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Interactive eAssessment of writing competency in French as a foreign language: development and implementation of an AI-enhanced progress monitoring system

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Abstract

The assessment of writing competency in French as a Foreign Language presents significant challenges due to the multidimensional nature of writing and heterogeneous evaluation practices. This research introduces an innovative framework integrating artificial intelligence and interactive visualization to support the formative assessment of writing competency. The developed Interactive Curves Graph system combines automated analysis with stakeholder engagement in a learner-centered approach.

Through a qualitative study involving 15 French as a Foreign Language teachers across 3 primary schools in Morocco, we investigated the effectiveness of an AI-enhanced progress monitoring system. The participating teachers (mean age = 37.25 years, mean teaching experience = 17 years) implemented the system with 190 students across 7 classes. The methodology employed a design-based research approach, incorporating iterative development phases and comprehensive validation through teacher feedback and usage analysis. Data collection spanned 1.5 months and included semi-structured interviews, system interaction statistics, and detailed feedback analysis using ATLAS.ti coding, with two distinct examination periods.

Results reveal three major contributions: (1) successful stakeholder integration through interactive visualization capabilities that support assessment objectivity, (2) AI-enhanced analysis facilitating pattern detection and immediate feedback, and (3) a multi-directional communication framework strengthening educational collaboration and decision-making. Teacher responses demonstrate that the Interactive Curves Graph system effectively addresses formative assessment challenges by combining computational rigor with pedagogical accessibility.

This research advances theoretical understanding and practical implementation of digital technologies in writing assessment. The findings suggest that the developed approach can significantly enhance writing competency eAssessment practices while opening perspectives for broader educational applications. The study's limitations, including sample size and context specificity, indicate directions for future research in cross-cultural validation and longitudinal impact assessment.
Keywords: eAssessment, French, writing competency, artificial intelligence, interactive, visualization, educational technology

Introduction

The evaluation of competencies in educational settings presents distinct challenges when addressing writing competency. Two significant observations emerge from both practical experience and assessment research. The first observation pertains to the inherent nature of writing competency. Unlike declarative knowledge, which can be assessed through relatively direct methods, this competency is characterized by its intrinsic multidimensionality. Deane et al. (2008) demonstrate that this complexity manifests through the interaction of multiple dimensions: linguistic, cognitive, social, and rhetorical, making its measurement particularly challenging (Deane et al., 2008). This complexity is further emphasized by Cumming (2013), who illustrates how writing assessment must consider not only the final product but also the underlying cognitive processes contributing to its production. The second observation addresses the heterogeneity of assessment practices (Cumming, 2013). Knoch (2021) highlights significant variability in the weighting of assessment criteria among educators (Knoch, 2021). This diversity in approaches is further documented by Eckes (2012), who identified distinct evaluator "types," each attributing varying importance to different aspects of writing competency (Eckes, 2012). Some prioritize communicative relevance, while others emphasize textual coherence, linguistic proficiency, ideational originality, or presentational quality (De Ketele & Gérard, 2005). Within the context of formative assessment, Brookhart (2018) emphasizes that this complexity poses a particular challenge for monitoring learner progression, specifically in providing clear and actionable feedback on various dimensions of writing competency (Brookhart, 2018).

The advancement of educational technology and the spreading eAssessment methods' adoption by primary school teachers in Morocco (Es-sarghini & Boumahdi, 2024) present new opportunities for enhancing writing competency eAssessment through artificial intelligence and computational methods. This research addresses a critical challenge in contemporary educational assessment: developing systems that combine precise quantification of writing competency with meaningful stakeholder engagement. Our primary research question asks:

> **"How can an AI-enhanced computational framework integrate stakeholder engagement, visualization capabilities, and automated analysis to support the formative eAssessment of writing competency development?"**

This central question is supported by three focused secondary inquiries:

1. How can interactive visualization systems effectively represent writing competency progression while maintaining accessibility for all stakeholders?

2. What approaches enable automated systems to balance standardized evaluation with personalized feedback?
3. How can eAssessment tools facilitate effective multi-directional communication among stakeholders?

Through these questions, we aim to develop an integrated eAssessment framework that bridges the gap between computational sophistication and practical pedagogical needs in educational settings.

Literature review

The Concept of Competency

Competency represents the autonomous capacity to mobilize internal resources (knowledge and procedural skills) and external resources (environmental tools) to resolve complex tasks within a specific context (De Ketele, 2010; Gérard, 2008; Jonnaert, 2002; Rey et al., 2003; Roegiers, 2004). Bronckart and Dolz (2002) emphasize that competency is theoretically constructed through situational engagement (Bronckart & Dolz, 2002). De Ketele and Gérard (2005) define it as "the capacity to respond to complex and novel situations through innovative combinations of known procedures (De Ketele & Gérard, 2005)." Rey et al. (2003) further elaborate that "authentic competency extends beyond responding with stereotypical procedures to predetermined signals, encompassing the ability to mobilize diverse resources for novel problem resolution (Rey et al., 2003)."

Writing Production Competency

Writing production constitutes a fundamental component of effective communication in both academic and authentic contexts, enabling learners to articulate ideas precisely and achieve communicative objectives (Iwashita & Spence-Brown, 2018). Chartrand (2013) emphasizes that mastery of linguistic resources or textual genre characteristics alone is insufficient for developing writing competency (Chartrand, 2013). Consequently, as a competency, written production cannot be reduced to simple mechanical exercises, such as singular-to-plural transformations or logical connector insertions (De Ketele, 2013). While these activities contribute to learning, they fail to capture the complexity inherent in writing competency.

Essential to competency development is engagement with complex, contextualized tasks that necessitate the mobilization of comprehensive learner resources. Tasks such as narrative composition, letter writing, dissertation development, or literary analysis engage complex competencies, requiring planning, structuring, and linguistic resource mastery (De Ketele, 2010). These activities demonstrate the multifaceted nature of written production competency and its integration of various cognitive and linguistic processes.

The Concept of Assessment

Assessment constitutes a systematic process of data collection designed to evaluate, measure, and document student preparedness, learning progression, competency acquisition, and academic outcomes (Munaroh, 2024; Zhou, 2023). Hadji (1989) defines it as "the act of formulating a value judgment on a specific object (individual, situation, action, project, etc.) through the comparison of two data series: factual data concerning the actual object being evaluated and ideal data representing expectations (Hadji, 1989)." De Ketele (2010) expands this concept, describing assessment as the collection of relevant, valid, and reliable information, subsequently compared against established criteria to determine alignment with expected outcomes (De Ketele, 2010). This process facilitates meaningful interpretation of collected data to support decision-making processes. Assessment thus transcends mere measurement, incorporating result interpretation based on well-defined criteria and utilizing diverse methodological approaches to support continuous student improvement and evidence-based educational decision-making (Zhou, 2023).

