools in their Chinese learning process? The novelty of the study lies in the integrated use of three types of smart tools in a natural classroom setting: a learning management platform, a smart Chinese teaching system, and a smart handwriting pen system. By combining classroom interaction data, online practice data, and handwriting trajectory data, the study provides a more detailed view of the learning process of Central Asian beginning Chinese learners and offers practical evidence for process-oriented formative assessment.

LITERATURE REVIEW

Smart teaching tools in language education

Smart teaching tools have become increasingly common in language education. They include learning management systems, online practice platforms, speech evaluation systems, artificial intelligence-supported resources, intelligent feedback systems, and digital handwriting tools. In language classrooms, these tools can support task distribution, interaction, feedback, assessment, and learning-process recording. Research on smart education suggests that intelligent technologies can reshape teaching and learning methods by improving access to learning resources, supporting personalised learning, and making learning behaviour more traceable (Yang *et al.*, 2025). E.J. Chukwuemeka (2025) argued that smart education creates opportunities for more interactive and accessible learning, but it also brings challenges related to infrastructure, privacy, and teacher readiness. In Chinese language education, smart teaching design has been discussed as a way to connect pre-class preparation, in-class interaction, after-class practice, and post-learning reflection (Wen & Liu, 2023). J. Cai & X. Liu (2023) proposed a multi-stage smart teaching model for international Chinese education, showing that smart platforms can support differentiated instruction and classroom participation.

Language learning studies have also examined digital and artificial intelligence-supported learning environments. E. Alhusaiyan (2025) reviewed current trends in artificial intelligence in foreign language learning and found that technology-supported systems can enhance writing quality, scoring accuracy, and learner engagement, but teacher intervention remains necessary. Y. Li *et al.* (2025)

reviewed large language model-supported smart educational services and emphasised personalised learning, assessment, data management, and ethical challenges. However, smart tools do not automatically improve learning. Their value depends on task design, teacher interpretation, learner engagement, and the connection between digital evidence and pedagogical feedback.

The first tool type is learning management systems, represented in this study by Chaoxing Learning Platform. Learning analytics research indicates that platform records of attendance, response frequency, and task completion can serve as useful indicators of behavioural engagement in higher education (Hernández-Campos *et al.*, 2025; Ngulube & Ncube, 2025). In Chinese language education, platform-supported teaching design has been shown to connect pre-class preparation, in-class interaction, and after-class practice into a continuous learning cycle (Wen & Liu, 2023; Zhou *et al.*, 2024). These studies justify the use of a learning management platform as the organisational basis of formative assessment in the present study.

The second tool type is online language practice systems, represented in this study by the International Chinese Smart Teaching System. Research on smart Chinese teaching has shown that platform-based speech imitation, online exercises, and assignment submission can support differentiated instruction and repeated corrective practice (Cai & Liu, 2023). C. Xu & J. Bai (2025) further demonstrated that behavioural analytics generated by smart education systems can support dynamic quality assessment in Chinese language courses. J. Fan & M. Tian (2026) showed that student engagement mediated the relationship between online learning environment factors and Chinese as a foreign language learning achievement among international students in China, which indicates that practice-platform records can provide meaningful evidence about learning processes.

The third tool type is digital handwriting technology, represented in this study by a smart handwriting pen system. Stroke-level handwriting research has demonstrated that trajectory data can reveal preparation and execution processes that remain invisible in final written products (Xu *et al.*, 2026). Computer-assisted stroke order learning has been shown to influence second language learners' Chinese character writing and comparisons of typing and handwriting suggest that handwriting supports distinctive orthography-sound and orthography-meaning mappings (Sun *et al.*, 2026; Shi *et al.*, 2026). For beginning learners of Chinese as a foreign language, character structural features observed during writing are closely related to the legibility of handwritten characters (Lai *et al.*, 2025). These findings support the use of smart handwriting tools for process-oriented writing assessment.

Formative assessment and learning analytics

Formative assessment refers to assessment activities that provide information for improving teaching and learning during the learning process. Unlike summative assessment, which mainly focuses on final achievement, formative assessment emphasises feedback, adjustment, and continuous improvement. P. Black & D. Wiliam (1998) argued that formative assessment is effective when evidence about student learning is used to adapt teaching to meet learner needs. J. Hattie & H. Timperley (2007) further indicated that effective feedback should help learners understand current performance, learning goals, and next steps.

