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Designing DARTS: A unified AI system for tutoring, classroom interaction, assessment, and students' success

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Abstract

Building on the conceptual foundation presented in the first article on the evolution of Mastery Learning to DARTS (Sarkar, 2025), this second paper presents the design and technical architecture of DARTS (Dynamic Academic Response and Tutoring System). DARTS is an AI-powered, mobile-first Intelligent Tutoring System (ITS) designed to operationalize Mastery Learning at scale by integrating real-time classroom data with personalized, SMS-based tutoring. This study addresses key research questions concerning the practical and pedagogical potential of mobile-enabled ITS platforms, particularly in enhancing accessibility, responsiveness, and equity in learning environments. The paper details DARTS' core system architecture, including its feedback loop, AI-powered decision engine, natural language processing (NLP) layer, and its innovative use of behavioral classroom signals (such as attendance, quiz participation, and engagement) to trigger timely, individualized instruction. Each classroom workflow for attendance, quizzing, and brainstorming, is described alongside the system's diagnostic and intervention processes. The design draws upon Bloom's 2 Sigma model and advances in AI to transition DARTS from concept to a deployable system. While this paper focuses on the design and implementation of the system, it does not assess instructional outcomes. That analysis will follow in the third paper of this three-part series, which will present empirical classroom findings. The DARTS architecture builds on insights from the author's doctoral research and teaching experience and is currently protected by two pending U.S. patents (Application Nos. 18/521,928 and 18/433,800).

Keywords: AI in education, intelligent tutoring system, mastery learning

Introduction

The persistent challenge of scaling high-quality instruction has been a central concern in educational research for decades. Bloom's seminal study on the "2 Sigma Problem" demonstrated that students who received one-on-one tutoring performed two standard deviations better than those in conventional classroom settings (Bloom, 1984) and is illustrated in Figure 1 below. While this individualized approach showed transformative results, it has remained largely unachievable at scale due to logistical, financial, and systemic constraints (Guskey, 2007). As education systems continue to seek scalable models that preserve the benefits of tutoring, there is a growing need for innovative, low-cost solutions that can adapt to diverse learning environments. Intelligent Tutoring Systems (ITS) and Student Response Systems (SRS) have emerged as partial answers to this challenge. However, traditional ITS models are often desktop-based, infrastructure-heavy, and poorly integrated into real-time classroom dynamics. Meanwhile, earlier SRS tools—such as clickers—offered promising insights into student engagement but suffered from deployment difficulties and limited personalization. As a result, both models have struggled to meet the needs of large, diverse classrooms, particularly in low-resource settings.

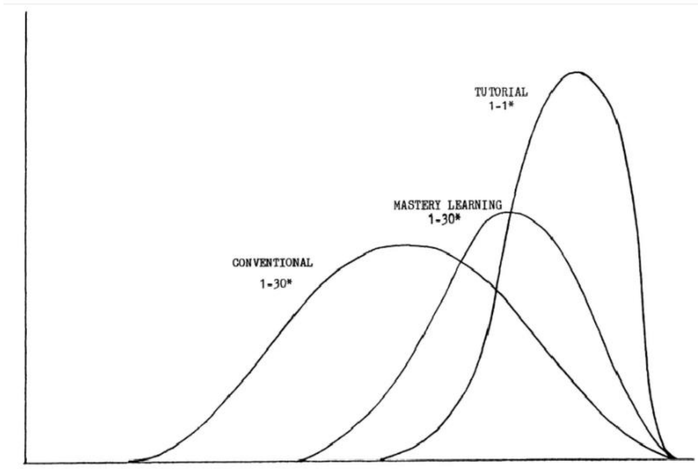

Figure 1. Bloom's 2 Sigma Problem: Comparative Student Achievement (Adapted from Bloom, 1984)

This paper introduces DARTS (Dynamic Academic Response and Tutoring System), a mobile-first, AI-powered Intelligent Tutoring System designed to overcome these limitations. DARTS offers a unified platform that supports in-class formative assessments (via attendance, quizzes, and brainstorming) and out-of-class personalized tutoring—all through SMS-based interaction that requires no apps, training, or internet connectivity. By embedding natural language processing (NLP) and AI decision engines within a mobile interface, DARTS functions as a real-time teaching assistant capable of guiding students based on their classroom behaviors and performance. To guide the system's design, this study investigates the following research questions:

- *How can a mobile interface be layered onto conventional ITS to support real-time, personalized instruction without requiring app installation or internet connectivity?*
- *What architectural and AI components are necessary to support dual functionality—as both a Student Response System and a tutoring engine?*
- *How can behavioral classroom data (such as attendance, participation, and quiz performance) be efficiently captured and used to personalize feedback?*
- *What structural adaptations are required to support DARTS' dual use as both an SRS and a tutoring engine?*

While DARTS has been developed and successfully piloted in a controlled academic environment, its large-scale implementation across diverse classroom settings remains a subject of ongoing investigation. Initial design iterations and technical validations were informed by focused student feedback and prototype testing. However, the broader questions surrounding its real-world effectiveness—such as long-term engagement, instructor adoption, and impact on student learning outcomes—require empirical evaluation. These questions will be addressed in the third paper of this research series, which will analyze classroom deployments, assess performance data, and explore how DARTS scale in varied educational contexts. This current paper focuses on the system's design, architecture, and pedagogical foundations that enable such scalability.

System Architecture Overview

This study focuses on the technical and architectural innovations necessary to support this dual functionality. DARTS implements these fundamental learning principles using reinvented ITS architecture. A typical ITS is made up of four core components (Figure 2): the domain model, which stores subject knowledge and expert strategies; the student model, which tracks learner progress and misconceptions to create a personalized profile; the tutoring (pedagogical) model, which selects instructional strategies and feedback; and the user interface model, which manages student-system interaction.

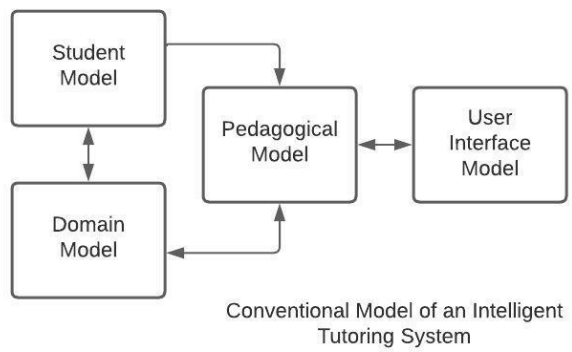

Figure 2. Models of a Conventional Intelligent Tutoring System

Figure 3 shows how mobile phone interfaces improve the ITS models, indicating a significant step forward in the technological growth of a conventional ITS (e.g. DARTS) toward a fully accessible, location-independent intelligent teaching system. In addition to the mobile interface's versatility, the AI engine in DARTS performs two key functions: (1) it creates a real-time student profile by analyzing individual learning behaviors—including prior knowledge, strengths, and weaknesses—which serve as input to the underlying student model; and (2) it delivers personalized learning content via conversational interactions powered by Natural Language Processing.