The Concept of eAssessment

ICT-based assessment, also known as eAssessment, refers to the integration of digital technologies and information-communication tools in educational evaluation processes (Bennett, 2002; Heap et al., 2004). According to Es-sarghini and Boumahdi (2024), this digital approach offers several key contributions to educational assessment as it enhances the learning experience by functioning beyond traditional grading and serving as a prognostic tool for personalizing learning paths. It also enables real-time assessment of complex competencies and offers features and analysis opportunities that are challenging through conventional assessment methods (Es-sarghini & Boumahdi, 2024).

Competency Assessment

Assessment serves multiple functions: informing students, parents, teachers, and educational institutions about learning progression, guiding course selection, and evaluating instructional effectiveness (Sievertsen, 2023). That's why their implementation requires clear criteria, pedagogical support, and balanced consideration of both process and outcomes (Heil & Ifenthaler, 2023; Munaroh, 2024). Weinert (1999) proposes a systemic approach to competency assessment, emphasizing the integration of "multiple interconnected knowledge domains, application across situational families, and goal orientation (Weinert, 1999)."

Competency assessment frequently involves tasks requiring students to demonstrate integrated text production capabilities, addressing both content and presentation dimensions (Iwashita & Spence-Brown, 2018). This assessment methodology necessitates the completion of complex tasks or problem-situation resolution by the observed individual, requiring methodological approaches distinct from traditional evaluation practices, particularly regarding a) translation of competency statements into complex tasks, b) performance observation and interpretation, c) equal emphasis on process and outcome evaluation (Scallon, 2004).

Assessment of Written Production Competency

The assessment of written productions represents a central challenge in pedagogical practices, raising complex questions regarding the objectivity and subjectivity of evaluative judgments. Romainville (2011) posits that absolute objectivity in assessment remains elusive, as it inevitably relies on human judgment influenced by cognitive and contextual biases (Romainville, 2011). This necessitates the development of assessment tools that are both normative and adaptable, reconciling objectivity requirements with the specific characteristics of written productions (Duvin-Parmentier et al., 2021). To mitigate potential biases, Romainville (2011) advocates for explicit, standardized criteria that structure assessment and reduce inter-rater variability (Romainville, 2011).

The Common European Framework of Reference for Languages (CEFR) provides descriptors for writing assessment, though their consistent application presents challenges (Díez-Bedmar, 2018). From this standpoint, De Ketele and Gerard (2005) differentiate between two criterion categories (De Ketele & Gérard, 2005):

a. **Minimal criteria (essential for certification):**
   - Communicative relevance;
   - Textual coherence;
   - Linguistic resource mastery.

b. **Enhancement criteria (desirable but not mandatory):**
   - Product presentation quality;
   - Ideational originality.

Even with standardized instruments, criterion interpretation remains subjective, emphasizing the necessity for comprehensive evaluator training to ensure assessment practice homogeneity (Romainville, 2011). To ensure assessment accuracy and reliability, De Ketele and Gérard (2005) recommend multiple readings of produced texts, focusing on one minimal criterion per reading. Each criterion should be evaluated holistically rather than as a mere sum of indicators.

For mathematical grade conversion, they propose two fundamental rules to prevent excessive failure rates (De Ketele & Gérard, 2005):

- **The three-quarters rule:** Minimal criteria must constitute at least 75% of the global score;
- **The two-thirds rule:** Achievement of at least two-thirds of minimal criteria scores is required for success.

These guidelines ensure students achieve a 50% success threshold while respecting the multidimensional nature of writing production competency. This framework provides a structured approach to writing assessment while acknowledging its inherent complexity and the need for balanced evaluation methodologies.

Methodology

Methodological Framework

This research adopts a Design-Based Research (DBR) methodology, selected for its particular suitability in developing and evaluating pedagogical innovations within authentic educational contexts (Anderson & Shattuck, 2012). This iterative approach facilitates the integration of technological development with scientific investigation while engaging stakeholders in the design process, enabling refinement and enhancement of educational products and processes through cycles of design, implementation, analysis, and redesign (Tinoca et al., 2022).

Following Wang and Hannafin's (2005) framework, our methodology incorporates five fundamental principles (Wang & Hannafin, 2005):

- **Pragmatic:** Addresses practical educational challenges;
- **Grounded:** Based on theoretical foundations and authentic contexts;
- **Interactive:** Facilitates researcher-practitioner collaboration;
- **Iterative:** Proceeds through design-test-revision cycles;
- **Flexible:** Allows methodological adjustments based on emerging needs.

Our implementation follows the Educational Design Research (EDR) model (McKenney & Reeves, 2018), providing a structured framework for developing and evaluating educational solutions while emphasizing continuous improvement and adaptation to specific stakeholder

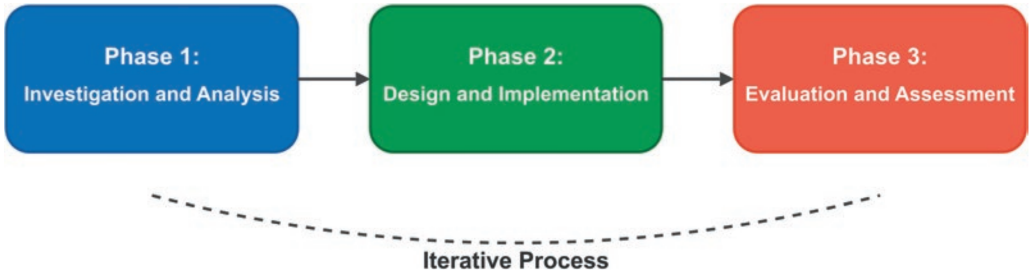

Figure 1 *Development phases of our Interactive Curves Graph system following the EDR Model*

needs. This model has demonstrated particular efficacy in creating innovative pedagogical materials and supporting teacher professional development (Dunn et al., 2019; Martriana et al., 2020; Rifandi et al., 2019). Previous applications of this framework include the development of scientific activity manuals facilitating observation, inquiry, and communication (Martriana et al., 2020) and the creation of instructional materials (Rifandi et al., 2019).

