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AI-Supported Formative Assessment and Its Role in Enhancing Feedback Quality: A Conceptual Framework, Evidence Synthesis, and Implementation

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Abstract:
Among the many factors impacting learning, formative assessment is reported to be one of the more effective, as it provides learners with continuous feedback on their progress toward reaching their educational goals [1]. Feedback in the classroom is frequently delayed, cannot be specific enough, or does not match well enough with stated academic goals, especially in large classes and those with limited working resources. The introduction of new technologies in artificial intelligence (AI)—specifically, analytics software; automatic feedback submission; and generative AI—offers promise for improving the timeliness; personalisation; diagnostic accuracy; and scalability of formative assessment feedback. The AI-FAST Framework (An AI-enabled formative assessment that is used to help students and teachers improve the quality of formative assessment) brings together the existing empirical evidence about the effectiveness of formative assessments and feedback from previous studies [1,5], and synthesizes newly generated evidence on feedback interventions powered by artificial intelligence and analytics-granted [6,7].
Six dimensions identify the quality of feedback that AI-FAST uses, namely: timeliness; specificity; actionability (forward-looking); Criterion alignment; Learner agency (two-way feedback); Equity/ethics. The framework also provides information on how AI supports feedback generation and decision-making but retains the professionalism and expertise of the teacher through a "human in the loop" model based on the principles of international best practice for the responsible use of AI in education [8]. The paper positions the AI-FAST model within the Indian National Policy on Technology for Education and Digital Education Ecosystems [9,10] and discusses the implications for teachers, school leaders, institutions of teacher education and researchers, including indicators of success and evaluation strategies. The paper concludes by indicating that AI has the potential to improve the quality of feedback when it is integrated into a quality formative assessment system and aligns with curriculum and is ethically-based.

Keywords: formative assessment; feedback quality; AI in education; learning analytics; automated feedback; generative AI; assessment for learning; educational policy.

1. Introduction:

Formative assessments are effective because they provide information that allows both teachers and stu-

dents to adjust their teaching and learning processes ASAP. However, the main source of impact from formative assessments is not actually the events themselves but rather the quality of the feedback given after the formative assessment and how the student acts based on that feedback. In many classrooms, feedback is often given late, is based on grades guidance, is extremely value-driven (not descriptive), thus making it difficult for the student to use the information provided to improve their performance in a timely manner. Studies show that while feedback itself can be beneficial, it can also have variable outcomes; for example, poorly designed feedback may have no effect or even negatively impact student motivation and/or focus [2, 5].

AI-supported formative assessment is increasingly seen as a way to overcome ongoing difficulties in giving students feedback. The analytical capabilities of AI tools can (a) identify patterns in student work, (b) give teachers immediate prompts or next actions, (c) identify students' misconceptions, and (d) provide feedback to teachers when there are high student-teacher ratios. With these opportunities, however, come risks, including inaccurate outputs, reliance on automated systems, privacy issues, and unequal access to AI-supported formative assessment solutions because of diversity in language, socioeconomic status, and [ability. [8].

Purpose;

The author of this research article has developed an evidence-informed conceptual framework for developing and implementing AI-supported formative assessment in order to enhance the quality of feedback received, understand the conditions under which these assessments are effective, and responsibly implement such assessments within India's policy framework on Technology Enabled Learning Ecosystems (as highlighted in UGC CARE) [9, 10].

2. Conceptual Foundations:

2.1 Formative assessment as a learning regulation mechanism

In their foundational literature review, Black and Wiliam defined formative assessment as "the practice of using information collected about student progress in order to inform instructional improvements" [1]. The emphasis is cyclical in nature:

Clarify goals → elicit evidence → interpret evidence → provide feedback → learner action → re-assess progress.

In this view, feedback is not an "add-on" but the engine that converts evidence into improvement [1].
In addition, Dylan Wiliam's later work reinforces that formative assessment is most successful when teachers embed it into the everyday work of teaching through the use of such strategies as establishing clear success criteria, facilitating strategic discussions, and activating students as owners of their learning; all of which are critical elements for incorporating AI into a formative workflow. [11]

2.2 Feedback quality: what counts as "good feedback"?

Hattie and Timperley identify three key questions that form the basis for quality feedback: "Where Am I Going?", "How Am I Doing?" and "What Is My Next Step?". These questions articulate the two essential components of feedback: goal clarity and feedforward [2]. Timely, specific, non-evaluative and actionable feedback based on learner's readiness/cognitive load as per Shute's review of effective formative feedback [3]. Nicol and Macfarlane-Dick propose several higher-level principles that link quality feedback to self-regulated learning, namely learner agency, dialogue, and opportunities to close the feedback loop between what learners can currently do, versus what is expected [4].