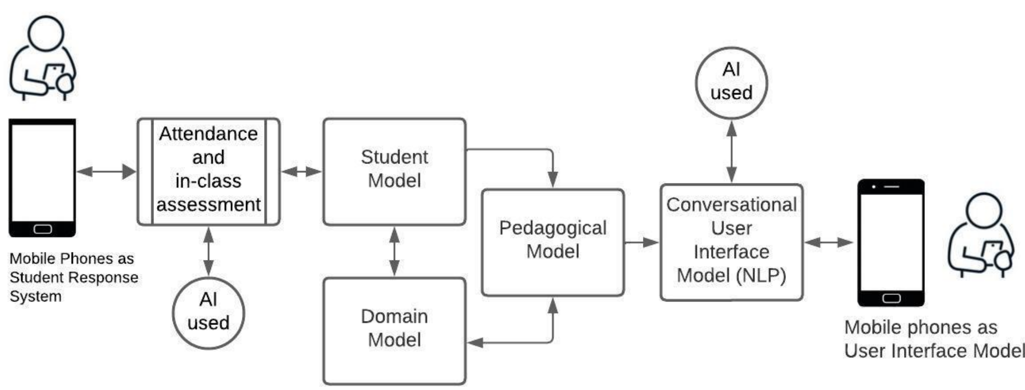

Figure 3. DARTS ITS Models with Mobile Interface and the Use of AI

Supporting Mastery Through out-of-class Tutoring

In a typical classroom, students differ in prior knowledge, aptitude, and learning speed, making it unrealistic for all to master a concept simultaneously. While some students grasp the material quickly, others need additional instruction and practice to catch up. Figure 4 illustrates these two learning paths and how the time required to mastering learning often exceeds classroom duration which highlighs the need for personalized support beyond scheduled instruction. For example, Student A achieves mastery within the fixed class duration and advances, while Student B follows a longer route involving corrective actions and reassessment before moving on. This highlights how varying amounts of time and support may be necessary for different students to reach the same level of understanding before progressing to the next instructional unit.

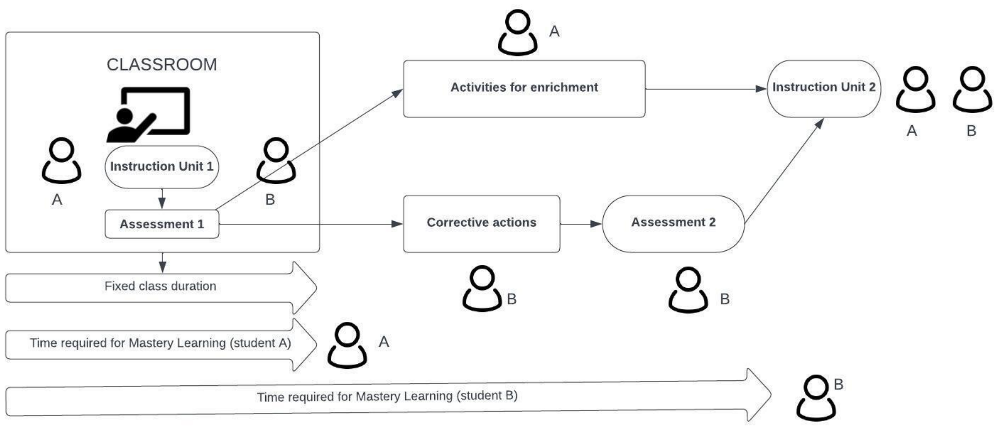

Figure 4. Time Required to Mastery Learning (Adopted from Sarkar, 2025)

To ensure that all students achieve mastery before the next unit is introduced e.g. Unit 2, we require a system to support learning outside of the classroom. DARTS is designed to fulfill this role by integrating in-class assessments to drive personalized tutoring, outside the classroom delivered via mobile phone, until mastery is achieved. This workflow is shown in Figure 5.

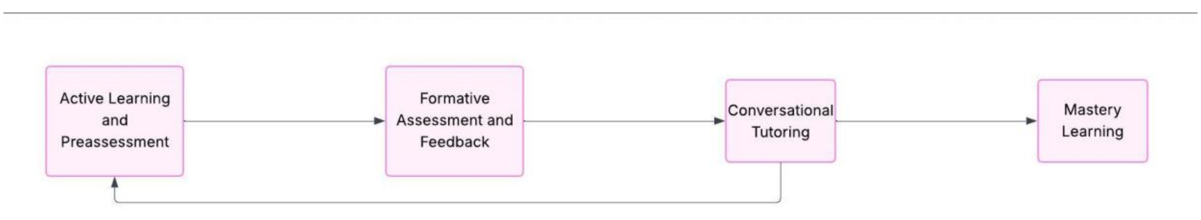

Figure 5. The Workflow for DARTS Mastery Learning

Design Rationale and Objectives

In DARTS, mobile devices serve dual purposes supporting real-time classroom interaction and enabling personalized out-of-class tutoring—through SMS-based communication that ensures continuous, accessible learning without requiring internet or apps. The system uses an AI engine to classify performance and initiate tailored interventions. The architecture also includes NLP modules for SMS-based tutoring and cloud services for data processing and storage. DARTS enhances this traditional framework by introducing:

- Classroom input streams (attendance, participation, formative assessments),
- AI-based interpretation of students' profile,
- SMS/NLP interfaces to support mobile, conversational tutoring,
- Teacher's dashboards that guide and initiate tutoring interventions.