The research proceeds through three sequential phases (Figure 1), integrating systematic investigation with practical implementation to ensure both theoretical rigor and practical applicability. This methodological approach enables the development of evidence-based solutions while maintaining sensitivity to contextual factors and stakeholder needs.

Implementation Methodology

The developed Interactive Curves Graph (ICG) system implementation adhered to a structured three-phase methodology, incorporating iterative feedback mechanisms throughout the development cycle. This approach aligns with established educational technology development frameworks (Martriana et al., 2020; Rahman et al., 2020).

Investigation and Analysis Phase

The initial phase encompassed comprehensive data collection and contextual analysis protocols. As emphasized by Wahyuni et al. (2021), this stage focused on identifying educational challenges (Wahyuni et al., 2021) related to writing competency assessment and understanding the implementation context. The investigation phase implemented systematic data collection methodologies, including structured observations and questionnaires, to assess educational framework challenges and opportunities. This approach enabled the development of a robust preliminary study (Martriana et al., 2020; Rahman et al., 2020).

Design and Implementation Phase

The development phase translated analytical findings into concrete technical solution (the ICG system). Following the framework proposed by Rifandi et al. (2019), this phase implemented real-time data visualization algorithms and integrated AI-driven analysis systems (Figure 2).

The development process included creating interactive user interfaces for both instructor and student applications, with secure data storage and retrieval mechanisms. This phase emphasized iterative testing and revision protocols based on teachers' feedback, ensuring continuous refinement of both algorithmic components and user interface elements (Martriana et al., 2020; Rahman et al., 2020).

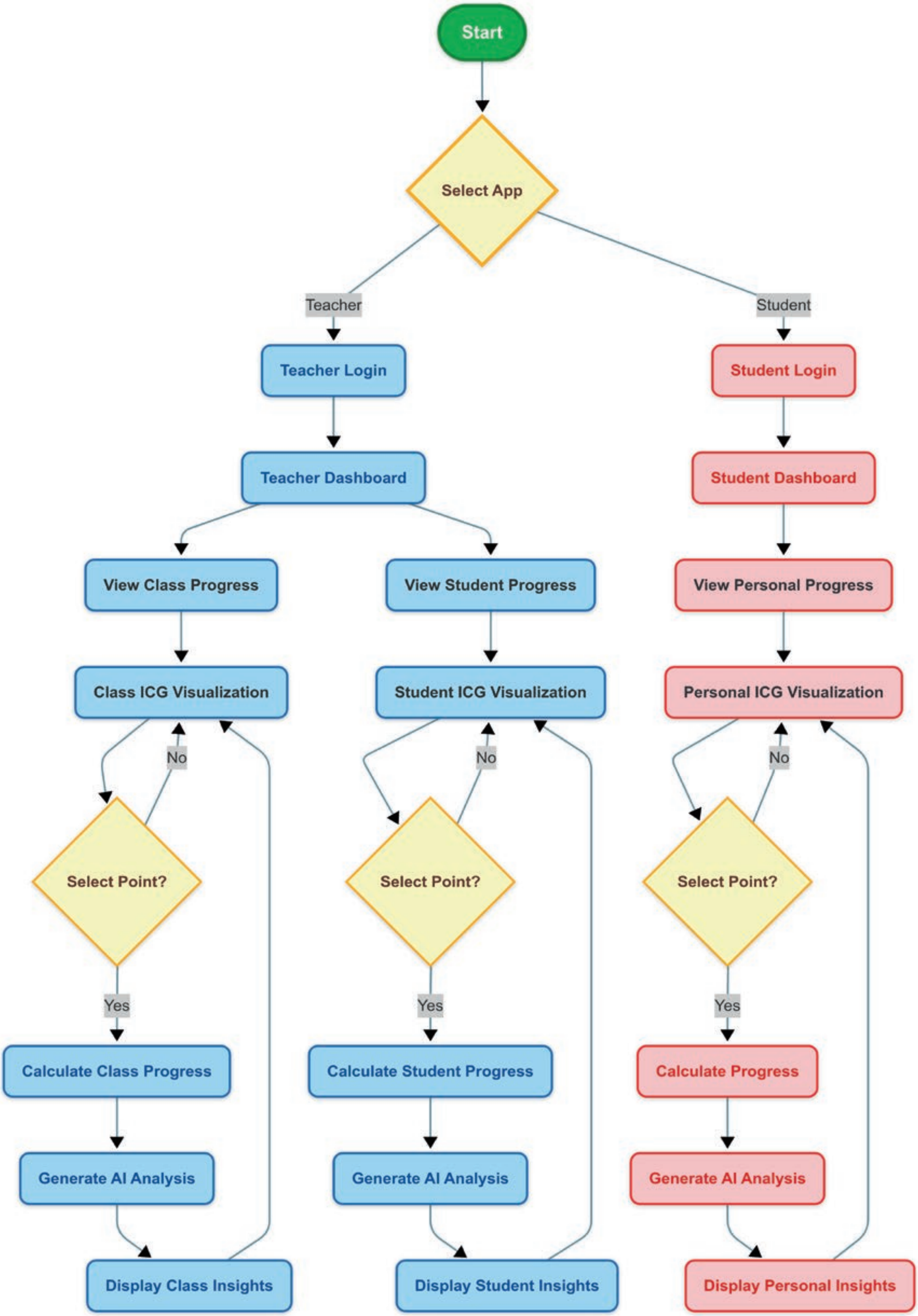

Figure 2 *Overall system workflow and user interaction paths*

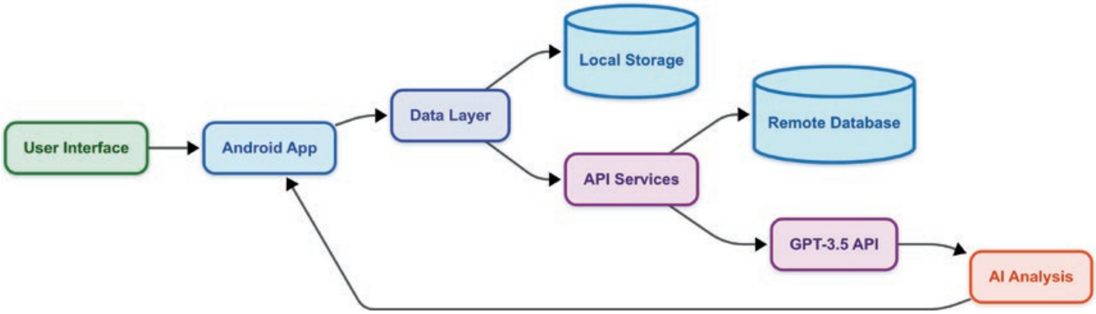

Figure 3 *Data flow between different system components*

Evaluation and Assessment Phase

The final phase implemented comprehensive evaluation protocols to assess our system efficacy. As outlined by Lisdiani et al. (2021), this included systematic evaluation of system performance metrics (Lisdiani et al., 2021), implementation of interactive visualization and AI-generated feedback mechanisms, and integration of performance analysis algorithms (Figure 3).