Key implication: AI improves feedback only when it strengthens these attributes—not when it simply increases the volume of comments.

2.3 Why feedback sometimes fails

From a meta-analytical viewpoint, providing feedback in a manner that takes an individual's focus off of his/her task at hand and places it on the individual him/herself (such as through negative feedback and judgmental styles of communication) is counterproductive to performance improvement. Providing an individual with too much non-actionable information [5] or other distractions (such as one's own performance) is also detrimental to learning. Therefore, it is vital for automated feedback systems to ensure that their feedback does not present harmful tones or excess information and targets that are out of alignment with learning.

3. Literature Synthesis: AI-Enabled Feedback and Formative Assessment

3.1 Automated feedback effects in technology-mediated learning

Automated feedback tools, particularly concerning writing, have provided evidence of meaningful learning gains when used in conjunction with revision cycles and when providing targeted feedback. In a recent multi-level Meta-Analysis, a medium effect size for writing performance has been found, while at the same time identifying large variability in context and design [6]. This finding also demonstrates that there are multiple types of "AI feedback" interventions; their effectiveness varies depending on how the feedback is implemented, how engaged the learner is with the feedback, and how the feedback is integrated into the instructional process [6].

3.2 Learning analytics as a feedback infrastructure

The analysis of learning (LA) provides the possibility of improving formative evaluation through the analysis of student performance and providing opportunities for timely intervention. The recent systematic review that mapped the use of LA for feedback practices used in Technology-Mediated Higher Education (HE) described a number of ways in which LA can contribute to establishing a more efficient feedback loop, but also reveals barriers related to the adoption by instructors, lack of understanding of the value and application of LA, and appropriate integration of LA into pedagogy [7]. This is consistent with the idea that data related to formative assessment provides information that supports decision-making by both the learner (learners) and the teacher, only when the learner (learners) take action based on the received data. [1]

3.3 Responsible and human-centred AI use

International guidance to this end states that the use of artificial intelligence in education should take precautions when it comes to privacy, transparency, equity, and human oversight — particularly for generative artificial intelligence (AI) systems, which may create seemingly realistic outcomes, yet are often wrong [8]. International guidance that includes these principles endorses using AI-in-education with "people in the loop," maintaining the teaching profession's judgement at the heart of it and utilizing AI to enhance and improve the quality of educators' feedback rather than replacing the pedagogy of teaching [8].

4. Methodology:

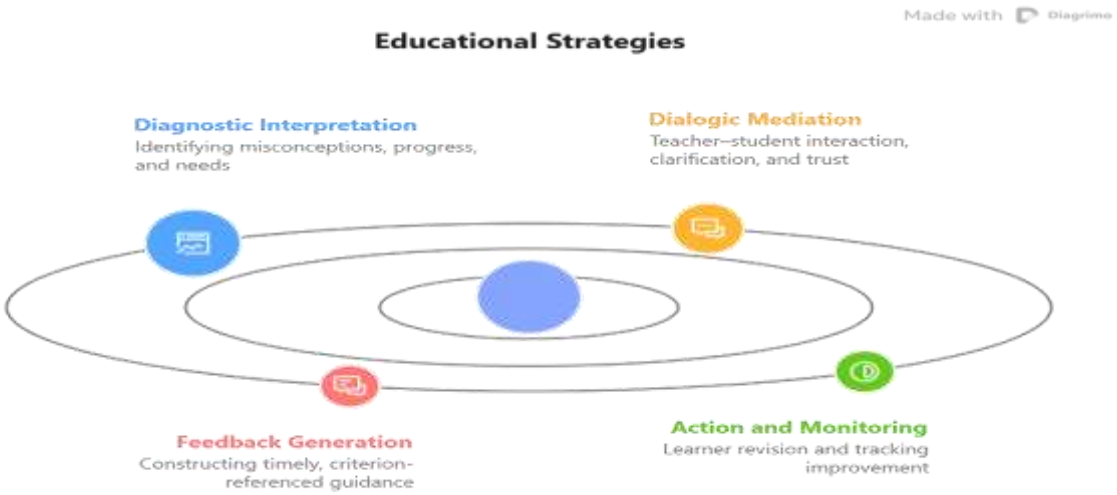
The focus of this article is on using a conceptual model and integrative review method to generate an integrated body of knowledge about formative assessment and feedback (foundational theories) [1,5]; how AI enables and analytics support feedback; and how our understanding of these areas can help shape policy regarding technology integration into education in India as part of the overall context of educational reform (policy documents) [9,10]. Through this synthesis of knowledge, this article proposes a new framework—the AI-FAST Framework—as a conceptual framework comprising the major components, interconnections, and appropriate metrics for future empirical validation.

