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Understanding Teachers' Feedback Strategies in Classrooms with Intelligent Tutoring Systems: A Survey Study with Storyboards

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Abstract: An increasing number of schools across the world have adopted (and are adopting) adaptive learning technologies. However, how school teachers give feedback in the classroom when students are working with adaptive learning software is underexplored. To address this gap, we conducted an online survey with illustrative storyboards to investigate what kinds of feedback teachers would give to students using intelligent tutors depending on the task difficulty and students' performance. Our findings showed that teachers prioritize feedback that promotes students' deep thinking, while feedback that prioritizes accuracy and efficiency (commonly used in intelligent tutors) was the least common among teachers. This study contributes an understanding of teachers' feedback strategies in classroom environments and how these strategies and adaptive learning technology can mutually complement each other to provide more effective and engaging feedback to students.

Introduction

Feedback is an established technique for effectively supporting student learning. Constructive feedback helps learners identify the differences between their current performance and desired goals, guiding them on how to improve their learning (Burgess et al., 2020; Wisniewski et al., 2020). In actual school classrooms, however, it is practically challenging for teachers to provide timely, specific, and individualized feedback to every student. To address this challenge, there have been a number of interactive technologies that provide feedback to support individual students' learning processes. Among others, Intelligent Tutoring Systems (ITSs) are a representative technology that offers adaptive, targeted, and step-by-step feedback tailored to individual learners (Ma et al., 2014). Studies have shown that adaptive, specific, and timely ITS feedback contributes to students' improved learning outcomes (Kochmar et al., 2020; Sato et al., 2024; VanLehn, 2011).

Nevertheless, even in classrooms where such learning technologies are used, teachers would continue to play an essential and irreplaceable role. For instance, most ITS feedback is still primarily designed to optimize efficiency and accuracy over fostering deeper understanding, and thus cannot fully replicate the nuanced and pedagogically rich feedback that human teachers would provide (Aleven et al., 2017). In contrast, teachers may dynamically adapt feedback to the characteristics of the student and the learning context. Teachers observe learners' engagement and motivation on that day, interpret their thought processes, and provide affective and motivational support that could complement automated feedback offered by adaptive systems (Wang et al., 2022). In other words, teachers would mediate between students and systems, fostering effective learning through flexible, context-sensitive feedback. Classroom observation studies indeed show that teachers employ a wide variety of feedback strategies. Eriksson et al. (2016), for example, classified teacher feedback into five categories: "expectation," "affective response," "normalization," "guidance," and "deliberation." Furthermore, learning sciences and AI in Education (AIED) studies have demonstrated that teachers can mediate between ITSs and student learning (Holstein et al., 2018). Further, Karumbaiah et al. (2023)'s analysis of teacher moves in a classroom where students practice with an ITS suggests that teachers' visits have a significant influence on student behaviors and attitudes. These studies suggest that teachers play an important role in effectively supporting individual student learning with adaptive learning systems in the classroom.

Despite its importance, however, how teachers provide feedback in the context of school classrooms with intelligent tutors has not received much attention in the literature. Although the aforementioned studies within AIED (Holstein et al., 2018; Karumbaiah et al., 2023) have investigated teachers' actions during ITS use in the classroom, it is not fully clear what kinds of feedback teachers would give to students who are working with intelligent tutors. While some studies have illustrated the potential of thought-provoking feedback within ITSs (Graesser et al., 2004), it remains unclear how teachers actually collaborate with such system-generated feedback in real classrooms.

We aim to fill this gap by investigating kinds of feedback teachers would provide when learners engage in problem solving using an ITS. We ask the following research question (RQ): *What types of feedback strategies would teachers use to support student learning in classrooms where Intelligent Tutoring Systems (ITSs) are used?* We conducted a survey with storyboards that depict ITS-supported classroom learning to develop a nuanced and contextualized understanding of teacher feedback and its variations.

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Methods

We conducted a survey with 70 school teachers between October 2024 and October 2025. We recruited participants through social media, as well as direct emails to two integrated middle- and high schools in Japan that the authors had contact with. We prepared English and Japanese versions (so teachers could choose the language of participation). Participation was fully voluntary.

The survey collected basic demographic information, including years of teaching experience and subjects taught. In addition, open-ended questions asked teachers to describe what they consider important when providing feedback in daily classroom teaching ("If there is anything you are particularly mindful of when giving feedback to students during lessons, please let us know"). Further, we used illustrative storyboards (see below) to elicit context-rich insights into the types of feedback strategies teachers would adopt based on task difficulty and student performance when working with an intelligent tutor.