The evaluation process incorporated expert validation protocols and real-environment testing methodologies to ensure practical applicability. This phase established automated progress tracking systems and implemented continuous feedback loops for system optimization (Martriana et al., 2020; Rahman et al., 2020).

The methodology maintained an iterative approach throughout all phases, enabling continuous system optimization based on performance metrics and user interaction data. This systematic framework facilitated the refinement of both technical components and pedagogical elements, ensuring alignment with educational objectives while maintaining technical robustness. The implementation methodology emphasized empirical validation while ensuring practical applicability within authentic educational contexts, as supported by contemporary educational technology research (Lisdiani et al., 2021; Martriana et al., 2020).

Experimentation Methodology

This study employed a mixed-methods approach to evaluate the effectiveness of the ICG system in supporting FFL writing competency assessment. The investigation was conducted over a 1.5-month period in 3 primary schools in Morocco.

The study involved 15 French as Foreign Language (FFL) teachers working across 7 classes, with a total student population of 190. Table 1 presents the demographic characteristics of the participating teachers.

Table 1 *Participant Demographics and Professional Experience*

Characteristic	Mean
Age (years)	37.25
Teaching experience	17

The implementation was structured across multiple educational settings to ensure comprehensive evaluation. Table 2 details the scope and scale of the implementation.

Table 2 *Study Implementation Framework*

Duration (months)	1.5
Examination periods	2
Classes involved	7
Total students	190
Participating schools	3
Teachers	15

The data collection strategy incorporated multiple sources and methods as shown in Table 3.

Table 3 *Data Collection Methods and Sources*

Method	Type of data	Collection frequency
Teachers' interviews	Qualitative	Post study
Written feedback	Mixed	Weekly
Assessment data	Quantitative	2 periods

Analysis Framework

The analysis of collected data followed a comprehensive dual-track approach, incorporating both qualitative and quantitative methodologies. For the qualitative component, ATLAS.ti coding software was employed to conduct a systematic thematic analysis of teachers' feedback and implementation insights. This process involved identifying recurring patterns, categorizing responses, and extracting meaningful themes from the narrative data collected through interviews and written feedback.

The quantitative analysis track focused on assessment performance data. System usage patterns were analyzed to understand teacher interaction with the ICG platform, including frequency of use and duration of assessment sessions. Assessment performance data was examined to evaluate the effectiveness of the system in supporting writing competency assessment.

This multi-layered analytical approach provided a rich understanding of both the technical performance of the ICG system and its practical impact on digital assessment practices, while maintaining methodological rigor throughout the analysis process.

Results

Description of the Developed Solution

The ICG is an innovative Android-based solution designed to facilitate the tracking and analysis of student progress in French as a Foreign Language (FFL) writing competency at the

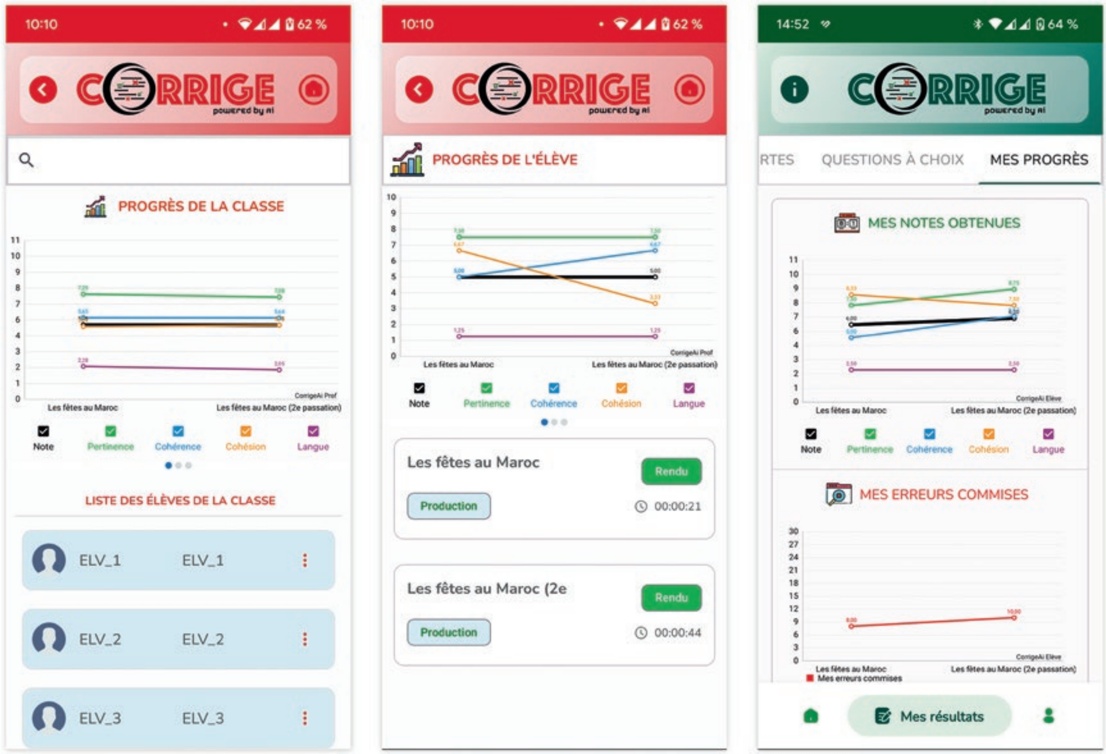

Figure 4 *ICG system user interface in teacher and student Android applications*

primary education level. This educational technology implementation leverages artificial intelligence to provide detailed analytical feedback on student performance across multiple assessment criteria.

The application architecture comprises two main components: a class-level analysis module and an individual student tracking interface. Both modules utilize interactive line charts to visualize performance trajectories across five distinct evaluation criteria: overall score, relevance, coherence, cohesion, and linguistic mastery. Each criterion is represented by a distinct curve with unique visual properties, allowing for simultaneous visualization and comparison of performance across different aspects of writing competency (Figure 4).