Key goals guiding DARTS' architecture include:

- Scalability: Support large classrooms through asynchronous SMS
- Accessibility: Operate without apps or internet
- Personalization: Adapt to participation and performance
- Teacher Augmentation: Empower instructors to guide interventions
- Pedagogical Alignment: Align with Mastery Learning and formative assessment

Student-Centered Development

Figure 6 illustrates how the traditional Intelligent Tutoring System (ITS) architecture is extended in DARTS through the addition of the Interface and AI Layer**.** The four classical components of an ITS—the Domain Model**,** Student Model**,** Tutoring (Pedagogical) Model**,** and User Interface Model—are preserved but connected through this additional layer, which functions as the operational hub.

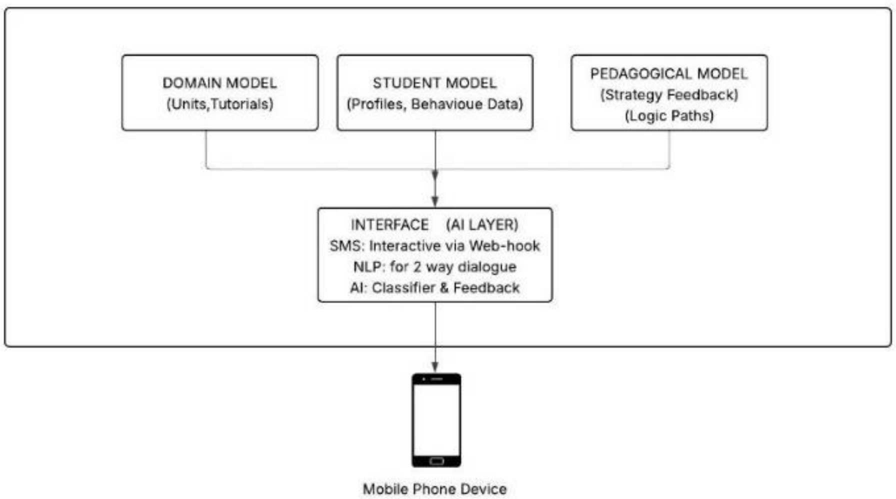

Figure . DARTS ITS Architecture

Within the DARTS architecture, the Interface and AI Layer plays a central role in reducing barriers to participation. Communication occurs through SMS, a channel already embedded in students' daily routines. This familiar environment contrasts with the potential anxiety students may experience when required to respond publicly in a classroom setting. By allowing students to engage privately from their own devices, whether in class or at home, the system provides a low-stress mode of interaction that encourages consistent participation.

The architecture also emphasizes ubiquitous accessibility. Because SMS operates on all types of mobile phones without requiring internet connectivity, app downloads, or training, DARTS can function in a variety of resource environments. Through cloud integration with webhooks, the Interface and AI Layer links incoming student responses to the underlying Domain, Student, and Tutoring Models, enabling real-time, personalized feedback. In this way, DARTS operationalizes the traditional ITS framework in a mobile-first form, extending its reach beyond the classroom while maintaining scalability and adaptability.

How DARTS Uses AI and NLP Interfaces

To operationalize personalized tutoring at scale, DARTS embeds artificial intelligence into multiple layers of the traditional ITS framework. The table below highlights the five critical points where AI functionality is integrated within the DARTS model:

Table 1. DARTS Integrates AI at Five Key Junctions in the ITS model:

Point	Functionality	Description
①	**AI-driven diagnostic engine**	Estimates student knowledge from classroom inputs to design personalized tutorials.
②	**AI-based pedagogical reasoning**	Selects the optimal feedback path based on student history and knowledge gaps.
③	**NLP interface for tutoring delivery**	Interprets and responds to student queries via SMS, enabling two-way conversational tutoring.
④	**Teacher's dashboard**	Allow instructors to initiate tutoring sequences or adjust interventions based on classroom signals.
⑤	**Student mobile interface**	Mobile-based interaction allows learning beyond the classroom—anytime, anywhere.