Recent studies have extended formative assessment into digital environments. C. Hankeln *et al.* (2025) discussed the development of digital formative assessment tools for deeper learning goals and argued that digital assessment should provide meaningful evidence rather than only surface-level correctness. B.P. Solis Trujillo *et al.* (2025) reviewed formative assessment and feedback in graduate studies and found that timely and specific feedback supports self-regulation and learning motivation. These findings are relevant to language learning because beginning learners need repeated practice, correction, and feedback before stable language habits can be formed. Learning analytics offers another important perspective. G. Siemens & P. Long (2011) described learning analytics as a way to use educational data to understand and optimise learning. Recent studies have shown that learning analytics systems often use engagement, platform behaviour, task completion, and performance records to evaluate learning outcomes in higher education (Hernández-Campos *et al.*, 2025). P. Ngulube & M.M. Ncube (2025) showed that learning analytics can improve the user experience of learning management systems, but data interpretation remains a challenge. M.Á. Rodríguez-Ortiz *et al.* (2025) further reported that machine learning and generative artificial intelligence are increasingly used in higher education learning analytics, although transparency and pedagogical grounding are still concerns. In the present study, learning analytics is not treated as automated prediction. Instead, platform data are used as formative evidence. Attendance records, classroom interaction, online practice scores, repeated submissions, and handwriting trajectories are interpreted together with classroom observation and student feedback.

Chinese character writing and digital handwriting evidence

Chinese character learning is a central challenge in Chinese as a foreign language education. Unlike alphabetic writing systems, Chinese characters require learners to coordinate form, sound, meaning, stroke order, stroke direction, component structure, and spatial arrangement. For learners from Central Asia, previous experience with Cyrillic or other alphabetic scripts may influence their perception of Chinese character structure and stroke production. Recent research has shown that Chinese writing development involves multiple linguistic and textual dimensions. L. Yang & J. Lin (2026) measured writing development in a Chinese as a foreign language context and showed that learners' progress is reflected not only in final text quality but also in character-level and structural development. J. Yu *et al.* (2026) found that Chinese as a foreign language

teachers generally regard Chinese character learning as essential for language development, though their instructional practices vary across teaching contexts.

Stroke order and handwriting processes are also important. H. Sun *et al.* (2026) showed that computer-assisted stroke order learning influenced Chinese character writing among second language learners. Q. Shi *et al.* (2026) compared typing and handwriting in Chinese character learning and suggested that different production modes support different mappings among orthography, sound, and meaning. C. Zhang & I. Tsimpli (2026) highlighted the interaction of phonology, orthography, and semantics in early Chinese character processing. Z. Xiao *et al.* (2025) further quantified regularities between orthography and phonology in the Chinese writing system, offering additional evidence for the complexity of Chinese character processing. Digital handwriting research provides direct support for process-oriented assessment. Z. Xu *et al.* (2026) constructed a stroke-level large-scale database of Chinese character handwriting and developed the OpenHandWrite_Toolbox, showing that handwriting trajectory data can reveal preparation and execution processes. Recent classroom-based research further showed that character structural features were closely related to the legibility of handwritten Chinese characters among beginning Chinese as a foreign language learners (Lai *et al.*, 2025). These studies suggest that Chinese character writing assessment should not focus only on final written products but should also examine how characters are produced.

MATERIALS AND METHODS

Participants and learning context. The participants were 17 international students enrolled in an elementary Chinese course at a university in China in 2025. The class was selected through convenience sampling because it was a natural elementary Chinese class taught by the author during the 2025 academic year. For privacy protection, the students were coded as S01 to S17. They came from Kyrgyzstan, Kazakhstan, and Russia, representing learners from Central Asia and neighbouring regions. Eleven students were from Kyrgyzstan, two from Kazakhstan, and four from Russia. Fourteen students were Dungan, and three were non-Dungan. Their ages ranged from 16 to 20 years, with a mean age of 17.5 years. Their previous Chinese learning experience ranged from one to six months.

Among the 17 students, 14 were true beginners, accounting for 82.4% of the class. Three students had limited previous exposure to Chinese, accounting for 17.6%. The participant group was pedagogically relevant because it represented a typical Central Asian beginner class with uneven oral and literacy development. Some Dungan students had certain oral familiarity with Chinese-related oral varieties, but most participants had limited experience with standard written Chinese and Chinese character writing. The course was an elementary Chinese course that included pronunciation, vocabulary, grammar, sentence patterns, communicative practice, and Chinese character writing. The teaching practice lasted 12 weeks from September to November 2025.