The ICG implements a sophisticated data visualization system using the MPAndroidChart library, featuring customizable line graphs with interactive elements. The visualization includes color-coded curves, adjustable visibility controls through checkboxes, and touch-responsive data points. The interface supports dynamic scaling, axis customization, and animated transitions, enhancing the user experience and data comprehension.

A notable feature of the ICG is its integration with OpenAI's GPT-3.5-turbo model for generating contextual analysis. When users interact with specific data points on the curves, the system triggers an API call to generate a detailed pedagogical commentary. This AI-driven analysis considers both the absolute performance value and the relative progress (calculated as the difference from the previous assessment) to provide targeted feedback and improvement suggestions specific to each evaluation criterion (Figure 5).

The system maintains a structured evaluation framework where each criterion is precisely defined: relevance addresses task compliance and vocabulary usage; coherence focuses on

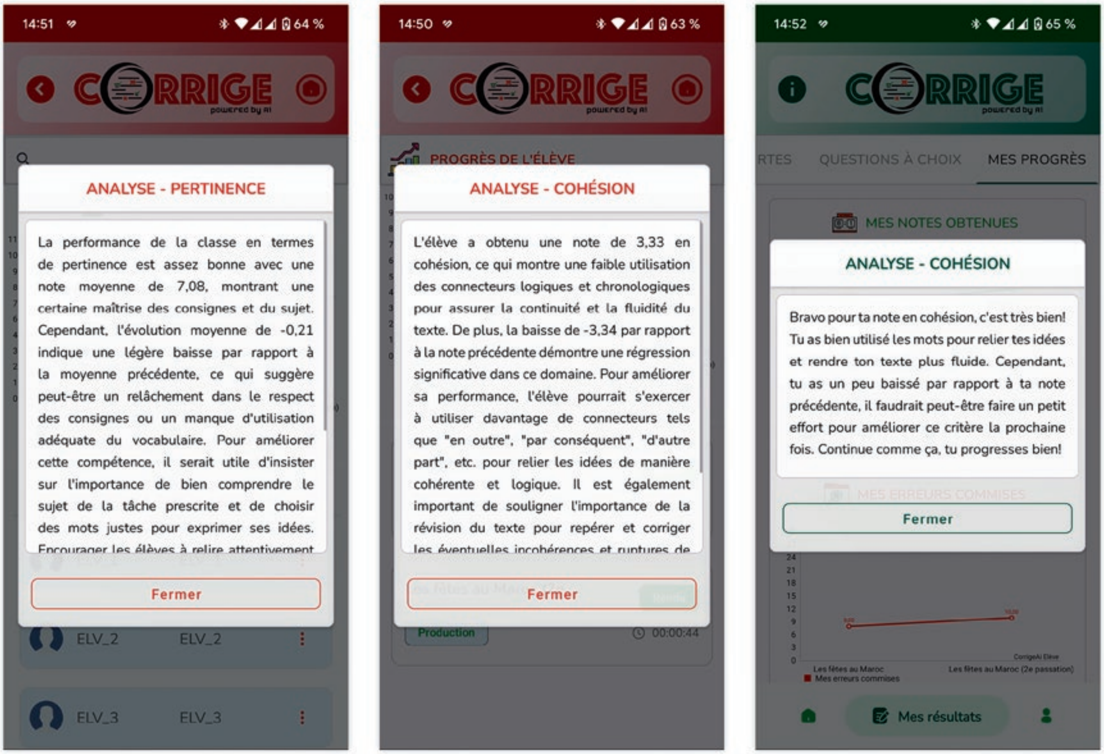

Figure 5 *AI-Driven Analysis Functionality within ICG in teacher and student Android applications*

sentence structure and meaning unity; cohesion evaluates logical connectors and idea flow; and linguistic mastery encompasses syntax, grammar, conjugation, and orthography rules in French language usage. Performance is measured on a scale from 0 to 10, with 5 representing both the average and the success threshold.

From a technical perspective, the application implements robust data handling through RESTful API interactions, secure token-based authentication, and efficient JSON parsing for data management. The user interface incorporates modern Material Design elements and supports responsive layouts with animated dialogs for displaying AI-generated feedback.

This educational technology solution represents a significant advancement in computer-assisted language learning assessment, providing educators and students with real-time, AI-enhanced insights into writing competency development while maintaining a user-friendly and intuitive interface for both classroom and individual use contexts.

Implemented Mathematical Model

The ICG implements a straightforward yet effective mathematical model for tracking and analyzing student performance in French language writing competency. The model's foundation lies in its multi-dimensional scoring system, which captures five distinct assessment criteria at each evaluation point (Figure 6).

The core of the model is represented by a score vector S(t) = [G(t), P(t), Co(t), Ch(t), L(t)], where each component corresponds to a specific evaluation criterion: Global score G(t), Pertinence score P(t), Coherence score Co(t), Cohesion score Ch(t), and Linguistic mastery