Two innovations distinguish DARTS from earlier ITS approaches:

1. The integration of real-time classroom inputs—such as attendance, participation, and formative assessments—which inform the AI's tutoring decisions.
2. The mobile-first, app-free tutoring model, which allows learning to occur beyond class hours and across all types of devices through SMS-based dialogue.

The table below illustrates how DARTS overcomes the limitations of conventional ITS models:

Table 2. DARTS vs. Conventional ITS Enhancements

Feature Area	Conventional ITS	DARTS Augmentation
Classroom Data	Not integrated	Live input from attendance, quizzes, participation
Mobile Access	Limited / app-based	SMS-based, no app or internet required
AI Use	Basic logic or static rule sets	Dynamic AI reasoning based on student model and classroom signals
NLP	Rare / script-based only	Full conversational interface via SMS
Feedback Loop	Limited / desktop only	Bidirectional, continuous via mobile and cloud
Learning Scope	In-class or web only	Seamless *in* and *out-of-classroom* mastery learning
Tutor Mimicry	Approximate only	NLP + behavior tracking emulates human tutors closely

Functional Workflows in the classroom

DARTS begins with in-class pre-assessment and uses real-time inputs to identify learning gaps, enabling personalized support outside the classroom. It serves as a unified system that connects classroom diagnostics with AI-driven SMS tutoring, creating a continuous learning cycle aligned with Mastery Learning principles.

Emphasizing Attendance: A Foundational Element of Student Success

- Student presence is essential for learning—without it, even the best pedagogy fails. Traditional attendance tracking methods (paper, manual roll calls, or expensive apps) are inefficient, insecure, and unsustainable.
- DARTS solves this using A2P 10DLC-compliant SMS, enabling secure, real-time attendance collection without internet or apps.

- Aggregates attendance data across all courses, offering a complete view of student participation over the semester.
- Handles legitimate absences through SMS, email, or codes, using AI to verify and log reasons automatically.
- Turns attendance into a diagnostic tool—enhancing student success without added cost, training, or technical barriers.

Attendance Workflow
Figure 7 illustrates AI-triggered response plans based on student presence and participation signals. For example, the system initiates the process by generating a "Take Attendance" signal. A timer ensures that responses are time-bound. Upon receiving student replies, the system verifies whether the attendance code is correct. For unexcused absences, DARTS automatically retrieves a tutoring plan generated by its AI engine and sends the student a personalized learning message. This ensures that students who miss class are immediately supported with relevant instructional content, preserving continuity in learning.

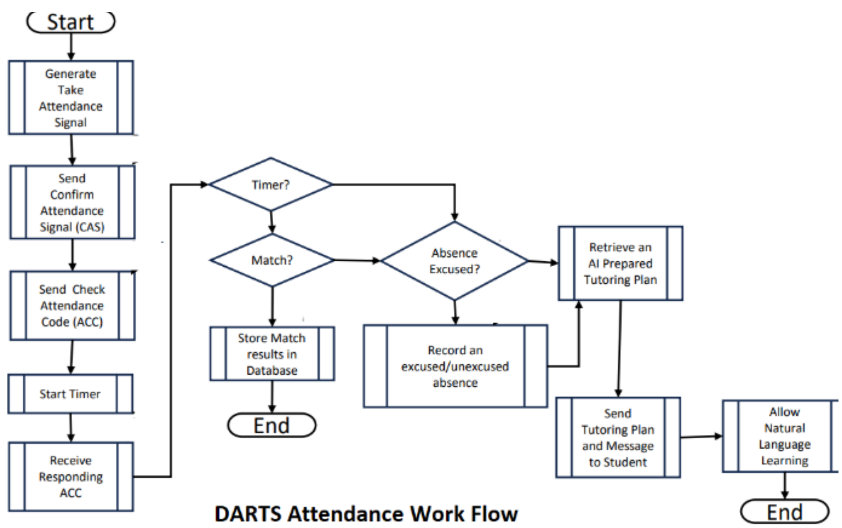

Figure 7. DARTS Attendance Workflow (Ref. DARTS patent application)

Class Quiz Workflow
Quizzes in DARTS are tightly integrated into classroom instruction using a real-time mobile interface. Quiz questions are displayed simultaneously on a classroom projector or screen and on students' mobile phones. Students respond using their phones within the preset time. The AI engine analyzes correctness and frequency of participation. Based on this, personalized feedback or review content is automatically pushed to the student's phone.