Smart teaching tools and data sources. Three smart teaching tools were used in the study. The first tool was Chaoxing Learning Platform. It was mainly used for classroom organisation, including attendance, quick response, random selection, discussion, homework distribution, and classroom interaction. The platform generated records of attendance, response frequency, participation, and homework-related interaction. The second tool was the International Chinese Smart Teaching System. It was used for online language practice, including speech imitation, online exercises, assignment submission, and learning records. The system generated data such as practice scores, number of submissions, completion time, and task performance. The third tool was a smart handwriting pen system. It was used to record Chinese character writing processes. The system captured handwriting trajectories, stroke order, stroke direction, writing time, and dynamic replay information. These data allowed the teacher to observe how students wrote characters instead of only checking final written products. The three tools were used together to support formative assessment. Chaoxing Learning Platform provided evidence about classroom participation; the International Chinese Smart Teaching System provided evidence about online practice and correction; the smart handwriting pen system provided evidence about Chinese character writing processes.

Formative assessment design. The formative assessment system consisted of three components: behaviour points, learning points, and handwriting points. Behaviour points were mainly derived from Chaoxing Learning Platform and reflected attendance, quick response, discussion, and homework interaction. Learning points were mainly derived from the International Chinese Smart Teaching System and reflected speech imitation, online practice, and assignment submission. Handwriting points were derived from the smart handwriting pen system and the smart teaching system, reflecting stroke order, stroke direction, starting position, writing trajectory, and character structure. The three components, their data sources, main indicators, and weights are presented in Table 1.

Table 1. *Components and data sources of the formative assessment system*

Component	Data source	Main indicators	Weight
Behaviour points	Chaoxing Learning Platform	Attendance, quick response, discussion, homework interaction	30%
Learning points	International Chinese Smart Teaching System	Speech imitation, online practice, assignment submission	40%

Table 1. *Continued*

Component	Data source	Main indicators	Weight
Handwriting points	Smart handwriting pen system and smart teaching system	Stroke order, stroke direction, starting position, writing trajectory	30%

Note: *the assessment system was designed for the elementary Chinese course in this study*
Source: *developed by the author based on the formative assessment design of the course*

The three components were combined into a total formative score. Behaviour points accounted for 30%, learning points accounted for 40%, and handwriting points accounted for 30%. The weighting was determined according to the course objectives. Language knowledge and practice tasks accounted for the largest proportion, while classroom participation and Chinese character writing were also considered important components. The points were summarised weekly. Students could see their recent performance in attendance, classroom participation, online practice, and handwriting tasks. Teachers used the weekly records to identify students with unstable participation, delayed submissions, or persistent handwriting difficulties.

Teaching procedure. The teaching practice lasted 12 weeks and included three stages. The first stage was preparation, covering Weeks 1 and 2. During this stage, the teacher prepared the digital tools and explained the learning rules. Students installed Chaoxing Learning Platform, registered for the International Chinese Smart Teaching System, received smart handwriting pens, and completed account binding. The teacher demonstrated attendance check-in, speech imitation, online exercises, assignment submission, and handwriting upload. Trial activities were conducted to ensure that students could use the tools.

The second stage was classroom implementation, covering Weeks 3 to 10. Teaching followed a cycle of pre-class analysis, in-class adjustment, and after-class feedback. Before class, the teacher reviewed the previous week's points and platform records to identify common problems and individual difficulties. During class, the teacher used different tools according to task type. Attendance, quick responses, and discussions were conducted through Chaoxing Learning Platform. Speech imitation and sentence-pattern practice were assigned through the International Chinese Smart Teaching System. Chinese character writing tasks were recorded with the smart handwriting pen system. After class, the teacher summarised attendance, interaction, online practice, and handwriting records, and updated weekly points. The third stage was summary and feedback, covering Weeks 11 and 12. During this stage, the teacher exported the full-cycle data, including points, practice records, handwriting trajectories, course grades, and student feedback. A questionnaire on students' satisfaction with smart teaching tools was administered. Semi-structured interviews and classroom observation notes were also used to understand students' perceptions of the tools and the formative assessment process.