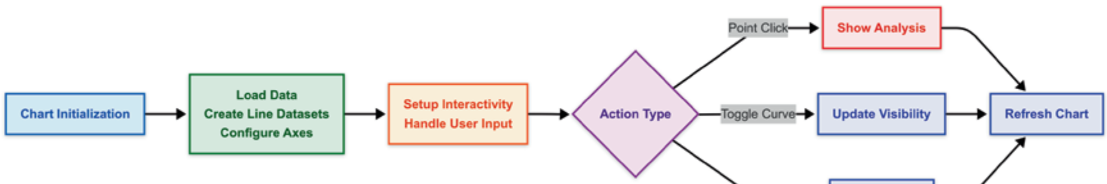

Figure 6 *Interactive visualization handling process*

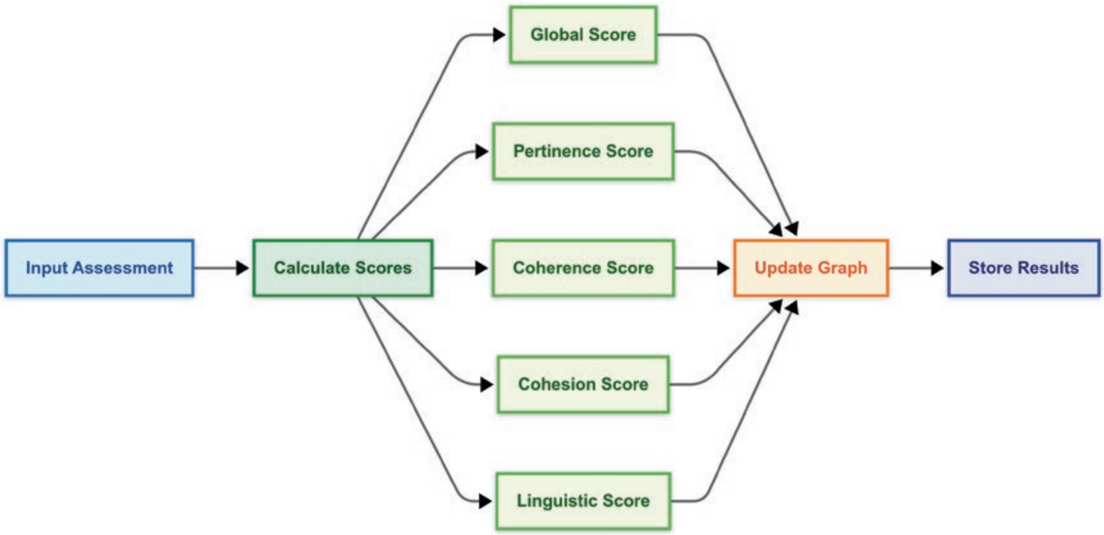

Figure 7 *Score calculation and storage process*

score L(t). All scores are constrained within a standardized range of [0, 10], ensuring consistent evaluation metrics across all assessments (Figure 7).

Progress monitoring is achieved through a differential calculation mechanism. For any given criterion c at time t, the system computes the progress gap Δc as the difference between the current and previous assessment scores: $\Delta c = c(t) - c(t - 1)$. This calculation enables the quantification of student progress or regression between consecutive evaluations.

For class-level analysis, the model incorporates a statistical component that calculates the mean performance μc for each criterion across all students (n) using the formula $\mu c = (1/n) \cdot \Sigma(ci)$. This statistical measure provides educators with insights into overall class performance and helps identify general trends in learning outcomes.

The visualization component of the model represents each assessment point as a coordinate pair $D(t) = (t, c(t))$, where t serves as the temporal index on the x-axis and c(t) represents the corresponding score value on the y-axis. This representation enables the creation of interactive performance curves that visualize progress over time.

The model's AI analysis component processes three key parameters: the current value c(t), the progress measure Δc, and the criterion type c, where c belongs to the set {G, P, Co, Ch, L}. These parameters serve as input for the AI system, which generates contextualized feedback and recommendations based on the observed performance patterns (Figure 8).

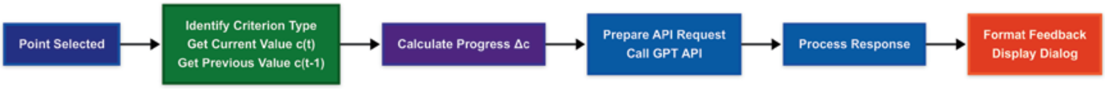

Figure 8 *AI-enabled analysis generation sequence*

This mathematical framework supports five primary functions: direct score tracking, progress calculation, statistical analysis of class performance, interactive data visualization, and AI-powered feedback generation. The simplicity and effectiveness of this model make it particularly suitable for educational applications, providing educators with quantitative tools for monitoring and analyzing student progress in language acquisition while maintaining accessibility for non-technical users.

The implementation of this model in the Android environment demonstrates its practical applicability in educational technology, offering a robust foundation for tracking and analyzing student performance in French language writing competency assessment.

The mathematical model described above was implemented throughout the experimentation phase, with teachers utilizing both the scoring system and AI-enhanced analysis features in their regular assessment practices. The practical application of this model enabled the systematic collection of both quantitative performance data and qualitative user feedback, providing insights into the system's effectiveness in real educational settings.

System Experimentation Results

During the 1.5-month implementation period, the ICG system was actively utilized across three primary schools, generating substantial usage data. The system recorded 380 individual assessment sessions, with teachers accessing the platform an average of 3.4 times per week. The AI analysis feature was triggered 287 times, providing automated feedback for both individual and class-level assessments. Each teacher (n = 15) conducted 2 assessments during the study period, evaluating student performance across all five competency criteria.

Teachers' Perceptions about the Effectiveness of ICG Implementation for Monitoring FFL Writing Competency

The analysis of teacher responses regarding the ICG system reveals a sophisticated educational technology solution that effectively addresses multiple facets of student assessment and stakeholder engagement. Through careful examination of the first word cloud (Figure 9) generated from ATLAS.ti coding, several interconnected themes emerge, demonstrating the tool's comprehensive impact on educational processes.

a. **Stakeholder engagement and user-centric design**
   At the heart of the ICG's effectiveness lies its strong focus on stakeholder engagement, with "student" emerging as the most prominently referenced term. This student-centric approach extends to include a broader network of educational partners, including teachers, parents, and family members. The tool's design deliberately facilitates a collaborative educational environment where all stakeholders can actively participate in the student's learning journey. This inclusive approach ensures that educational support extends beyond the classroom, creating a cohesive support system for student development.

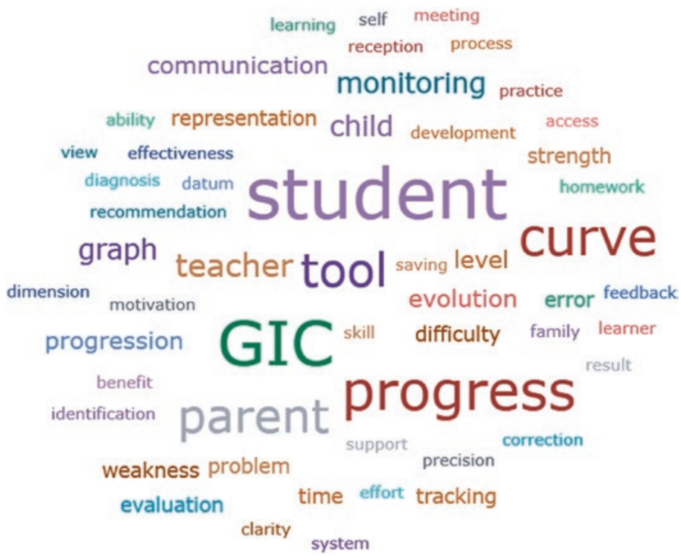

Figure 9 *Main concepts related to teachers' responses regarding the effectiveness of the ICG tool*

> ***Supporting Evidence:***
> *"For teachers: Significant time/effort savings, greater error tracking precision, easier diagnosis through curves."*
> *"For students, it's motivating to see their curve rise."*
> *"Curves allow students to self-evaluate."*
> *"For students: Easier homework reception, error identification/correction, clear visualization of strengths/weaknesses."*
> *"Parents to understand their children's level through clear graphic representation."*

b. Technical infrastructure and visualization capabilities

The ICG's technical framework demonstrates sophisticated functionality while maintaining user accessibility. The integration of interactive curves and graphical representations transforms complex performance data into easily interpretable visual information. This visualization capability serves as a cornerstone feature, enabling stakeholders to track progress, identify trends, and understand performance patterns effectively. The system's design emphasizes clarity and precision in data presentation, making it particularly valuable for monitoring longitudinal progress and development.