Brainstorming Workflow
The instructor initiates brainstorming by selecting a question from a pre-built **question bank** or entering a custom question during class. This prompt is displayed on the classroom screen and simultaneously sent to students' mobile phones via SMS. Students reply with their thoughts, which are displayed live on-screen in a scrolling format. Duplicate responses are automatically detected and marked with frequencies as suffixes (e.g., "(3)").

An optional timer can be set to limit response time and encourage immediate participation. The AI engine within DARTS analyzes all incoming responses to (1) Identify students who did not participate, respond multiple times, or submitted off-topic answers, (2) Assess the quality and relevance of each response. (3) Recommend follow-up tutoring or enrichment tasks based on inferred strengths and weaknesses. Over time, DARTS can also analyze trends across multiple classroom sessions, giving instructors a clearer picture of conceptual mastery and engagement.

Table 3. Summary Table: Key Features of DARTS Functional Workflows

Feature	Attendance	Quiz	Brainstorming
AI-Driven Feedback	Yes (for absentees)	Yes (score trends)	Yes (response analysis)
Timer Support	Yes	Yes	Optional
Mobile Interface	SMS-based	SMS-based	SMS-based
NLP Interpretation	Limited (absence response)	Yes (quiz explanation)	Full (relevance, duplication)
Real-Time Display	No	Yes	Yes (scrolling)
Teacher-Initiated	Yes	Yes	Yes (manual or question bank)
Follow-up Tutoring	Yes	Yes	Yes (based on AI insights)

DARTS Implementation Strategy and Challenges

While DARTS offers a scalable, low-cost solution to deliver Mastery Learning through mobile-based AI tutoring, several challenges may arise in its real-world deployment:

1. A2P 10 DLC Compliance **:** DARTS needs to maintain messaging compliance by adhering to **A2P 10DLC, a** U.S. carrier-regulated system that authorizes and verifies Application-to-Person SMS communication using a 10 digit long phone number (10 DLC).

2. Institutional Readiness and Alignment**:** Many institutions may lack the administrative flexibility or digital policy frameworks to integrate an AI-driven Intelligent Tutoring System (ITS) into their pedagogy. Adapting classroom routines to support SMS-based assessment and tutoring may require faculty training and administrative endorsement.

3. Mobile Number Registration and Consent**:** Since DARTS relies on SMS-based interaction, successful implementation depends on accurate student contact information, user consent protocols, and compliance with A2P 10DLC messaging standards. Establishing opt-in/opt-out procedures and managing data privacy remain logistical concerns.
4. Content Localization and Curriculum Integration: For DARTS to be effective, its instructional content must align with course curricula and learning standards. This may involve adapting the system's knowledge base and feedback engine to support domain-specific requirements in different regions or disciplines.

5. Language and Accessibility Constraints**:** Although SMS is widely available, language barriers may limit DARTS' effectiveness in multilingual environments. Natural language understanding and response generation may need enhancement to support vernacular or regional dialects.

6. Student Motivation and Engagement: SMS-based platforms may struggle to maintain sustained student engagement without visual interfaces or gamified features. Ensuring that students view DARTS as supportive learning companion—rather than a testing tool—requires thoughtful instructional design.

7. Technology Reliability and Data Syncing**:** While DARTS is designed to work in low-bandwidth environments, delayed message delivery or cloud-sync issues may affect timely feedback. Robust webhook infrastructure and offline caching strategies may be necessary for areas with intermittent connectivity.

8. Scalability and Maintenance: As the user base grows, ensuring reliable performance, system monitoring, and model retraining will require cloud infrastructure and dedicated support teams. Institutions must plan for technical support and resource allocation.