Data collection and analysis. The study collected both quantitative and qualitative data. Quantitative data included classroom interaction records, attendance records, online practice scores, number of assignment submissions, course grades, and questionnaire responses. Qualitative data included classroom observation notes, open-ended questionnaire responses, interview comments, and handwriting trajectory examples. Descriptive statistics were used to analyse classroom interaction frequency, participation rate, online practice scores, assignment submission times, course grades, and satisfaction scores. Percentages, means, maximum values, and minimum values were calculated where appropriate. The questionnaire was designed with reference to the technology acceptance model, especially perceived usefulness and perceived ease of use (Davis, 1989). It included 14 items and used a 5-point Likert scale. The items covered perceived usefulness, perceived ease of use, classroom interaction, online practice, handwriting feedback, and overall satisfaction. The questionnaire was newly developed for this study rather than adapted from an existing validated instrument: its items were constructed on the basis of the perceived usefulness and perceived ease of use constructs of the technology acceptance model (Davis, 1989) and were adjusted to the three smart tools used in the course. To ensure content validity, the draft items were reviewed by two specialists in international Chinese language education and one specialist in educational measurement, who evaluated the relevance, clarity, and completeness of each item, and items judged ambiguous or overlapping were revised or removed. The revised questionnaire was then piloted with five international students from a parallel elementary Chinese class, and minor wording adjustments were made according to their feedback. The internal consistency of the final 14-item questionnaire was acceptable (Cronbach's $\alpha = 0.86$).

Qualitative data were used to interpret the quantitative findings. Classroom observation, interview feedback, and handwriting trajectory replay were compared with platform data. This triangulation helped the teacher understand whether low points resulted from absence, low participation, incomplete online practice, or specific handwriting difficulties. The study did not use a control group or a pre-test/post-test experimental design. Therefore, the analysis focused on classroom implementation, learning-process evidence, and student perceptions. The study did not make causal claims about the effect of smart tools on language achievement.

All student data were anonymised. Students were coded as S01 to S17 in the analysis. Participation in the questionnaire and interviews was voluntary, and informed consent was obtained from all participants; for students under 18, consent was obtained from their parents or legal guardians. No personally identifiable information was

reported. The study used classroom data only for teaching research and formative assessment analysis. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (World Medical Association, 2013).

RESULTS AND DISCUSSION

Smart classroom interaction broadened participation

Chaoxing Learning Platform records showed that digital classroom interaction was used frequently during the 12-week practice. On average, 4.6 digital interactions, including attendance, quick responses, discussions, and homework-related activities, were initiated in each 50-minute class. The average interaction frequency increased from 3.2 times per class in Week 1 to 5.1 times per class in Week 12. Among different types of interaction, quick response activities were the most frequent. There were 103 quick response activities, accounting for 41.4% of all recorded interactions. Homework-related interactions occurred 86 times, accounting for 34.5%. Attendance activities occurred 49 times, accounting for 19.7%. In relatively demanding classroom tasks such as recitation and translation, the average participation rate reached 94.1%, which means that approximately 16 students participated in each task on average.

Classroom observation showed that the platform broadened participation opportunities. In traditional classroom interaction, students usually responded by raising their hands. In this situation, answers often came from a small number of active students. After quick response and random selection were introduced, more students entered classroom activities. The teacher could also identify students who were less active and invite them to participate in appropriate tasks. The time needed for different tasks also varied. For simple response tasks, such as reading names or answering multiple-choice questions, the average response time was 2.36 seconds. For complex production tasks, such as reading aloud and retelling, the average completion time was 229.42 seconds. This difference indicates that oral production tasks required more language processing and output time than simple recognition tasks.

These findings suggest that smart classroom tools made participation more visible. The result is consistent with learning analytics research indicating that platform behaviour and engagement are important indicators in evaluating learning processes and outcomes (Hernández-Campos *et al.*, 2025; Ngulube & Ncube, 2025). It also supports the view that smart education can create more interactive and traceable learning environments (Yang *et al.*, 2025; Chukwuemeka, 2025). However, participation frequency should not be interpreted as direct evidence of learning quality. High response frequency may indicate active engagement, but it does not automatically prove deeper language acquisition. Therefore, platform data should be combined with task quality, teacher observation, and student feedback. A concrete case from the present data illustrates this point. One student (S09) ranked among the five most active students in quick-response activities throughout the twelve weeks but obtained a final course grade of 62, only slightly above the passing threshold; classroom observation and interview data suggested that his rapid responses often relied on recognising familiar words rather than on stable language knowledge. In contrast, another student (S14) took part relatively rarely in whole-class quick-response activities but achieved a final grade of 95 through steady online practice and repeated handwriting revision. These two cases show that high interaction frequency does not necessarily correspond to strong learning outcomes, and that limited visible interaction does not necessarily indicate weak learning.

The point system provided continuous feedback. During the practice, the overall class points showed an upward trend, and rankings changed frequently. For example, S01 was not ranked high in the early stage, but later improved through stable attendance, active response, and completion of handwriting tasks. This suggests that the formative point system did not fix students' positions at the beginning. Instead, students could improve their performance through continuous participation. This is consistent with formative assessment theory, which emphasises the use of evidence to support learning adjustment during the learning process (Black & Wiliam, 1998).