> ***Supporting Evidence:***
> *"allows clear visualization of competency development"*
> "Curves allow instant visualization of progress or difficulties"
> "ICG solves these problems by offering clear, objective visualization"

c. **Progress monitoring and educational assessment**
The tool's robust progress monitoring capabilities represent a significant advancement in educational assessment technology. Teachers can track multiple aspects of student development, from specific competency progression to overall performance trends. The system facilitates both formative and summative assessment through various features including evolution tracking, progression monitoring, and performance mapping. This comprehensive approach to assessment enables educators to make data-driven decisions and implement timely interventions when necessary.

> ***Supporting Evidence:***
> *"Allows objective tracking of student progress"*
> *"they provide clear, professional view of student progress"*
> *"Curves allow instant visualization of progress"*

d. **Communication and collaboration framework**
A particularly noteworthy aspect of the ICG is its role in facilitating communication among stakeholders. The tool serves as a bridge between classroom activities and home support, enabling structured meetings, facilitating regular updates, and ensuring accessible information sharing. This enhanced communication framework supports more informed decision-making and enables timely interventions when learning challenges are identified. The system's ability to facilitate multi-directional communication strengthens the educational partnership between teachers, students, and parents.

> ***Supporting Evidence:***
> *"Excellent communication tool."*
> *"effective for family communication"*
> *"Curves particularly useful for motivating students and communicating with parents."*

e. **Support features and performance analysis**
The ICG incorporates comprehensive support features that extend beyond basic monitoring capabilities. The system includes targeted recommendations, motivational elements, and structured feedback mechanisms that contribute to a more engaging learning environment. Performance analysis capabilities enable precise identification of strengths and weaknesses, allowing for personalized learning support and intervention strategies. The combination of diagnostic tools, evaluation features, and correction mechanisms creates a complete assessment cycle that serves both evaluative and developmental purposes.

> ***Supporting Evidence:***
> "better ability to support children"
> "detect strengths and weaknesses."
> "suggests appropriate remediation activities."
> "Allows quick identification of remediation needs"
> "suggests personalized remediation paths."

Figure 10 *Main concepts related to teachers' perceptions regarding the AI-Performance Analysis Feature integrated within the ICG system*

The analysis reveals that the ICG tool successfully fulfills its intended educational objectives across multiple dimensions. Its effectiveness stems from the seamless integration of progress monitoring, stakeholder communication, and comprehensive assessment capabilities. The tool's ability to maintain precision in measurement while facilitating educational partnerships makes it a valuable asset in modern educational settings. Teachers' responses indicate strong satisfaction with the tool's functionality, particularly in its ability to support student progress monitoring, enhance communication, and provide detailed performance analysis.

The prominence and interconnection of these various elements suggest that the ICG represents a significant advancement in educational technology, particularly in its ability to integrate various aspects of student assessment and stakeholder communication into a single, coherent platform. This comprehensive analysis supports the continued implementation and development of such interactive graphical tools in educational settings, emphasizing their potential to enhance both teaching and learning processes.

Teachers' Perceptions Regarding the AI-Enhanced Performance Analysis Feature Integrated Within the ICG System

The analysis of teacher responses regarding the artificial intelligence-enhanced performance analysis functionality integrated within the ICG system reveals several significant findings regarding its implementation in formative assessment of written production competency (Figure 10).

a. **Core analytical components**
   The predominant theme emerging from the analysis centers on the tool's analytical capabilities, with "analysis" and "evaluation" appearing as central concepts. Teachers particularly emphasized the system's ability to provide comprehensive performance assessment

through AI-driven analysis. This integration of artificial intelligence enables automated detection of various performance indicators, supporting both immediate and longitudinal evaluation processes.

Supporting Evidence:
"AI brings in-depth analysis dimension that considerably enriches evaluation."
"AI analysis is real asset. Offers objective, detailed analysis, quickly identifying areas for improvement.
"AI performance analysis benefits teachers through comprehensive analysis of student evolution."
"AI provides valuable help in production analysis. Enables more objective evaluation and personalized recommendations."

b. Performance monitoring and assessment features

The system demonstrates robust functionality in performance monitoring, incorporating multiple analytical dimensions. Teachers highlighted the tool's capacity for detecting patterns, identifying errors, and tracking student progress through various performance indicators. The AI component facilitates rapid identification of strengths and weaknesses, enabling more precise and objective assessment of written production competency. This automated analysis provides consistent evaluation parameters while maintaining the flexibility needed for individualized assessment.

Supporting Evidence:
"Facilitates monitoring and provides detailed feedback on individual and collective levels."
"It quickly identifies recurring weaknesses and suggests relevant improvement paths."
"AI brings welcome objectivity. Quickly identifies weaknesses and suggests appropriate remediation activities."

c. Pedagogical implementation and support

A significant advantage noted by teachers is the tool's ability to provide immediate feedback and targeted recommendations. The system's intervention support features enable teachers to implement timely pedagogical adjustments based on AI-generated insights. The combination of speed and precision in analysis allows for more efficient formative assessment processes, with teachers particularly valuing the time-saving aspects of automated evaluation.

Supporting Evidence:
"Provides feedback to improve student levels and encourage continuous self-evaluation."
"Enables more objective evaluation and personalized recommendations."
"Offers personalized improvement suggestions."

d. Decision support and differentiation

The AI functionality demonstrates significant utility in supporting educational decision-making processes. Teachers emphasized the system's capability to facilitate differentiated instruction through detailed performance analysis and targeted suggestions. The tool's ability to identify specific areas requiring intervention enables more focused and effective pedagogical responses, supporting both individual and group-level instructional planning.