DARTS Implementation Workflow
The implementation of DARTS begins with university or departmental approval, followed by instructor-led onboarding within the classroom. At the start of a course, the teacher introduces DARTS to students and invites them to register for class participation. Students are prompted to dial the designated DARTS number from their mobile phones. Upon initiating contact, the system automatically sends opt-in messages requesting the student's consent to receive academic communication via SMS. Once consent is received, the student's number is securely registered on the DARTS platform. From that point onward, the mobile phone serves a dual purpose: it functions as a Student Response System (SRS**)** during in-class activities—such as attendance, quizzes, and brainstorming—and as a communication tool fo**r** personalized tutoring outside. DARTS is designed with a strong emphasis on data security, scalability, and accessibility to ensure trust, performance, and inclusiveness in educational environments.

- Security: DARTS employs secure cloud-based databases with encrypted data transmission and storage. All student data—such as attendance, participation, and assessment responses—is handled in compliance with institutional policies and FERPA (Family Educational Rights and Privacy Act), a U.S. federal law that protects the confidentiality of student education records.
- Scalability: Its modular, cloud-native design allows DARTS to scale effortlessly from small classes to large institutions, managing asynchronous SMS interactions without needing real-time infrastructure.
- Accessibility: DARTS is accessible on basic mobile phones via SMS, requiring no apps, internet, or training, making it ideal for students with limited digital access or resources.

Limitations, Design Trade-offs, and Conclusion

DARTS leverages SMS for broad accessibility but faces limitations in interactivity and long-form text analysis. It uses rule-based AI in select components to ensure reliability and clarity, though this may reduce adaptive flexibility. DARTS fulfills the long-standing vision of delivering personalized, mastery-based education at scale. By leveraging mobile phones—ubiquitous tools in students' daily lives—it enables real-time, AI-powered instruction and feedback without requiring apps, internet, or specialized training. This mobile-first approach makes mastery learning both equitable and cost-effective. Designed for practical implementation, DARTS minimizes technical barriers through SMS-based interaction and webhook-enabled communication. Its secure, cloud-hosted infrastructure ensures compliance with privacy standards like FERPA, while also supporting scalability across diverse institutional settings. The platform's architecture—featuring modular AI components and rule-based logic—allows for flexible deployment, even in low-bandwidth or underserved environments. This paper details the system's design rationale, architecture, and classroom workflows. Future work will evaluate DARTS in real-world classrooms, measuring its effectiveness in improving student engagement, learning outcomes, and closing performance gaps.

References

Allen, V. L. (1976). *Children as teachers*: Theory and research on tutoring. Academic Press.

Anderson, L. W. (1994). *How classroom instruction works: Research and theory*. National Education Association.

Block, J. H., & Burns, R. B. (1976). Mastery learning. In L. S. Shulman (Ed.), Review of Research in Education (Vol. 4, pp. 3–49). Peacock Publishers.

Bloom, B. S. (1968). Learning for mastery. Evaluation Comment, 1(2), 1–12.

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. Educational Researcher, 13(6), 4–16.

Briggs, L. J., & Aronson, L. (1975). Instructional design: Principles and applications. Educational Technology Publications.

Edling, C. R. (1971). Programmed instruction in the classroom. Wadsworth Publishing.

Glaser, R., & Rosner, B. (1975). Individualized instruction and mastery learning. In L. J. Briggs (Ed.), Instructional design: Principles and applications (pp. 309–338). Educational Technology Publications.

Guskey, T. R. (2007). Closing achievement gaps: Revisiting Benjamin S. Bloom's learning for mastery. Journal of Advanced Academics, 19(1), 8–31.

Klausmeier, H. J. (1975). Instructional design and the learning process. Harper & Row.

Sarkar, T. K. (2022). A case study validation of an intelligent tutoring system prototype ITS-DARTS, using mobile technology: Applications in business and STEM education (Doctoral dissertation, Southern University and Agricultural and Mechanical College).

Sarkar, T. K. (2025). The evolution of mastery learning to DARTS-ITS. Unpublished manuscript, Southern University and Agricultural and Mechanical College.

Slavin, R. E. (1987). Mastery learning reconsidered. Review of Educational Research, 57(2), 175–213. https://doi.org/10.3102/00346543057002175

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. Educational Psychologist, 46(4), 197–221. https://doi.org/10.1080/00461520.2011.611369