5. The AI-FAST Framework:

5.1 Framework overview

AI-FAST (AI-enabled Formative Assessment for Strengthening Feedback Quality) proposes that AI enhances feedback quality when it strengthens the formative cycle through five functional stages:

1. **Evidence captures** (collecting learning traces)
2. **Diagnostic interpretation** (identifying misconceptions, progress, and needs)
3. **Feedback generation** (constructing timely, criterion-referenced guidance)
4. **Dialogic mediation** (teacher–student interaction, clarification, and trust)
5. **Action and monitoring** (learner revision + tracking improvement)



This structure operationalizes formative assessment's core logic—using evidence to adapt learning—while positioning AI as an enabling layer rather than the pedagogical driver [1].

5.2 Feedback quality dimensions in AI-FAST

AI-FAST defines feedback quality across **six dimensions** grounded in feedback theory:

D1: Timeliness – feedback reaches learners while the task is still "alive" [3].

D2: Specificity and diagnostic – feedback identifies *what* is wrong and *why* (misconception patterns) [2,3].

D3: Actionability (feedforward) – feedback provides next steps ("Where to next?") [2].

D4: Criterion alignment – feedback references clear success criteria and learning intentions [1,2].

D5: Learner agency and dialogue – feedback supports self-regulation and includes opportunities for clarification and use [4].

D6: Equity, ethics, and wellbeing – feedback avoids harmful personalization, respects privacy, and mitigates bias [8].

5.3 How AI strengthens feedback quality

AI can support each dimension when used appropriately:

- **Timeliness (D1):** Automated hinting and rapid response cycles reduce delay, especially for routine errors and practice tasks [3,6].
- **Diagnostic (D2):** Analytics dashboards can identify class-wide misconceptions; automated tools can detect recurring language, logic, or structure issues [7].
- **Actionability (D3):** Well-designed systems provide "next-step" prompts, examples, and scaffolded practice aligned to misconceptions [2,3].
- **Criterion alignment (D4):** Rubric-based automated checks and teacher-defined criteria help anchor feedback to learning goals rather than generic advice [1,2].
- **Learner agency (D5):** Feedback becomes more effective when learners revise work, reflect, and engage in dialogue—requiring teacher orchestration, not automation alone [4,11].
- **Ethics/equity (D6):** Human oversight is essential because AI outputs can be inaccurate, biased, or inappropriate; transparency and governance reduce harm [8].

6. Implementation Models for Classrooms and Institutions:

6.1 Classroom-level model: "Teacher-led, AI-assisted feedback loops"

The following is a practical implementation sequence (as outlined above) based on formative assessment principles is:

1. Define Expectations (Teacher + Learners),
2. Gather Evidence (Learner Work, Quizzes, Dialogue),
3. Use Artificial Intelligence to Analyse Evidence/Identify Patterns (Common Mistakes & Groups of Misconceptions),
4. Provide Multiple Sources of Feedback - Automation (1st Step) + Teacher (2nd Step) for Conceptual and/or Emotional Aspects of Learning,
5. Require Student Action - Revise & Reflect + Submit Again,
6. Track Student Progress Through Brief Re-Checks.

This sequence is an example of Feedback Intervention Theory: Keep Feedback Task-Oriented and Manageable, Do Not Overwhelm & Emotionally Shock by Providing Too Much Feedback at One Time. [5].