> ***Supporting Evidence:***
> *"Offers personalized improvement suggestions."*
> *"AI analysis very effective at detecting recurring errors and proposing adapted solutions. Enables more efficient pedagogical differentiation."*
> *"Facilitates monitoring and provides detailed feedback on individual and collective levels."*

e. Formative assessment enhancement

In the context of formative assessment, teachers highlighted several key strengths of the AI-enhanced analysis:

- Rapid identification of learning gaps and difficulties;
- Consistent evaluation criteria application;
- Objective performance measurement;
- Detailed diagnostic capabilities;

> ***Supporting Evidence:***
> "AI brings objective and scientific dimension to evaluation."
> "AI performance analysis benefits teachers through comprehensive analysis of student evolution, determining strengths and gaps; helps with formative evaluation and facilitates support work."
> "AI analysis is real asset. Offers objective, detailed analysis."

The analysis reveals that teachers perceive the AI-enhanced analysis functionality as a valuable asset in formative assessment of written production competency. The system's ability to combine rapid analysis with detailed diagnostic capabilities supports more efficient and effective assessment practices. The integration of artificial intelligence into the evaluation process appears to enhance both the precision and utility of formative assessment, while providing valuable support for pedagogical decision-making.

> ***Supporting Evidence:***
> *"Excellent pedagogical decision-making tool."*

These findings suggest that AI-enhanced assessment tools can significantly contribute to the effectiveness of formative evaluation in language instruction, particularly in the context of written production competency. The combination of automated analysis with traditional assessment approaches appears to create a more comprehensive and efficient evaluation framework.

Synthesis of Technical Implementation and User Experience

The integration of the technical architecture with the mathematical model demonstrated significant synergies during the experimentation phase, particularly in three key areas. The visualization capabilities, powered by the MPAndroidChart library, effectively supported stakeholder engagement through interactive curves and color-coded representations of assessment criteria. These features enabled immediate performance insights and facilitated comprehensive assessment practices, enhancing understanding of student progress across all stakeholders.

The AI integration, implemented through GPT-3.5-turbo model, successfully translated mathematical calculations into actionable pedagogical insights. This automated analysis system reduced teacher workload while maintaining assessment quality, creating a balanced framework for both detailed evaluation and practical intervention strategies. The Android-based platform's accessibility, combined with the mathematical model's simplicity, enabled consistent evaluation practices across different educational contexts.

Several implementation considerations emerged during the study. The system's dependence on stable internet connectivity occasionally affected AI analysis response times, while teachers required approximately one week to master the visualization interface. Early-phase limitations due to minimal historical data gradually resolved as usage increased.

These findings demonstrate that the technical implementation successfully supported pedagogical objectives, with the mathematical model providing a robust foundation for automated analysis and user interaction. The positive alignment between technical features and user needs indicates the system's potential for sustainable integration into educational assessment practices.

Discussion

Our findings reveal three significant theoretical contributions to educational assessment frameworks. First, the success of student-centered design in the ICG system validates De Ketele's (2010) emphasis on learner-centered assessment approaches (De Ketele & Gérard, 2005). The system's visualization capabilities effectively address Romainville's (2011) concerns about assessment objectivity (Romainville, 2011) while implementing De Ketele and Gerard's (2005) multiple-criteria framework (De Ketele & Gérard, 2005). This integration demonstrates the importance of incorporating social dimensions alongside technical considerations in assessment technology.

Second, the AI component's enhancement of assessment practices aligns with Bronckart and Dolz's (2002) framework of situated competency construction (Bronckart & Dolz, 2002). The system's pattern detection and immediate feedback capabilities support Chartrand's (2013) holistic view of writing competency development (Chartrand, 2013), demonstrating how artificial intelligence can effectively support formative assessment while maintaining pedagogical validity.

Third, the system's communication capability aligns with Sievertsen's (2022) multi-functional view of assessment, which emphasizes how assessment serves to inform students, parents, teachers, and educational institutions about learning progression while guiding instructional decisions (Sievertsen, 2023). The success of multi-directional stakeholder communication in the ICG system demonstrates how digital assessment tools can effectively fulfill these multiple functions by integrating robust communication features alongside their computational capabilities.

Several limitations warrant consideration. The study's scope (n = 15 teachers in FFL context) and duration may limit generalizability, while the absence of longitudinal data prevents definitive conclusions about long-term impacts. Future research should focus on broader validation studies, cross-cultural implementations, and longitudinal investigations of stakeholder interactions. Additionally, the development of more sophisticated AI algorithms and integration with existing educational frameworks represent promising directions for future development.

This research advances assessment theory by demonstrating how technological integration can balance standardized evaluation with personalized feedback. The findings suggest that successful writing competency assessment tools must harmonize objective measurement with stakeholder engagement, automated analysis with human judgment, and standardized criteria with personalized feedback. The ICG system's effectiveness indicates that future theoretical frameworks should conceptualize technological tools as platforms for educational collaboration rather than merely measurement instruments.

Conclusion

The experimental implementation of the ICG system provides significant insights into the integration of AI-enhanced writing assessment frameworks in educational settings. The results demonstrate that combining AI-driven analysis with interactive visualization tools effectively supports formative assessment while maintaining strong stakeholder engagement. The system successfully bridges the gap between automated assessment and human-centered educational practices through a user-centric design approach.

The findings reveal that interactive graphical curves serve as an effective medium for translating complex assessment data into accessible insights. Teachers' responses emphasized how the visualization capabilities enhanced their ability to track progress and communicate findings with stakeholders, confirming that visual representation acts as a crucial interface between AI-powered analysis and practical application in educational contexts.

The ICG system achieved a balanced approach to assessment through its layered methodology, where AI-driven analysis provides consistent evaluation parameters while supporting individualized feedback mechanisms. Teachers' feedback highlighted how the system's ability to detect patterns and suggest personalized interventions, while maintaining objective assessment criteria, created a comprehensive evaluation framework.

The multi-directional communication functionality emerged as a critical success factor, with the system's ability to facilitate structured interactions between teachers, students, and parents supporting informed decision-making and timely interventions. This finding establishes communication channels as a fundamental component rather than an auxiliary feature in digital assessment tools.

These results advance our understanding of how technological solutions can enhance writing competency assessment while maintaining educational validity. The success of the ICG system suggests that future educational technology development should prioritize the integration of AI capabilities with visualization tools and communication features, grounded in user-centered design principles.

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