Online practice showed repeated corrective learning

The International Chinese Smart Teaching System provided records of online practice, assignment submission, and repeated correction. The average online practice score of the 17 students was 90.1. All students obtained a full score at least once. Some students showed particularly stable performance. For example, S02 obtained full scores in 16 of 17 exercises, and S03 obtained full scores in 17 of 18 exercises. S01 also achieved full scores in several consecutive course exercises. A notable feature of the online practice data was repeated submission. On average, each assignment was submitted 6.3 times by each student. The maximum number of submissions was 12, and the minimum was 3. Most repeated submissions occurred two to three days before the assignment deadline. This indicates that many students did not stop after one attempt. Instead, they used platform feedback to revise answers and improve task completion. Compared with previous research, this level of repeated submission is relatively high: in a study of online assessments with unlimited attempts, students used an average of 2.56 attempts per quiz (Brazhkin & Strakos, 2023). The higher average in the present study suggests that the combination of immediate platform feedback, weekly points, and teacher follow-up encouraged sustained corrective practice beyond what is usually observed in online assessment settings.

Repeated submission should not be interpreted as direct proof of learning improvement. However, it does show that students were willing to correct their work based on feedback. Similarly, high platform scores should be interpreted as evidence of task completion and correction rather than as a direct measure of overall Chinese proficiency. For

beginning learners, pronunciation, vocabulary, sentence patterns, and Chinese characters all require repeated input, output, and correction. The smart teaching system recorded practice frequency, submission time, scores, and revision behaviour, allowing the teacher to observe students' learning rhythm and identify those who needed additional support.

Course grades were also examined. The final course grade consisted of regular performance and final examination results, each accounting for 50%. Regular performance included attendance, classroom interaction, online practice, assignment submission, speech imitation, and handwriting tasks. The average regular performance score was 90.12. The highest score was 100, and the lowest was 80. The average final course grade was 76.94. The highest final grade was 99, and the lowest was 60. The passing rate was 100%, and the excellent rate was 35.3%. The difference of approximately 13 points between the average regular performance score (90.12) and the average final course grade (76.94) requires careful interpretation, as it represents one of the most pedagogically significant findings of this study. Three factors may explain this gap. First, platform-based tasks allowed repeated attempts and immediate feedback, so regular scores reflect students' best corrected performance rather than their unaided competence. Second, the final examination required independent, one-time production under time constraints, including open-ended tasks in which students could not rely on platform scaffolding or corrective feedback. Third, regular performance also included attendance and participation components, which raised the average independently of language mastery. This pattern is consistent with formative assessment research showing that performance in digitally scaffolded tasks does not automatically transfer to unaided performance in summative settings (Black & Wiliam, 1998; Hankeln *et al.*, 2025). The gap therefore indicates that high platform scores should be read as evidence of engagement in corrective learning rather than as direct predictors of final achievement, and that formative practice should be complemented with unaided, transfer-oriented tasks that prepare students for final assessment.

These results indicate that the students generally met the course requirements and engaged in repeated corrective practice. Digital formative assessment research has shown that digital tools can provide timely evidence and support learning adjustment when they are connected to meaningful feedback (Hankeln *et al.*, 2025; Solis Trujillo *et al.*, 2025). In the present study, repeated submissions and online scores functioned as process evidence rather than as final achievement indicators. This distinction is important because a high number of submissions may indicate active correction, but it may also indicate uncertainty or task difficulty. Therefore, submission records should be interpreted together with score changes, task quality, and classroom observation. These findings are also relevant to Chinese learning in online environments. J. Fan & M. Tian (2026) found that student engagement mediated the relationship between online learning environment and Chinese as a foreign language learning achievement among international students in China. C. Xu & J. Bai (2025) also discussed dynamic quality assessment in Chinese language courses through smart education systems and behavioural analytics. The present study adds classroom-level evidence by showing how repeated practice records can support teacher decision-making in an elementary Chinese class.