6.3 System-level alignment (Indian policy relevance)

The integration of technology within education via the NEP 2020 is being focused on improving the qua-

lity and equity of education, through the enhanced use of Educational Technology [9]. The vision of the National Digital Education Architecture (NDEAR) includes the creation of interoperable Digital Infrastructure, which will facilitate the creation of Assessment and Learning Data Flows. These conditions are necessary for creating scalable Formative Assessment & Feedback Systems that can be produced within an Ecosystem Context [10]. AI-FAST can function within such an Ecosystem Framework if Ethical Governance & Capacity Building are considered first [8, 10].

7. Challenges, Risks, and Ethical Safeguards

7.1 Accuracy, hallucination, and over-trust

Generative AI can produce persuasive but incorrect explanations. Over-trusting AI feedback may institutionalize misconceptions. Mitigation: teacher verification routines, constrained prompts aligned to rubrics, and transparency that AI suggestions require validation [8].

7.2 Equity and bias

Automated feedback may perform unevenly across languages, dialects, or disability-related expression patterns. Mitigation: local validation, inclusive dataset evaluation where possible, and monitoring differential error rates across learner groups [8].

7.3 Privacy and data protection

Formative data (drafts, mistakes, behavioural traces) is sensitive. Mitigation: consent, data minimization, secure storage, and institutional procurement standards consistent with human-centred AI guidance [8].

7.4 Feedback overload and reduced learner agency

More feedback doesn't equal better feedback. Having too many automated responses can swamp learners and minimize learner ownership of their performance results. To Avoid this, prioritize high-leverage feedback; provide staged feedback through cycles; and allow for learner reflection and choice are all key strategies for promoting learner self-regulation [4, 5].

8. Evaluation Strategy: Measuring “Feedback Quality Gains”

AI-FAST recommends evaluating impact across three levels:

Level 1: Quality of feedback will be determined by:

1. How quickly it was sent;
2. How closely it attached to the rubric;
3. How many feedback statements were actionable;
4. how Learners perceive the quality and usefulness of Feedback.

Level 2: Learner's engagement with feedback will be evaluated by:

1. What percentage of revisions were adopted;
2. The quality of revisions;
3. The responses from Learners reflecting how well they understood the goals of their revisions.

Level 3: The level of learning achieved by the Learners will be evaluated by:

1. Improvement in aligned assessments;
2. The decrease in recurring misconceptions; and
3. The amount of improvement in writing and/or problem-solving ability (is dependent on context).

Learning analytics provide support for evaluating learning, but should be understood from a pedagogical perspective, where evidence leads to a course of action versus creating a circumstance of appointing an overt form of data collection or stringently monitoring.

9. Implications for Research and Practice

9.1 Research implications

Future studies should empirically test AI-FAST using experimental or design-based research approaches, comparing:

- AI-assisted feedback loops vs. conventional teacher-only feedback,
- automated-only vs. human-in-the-loop feedback designs, and
- differential effects by student prior achievement, language proficiency, and task type.

Researchers should report feedback *process* variables (timeliness, uptake, revision quality) alongside outcome measures, consistent with formative theory [1, 2, 3, 4].

9.2 Practice implications

In order to enhance the quality of their work with students, educators must:

- establish success criteria as a foundation,
- utilize artificial intelligence for the purposes of triaging and identifying patterns (and not to supplant their judgement),
- expect student response (in terms of both revision and reflection), and• implement a recurring system of dialogic feedback (e.g., conferences, peer feedback, student self-assessment) [4,11].

9.3 Policy implications

Education and training industry officials need to:

- Provide educators the opportunity to increase their knowledge and skills in utilizing data/AI to enhance their teaching practices.
- Develop a strong governance framework to ensure the ethical procurement and use of AI tools in education;
- Integrate administrative processes (curricula) and accountability measures (assessments) as part of the integration of technology into schools [8, 9,10].

10. Conclusion:

AI-supported formative assessments provide a range of additional benefits and opportunities for improving the quality and timing of the formative assessment process. With AI-supported formative assessments, educators and learners have access to a wider range of tools and resources that allow them to create and deliver effective feedback for improvement. The capabilities of AI developed for use in formative assessments must also be based on established principles of formative assessment and should be evaluated against established ethical guidelines. In UGC CARE based scholarship and practice; the AI-FAST framework provides a framework for developing, implementing and evaluating AI-supported learning environments and other digital forms of educational delivery systems.

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