Smart handwriting trajectories revealed process-level errors

Chinese character writing was one of the most important areas in which smart teaching tools provided additional evidence. Classroom observation and handwriting trajectory replay showed that Central Asian beginning learners' errors were mainly concentrated in stroke order, stroke direction, starting position, and structural layout. Some students wrote the character "十" by writing the vertical stroke before the horizontal stroke. Some students wrote the internal strokes of "田" in an incorrect order. These examples indicate that students were not yet familiar with basic stroke order rules. Other students wrote the first horizontal stroke of "平" like a left-falling stroke, or wrote the left-falling stroke of "女" with an inaccurate angle. These examples suggest weak awareness of stroke direction. In characters such as "国", some students placed the internal component inaccurately, leading to poor proportion and structural imbalance. The smart handwriting pen system allowed the teacher to replay students' writing trajectories. When many students made similar mistakes, the teacher displayed trajectory replay in class, compared student writing with standard stroke order, and explained the correct writing process step by step. This process helped students compare their own writing with standard character production.

Figure 1 presents a handwriting sample of the Chinese character "祝" recorded by the smart handwriting pen system. The left panel shows the student's original written form, the middle panel presents the dynamic trajectory replay, and the right panel shows the stroke order and structural decomposition in different colours. The example demonstrates that trajectory replay can reveal process-level problems in stroke order, stroke direction, starting position, and character structure that may not be fully visible from the final written form alone.

Figure 1. *Student writing, dynamic trajectory replay, and stroke-structure decomposition of the Chinese character "祝"*
Note: *student information was anonymised*
Source: *classroom handwriting data collected by the smart handwriting pen system*

Questionnaire results showed that students' satisfaction with the handwriting demonstration and trajectory replay function was 4.12 out of 5. One student commented that when writing at home, it was difficult to know whether the writing process was correct, but the online demonstration made it easier to understand how to write the character. This feedback indicates that smart handwriting tools can transform the invisible writing process into observable feedback materials. These findings are consistent with recent Chinese character writing and digital handwriting research. H. Sun *et al.* (2026) showed that computer-assisted stroke order learning influenced Chinese character writing among second language learners. Z. Xu *et al.* (2026) demonstrated that stroke-level handwriting trajectories provide fine-grained evidence for analysing handwriting preparation and execution. J. Yu *et al.* (2026) also showed that Chinese character instruction remains a central component of Chinese as a foreign language education. In the present study, the smart handwriting pen system played a formative role by allowing the teacher to observe not only whether a character was written correctly, but also how the character was produced.

The findings also correspond to previous research on Central Asian learners. Y. Lai *et al.* (2025) showed that character structural features were related to the legibility of handwritten Chinese characters among beginning learners. The present study extends these findings by showing how handwriting trajectory data can be used as formative assessment evidence in everyday classroom instruction. For Central Asian learners with alphabetic writing backgrounds, Chinese character writing requires new visual-spatial and motor habits. Dungan students may have oral familiarity with Chinese-related speech varieties, but this does not automatically support standard Chinese character writing. Therefore, process-oriented writing feedback is necessary. Smart handwriting pens can complement traditional correction by showing whether an error originates from stroke order, stroke direction, starting position, or structural layout.

Student satisfaction confirmed practical acceptability

At the end of the teaching practice, 17 valid questionnaires were collected. The results showed that students generally accepted the smart teaching tools positively. The average satisfaction score across all tool functions was 4.19 out of 5. Among the specific functions, the point system received the highest score, with a mean of 4.41 and a standard deviation of 0.71. The quick response function received a mean score of 4.35 and a standard deviation of 0.79. Random selection and photo-based attendance both received mean scores of 4.18. The handwriting demonstration and trajectory replay function received a mean score of 4.12. Grouping and online question answering both received mean scores of 4.06. In addition, 88.2% of students believed that online tools improved their Chinese learning efficiency, while 11.8% believed that the tools might be helpful.

Open-ended responses showed that students particularly valued the point system, quick response activities, and handwriting trajectory replay. Among the 12 students who gave the point system a score of 5, 10 were relatively active in quick response activities. This suggests that students' positive evaluation of the point system was generally consistent with their classroom participation. Students who had weaker Chinese character writing foundations tended to value trajectory replay more strongly. This indicates that students' acceptance of different tools was related to their individual learning needs. The findings correspond to the technology acceptance model, which suggests that perceived usefulness and perceived ease of use influence users' willingness to use technology (Davis, 1989). In this study, students' satisfaction was not distributed evenly across all functions. More active students tended to value point-based interaction, while students with weaker handwriting foundations valued trajectory replay. This suggests that smart tool acceptance depends not only on technical design but also on learners' specific difficulties.

The results also show that smart tools require teacher interpretation. Digital data did not automatically produce pedagogical decisions. Low participation might result from absence, low confidence, task difficulty, or unfamiliarity with the platform. A handwriting error might result from misunderstanding of stroke rules, lack of practice, or technical issues. Therefore, smart tool data should be used as evidence for teacher judgment rather than as a replacement for teacher judgment. The integration of multiple data sources was useful because each tool had limitations. Classroom interaction data showed participation but not necessarily learning quality. Online practice data showed scores and submissions but not all learning difficulties. Handwriting trajectory data showed writing processes but covered only character tasks. When these sources were combined, the teacher obtained a more complete picture of student learning. This has practical significance for international Chinese education because beginning Central Asian learners often show uneven development across oral communication, online practice, and written Chinese.

CONCLUSIONS

This study explored the use of smart teaching tools in formative assessment for Central Asian beginning Chinese learners. The 12-week classroom practice showed that Chaoxing Learning Platform, the International Chinese Smart Teaching System, and a smart handwriting pen system could provide complementary evidence about classroom participation, online practice, repeated correction, and Chinese character writing processes. The results indicate that smart tools helped make students' learning behaviours more visible. Digital classroom interaction was used 4.6 times per class on average, and the average participation rate in demanding tasks reached 94.1%. Online practice data showed that students achieved an average score of 90.1 and submitted each assignment 6.3 times on average. Handwriting trajectory data helped identify stroke order,

stroke direction, starting position, and structural layout problems. Students also reported generally positive attitudes toward the tools, with an average satisfaction score of 4.19 out of 5. At the same time, the average final course grade (76.94) was markedly lower than the average regular performance score (90.12). This gap suggests that strong performance in scaffolded, feedback-rich platform tasks did not fully transfer to independent, one-time examination performance, and that formative online practice should be combined with unaided, transfer-oriented tasks.

The findings are particularly relevant to Central Asian Chinese learners. Some students may have oral familiarity with Chinese-related language environments, but their standard Chinese literacy skills, especially Chinese character writing, still require systematic support. Smart handwriting trajectories were useful for revealing writing-process problems that could not be fully observed through final written products alone. Pedagogically, the findings suggest that teachers of beginning Chinese learners can combine platform participation records, online practice data, and handwriting trajectory feedback to identify different types of learning difficulties and provide more targeted formative support. It should also be noted that, because only three participants were non-Dungan, the present data did not allow a systematic comparison between Dungan and non-Dungan learners; the findings therefore describe the class as a whole rather than differences between these two groups.

The study also has limitations. First, it was based on a small natural class of 17 students, and the participants came mainly from Central Asia. Therefore, the findings cannot be directly generalised to all international Chinese classrooms. Second, the study did not include a control group or a pre-test/post-test design. As a result, it cannot prove that smart tools caused improvement in language achievement. Third, data integration depended largely on manual exporting and recording by the teacher, which increased workload. Fourth, although the point system encouraged participation, it might also create pressure for students with lower scores. Fifth, the small number of non-Dungan students (n = 3) did not permit a direct comparison between Dungan and non-Dungan learners, so possible group differences could not be examined. Future research should include larger samples, longer observation periods, comparative designs, and automated integration of multi-source data. Further studies may also compare different groups of Central Asian Chinese learners and examine how smart handwriting feedback influences long-term character learning. In particular, future studies with larger samples should directly compare Dungan and non-Dungan learners in order to clarify how community language background interacts with smart tool-supported Chinese learning.

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CONFLICT OF INTEREST

None.

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Борбордук Азиядан келген кытай тилин үйрөнүүчүлөр үчүн акылдуу куралдар

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Аннотация. Борбордук Азиядан келген кытай тилин жаңыдан үйрөнүп баштаган студенттер көбүнчө сабакка катышуу, онлайн практика жана кытай иероглифтерин жазуу сыяктуу багыттарда бирдей эмес өнүгүүнү көрсөтүшөт. Бул изилдөөдө баштапкы деңгээлдеги эл аралык кытай тили сабагында акылдуу окутуу куралдары формативдик баалоону жана окуу процессиндеги кайтарым байланышты кандайча колдой тургандыгы изилденди. 12 жума бою Кыргызстан, Казакстан жана Россиядан келген 17 студенттин катышуусунда окутуу жүргүзүлдү. Алар Борбордук Азия жана ага чектеш аймактардын окуучуларын түзүшкөн; алардын 14ү дунган улутундагы студенттер болгон. Chaoxing Learning Platform, Эл аралык кытай тилин акылдуу окутуу системасы жана иероглифтерди жазуу үчүн акылдуу калем системасы аркылуу чогултулган көп булактуу маалыматтар сыпаттама статистика жана сапаттык байкоо ыкмалары менен талданды. Натыйжалар санариптик өз ара аракеттенүү 50 мүнөттүк бир сабакта орточо 4,6 жолу колдонулганын көрсөттү. Бул көрсөткүч биринчи жумада 3,2 жолудан он экинчи жумада 5,1 жолуга чейин өскөн. Жаттоо жана котормо сыяктуу татаал тапшырмаларга катышуунун орточо деңгээли 94,1 % түзгөн. Онлайн практиканын орточо упайы 90,1 болуп, ар бир тапшырма орточо 6,3 жолу тапшырылган. Бул студенттердин платформа берген кайтарым байланыштын негизинде каталарын оңдоо үчүн тапшырмаларды кайра-кайра аткаргандыгын көрсөтөт. Учурдагы жетишкендиктин орточо баасы 90,12, курстун жыйынтыктоочу баасы 76,94, ал эми өтүү көрсөткүчү 100 % түзгөн. Иероглиф жазуу траекторияларын талдоо даяр жазуу иштеринен дайыма эле көрүнбөгөн көйгөйлөрдү аныктоого мүмкүндүк берди. Аларга сызыктардын жазылуу тартиби жана багыты, жазуунун баштапкы чекити жана иероглифтин түзүмдүк жайгашуусу кирет. Мисалы, “十” сыяктуу жөнөкөй иероглифтерде тик сызыкты туурасынан мурда жазуу көйгөйү байкалган. Студенттердин акылдуу окутуу куралдарына болгон мамилеси оң болгон. Канааттануунун орточо көрсөткүчү 5 баллдан 4,19 түздү. Упай системасы эң жогорку баага ээ болуп, 4,41 баллды түздү. Изилдөөнүн жыйынтыктары акылдуу окутуу куралдары Борбордук Азиядан келген кытай тилин үйрөнүүчүлөрдүн окуу процессин ачык-айкын көрсөтүүгө мүмкүндүк берерин көрсөттү. Ошондой эле алар сабактарды жөнгө салуу, жазуу боюнча кайтарым байланыш берүү жана формативдик баалоону жүргүзүү үчүн практикалык негиз түзөт

Негизги сөздөр: окуу аналитикасы; дунган окуучулары; кытай иероглифтерин жазуу; формативдик баалоо; класстагы өз ара аракеттенүү; окуу процессиндеги кайтарым байланыш

Интеллектуальные инструменты для изучающих китайский язык из Центральной Азии

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Аннотация. Начинающие изучающие китайский язык из Центральной Азии часто демонстрируют неравномерное развитие в таких аспектах, как участие в занятиях, онлайн-практика и написание китайских иероглифов. В данном исследовании изучалось, как интеллектуальные инструменты обучения поддерживают формативное оценивание и предоставление обратной связи в процессе обучения на начальном уровне международного китайского языка. В течение 12 недель проводилось обучение с участием 17 студентов из Кыргызстана, Казахстана и России, представляющих страны Центральной Азии и соседние регионы; 14 из них были дунганами. Многоисточниковые данные, собранные с помощью платформы Chaoxing Learning Platform, системы интеллектуального обучения международному китайскому языку и системы интеллектуальной ручки для письма, анализировались с использованием описательной статистики и качественного наблюдения. Результаты показали, что цифровое взаимодействие использовалось в среднем 4,6 раза за 50-минутное занятие: показатель увеличился с 3,2 раза на первой неделе до 5,1 раза на 12-й. Средний уровень участия в сложных заданиях, таких как пересказ и перевод, достиг 94,1 %. Средний балл онлайн-практики составил 90,1, при этом каждое задание выполнялось в среднем 6,3 раза, что свидетельствует о повторном корректирующем обучении на основе обратной связи платформы. Средний балл за текущую успеваемость составил 90,12, итоговая оценка курса – 76,94, а показатель успешности – 100 %. Траектории письма позволили выявить проблемы с порядком и направлением черт, начальной точкой и структурным расположением, которые не всегда были заметны в готовых письменных работах, например написание вертикальной черты перед горизонтальной в простых иероглифах, таких как «十». Средняя удовлетворенность студентов инструментами составила 4,19 из 5, при этом система баллов получила наивысшую оценку – 4,41. Полученные результаты показывают, что интеллектуальные инструменты делают процесс обучения китайскому языку у студентов из Центральной Азии более наглядным и предоставляют практические основания для корректировки занятий, обратной связи по письму и формативного оценивания

Ключевые слова: аналитика обучения; дунганские учащиеся; написание китайских иероглифов; формативное оценивание; взаимодействие в классе; обратная связь в процессе обучения