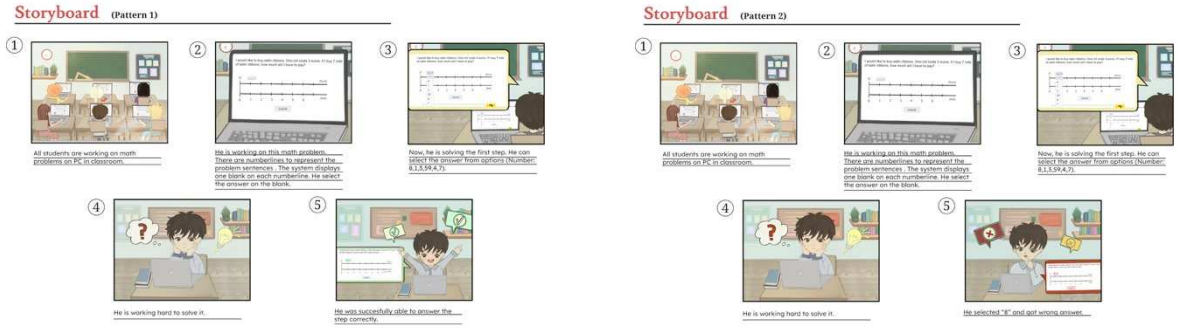
Storyboards to probe teachers' feedback strategies

We prepared four distinct scenarios of ITS use, depicted as storyboards (Figure 1). The scenarios focused on four types of problem-solving situations, structured following a 2×2 design: whether the student perceived the problem as difficult or easy, and whether the student was able to solve the problem or not (Table 1).

This classification aimed to clarify the appropriate level of student effort and the optimal feedback for correct and incorrect responses. For example, Pattern 1 (Easy - Correct) depicts a student who perceived a task as easy and was able to solve it. Teachers, when presented with each of the scenarios, were asked in the survey, "If you were a teacher in this scenario, what kind of feedback would you give to the student in scene 5 (the last scene in each storyboard)?" (they were asked this same question for all four scenarios) (Figure 1). The survey presented the scenarios in the fixed order (Pattern 1, Pattern 2, Pattern 3, and Pattern 4).

Figure 1

Storyboards Showing Different Situations of Math Problem Solving using an Intelligent Tutor in a Classroom.



Following the 2x2 design (Table 1), we prepared four different scenarios. Pattern1 (left) & Pattern2 (right):

Table 1

2 × 2 Design of Scenarios

	Student was able to solve	Student was not able to solve
Student perceived as easy	Pattern 1 (Easy - Correct)	Pattern 2 (Easy - Incorrect)
Student perceived as difficult	Pattern 3 (Hard - Correct)	Pattern 4 (Hard - Incorrect)

Data analysis

We used the Affinity Diagram method to categorize free-text responses obtained from teachers on their feedback strategies into meaningful groups (for the question: "If there is anything you are particularly mindful of when giving feedback to students during lessons, please let us know"). Affinity Diagramming is a common analysis method in Human-Computer Interaction research that allows researchers to find similar themes and patterns through structuring data into a hierarchical structure (Holtzblatt et al., 2015). The categories generated from this analysis were also used for grouping teachers' free-text responses for the following question: "If you were the teacher in this scenario, what kind of feedback would you give to the students?"

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Findings and discussion

The Affinity Diagramming process resulted in eight high-level categories, which we labeled as eight different types of teacher feedback (Table 2). Overall, we found that teachers prioritize feedback that encourages students to reflect on their thoughts, efforts, and emotional engagement (*promote thought*, *effort-based, positive*), rather than feedback that merely evaluates performance (*performance-based*). The most frequently-observed type was *promote thought* (24 responses), involving feedback that encouraged students to think more deeply about the task. For example, this type of feedback includes "What do these numbers mean?", "Why do you think that's the answer?", and "Let's think about why you made a mistake and what the reason might be." This finding indicates that teachers tend to provide feedback that focuses on supporting students' metacognitive and reasoning processes, which is consistent with previous studies emphasizing feedback as scaffolding for self-regulation and deeper learning (Belland, 2014). The finding provides an important insight that, while intelligent tutors typically focus on performance-based feedback (e.g., Aleven & Koedinger, 2002), teachers would rather employ different techniques that promote deeper thinking among students.

Table 2
Feedback Categories Based on Open-Ended Question on Teachers' Feedback Strategies

Feedback Category	Description	Example Answer from Teachers	Frequency
Promote thought	Supporting students in thinking more deeply about the content of learning contents	"[I would] clearly explain the reasons, whether the performance is good or needs improvement"	24
Effort-based	Focusing on the process of learning	"[I would] consciously praise the process rather than the result"	15
Individualized support	Changing the message based on the student's personality, relationships, and the difficulty of the task	"It depends on the students ability and my relationship with them"	12
Positive	Even if students make a mistake, try to reassure the students	"I want them to cherish the moments they make mistakes too"	12
Encourage	Motivating students to learn	"[I would] use encouraging words that motivate the child to take action"	7
Praise their strengths/personality	Praising students' strengths and build their confidence	"[I would] praise children's good qualities immediately"	5
Feedback techniques	Focusing on how to deliver feedback rather than the content itself	"[I would] speak slowly and explain things at a child's level"	4
Performance-based	Focusing on the successful performance	"Ideally, I like to highlight something the student did well"	2
Others	–	–	3

Note: There were nine cases in which a response was grouped into two or more feedback categories.

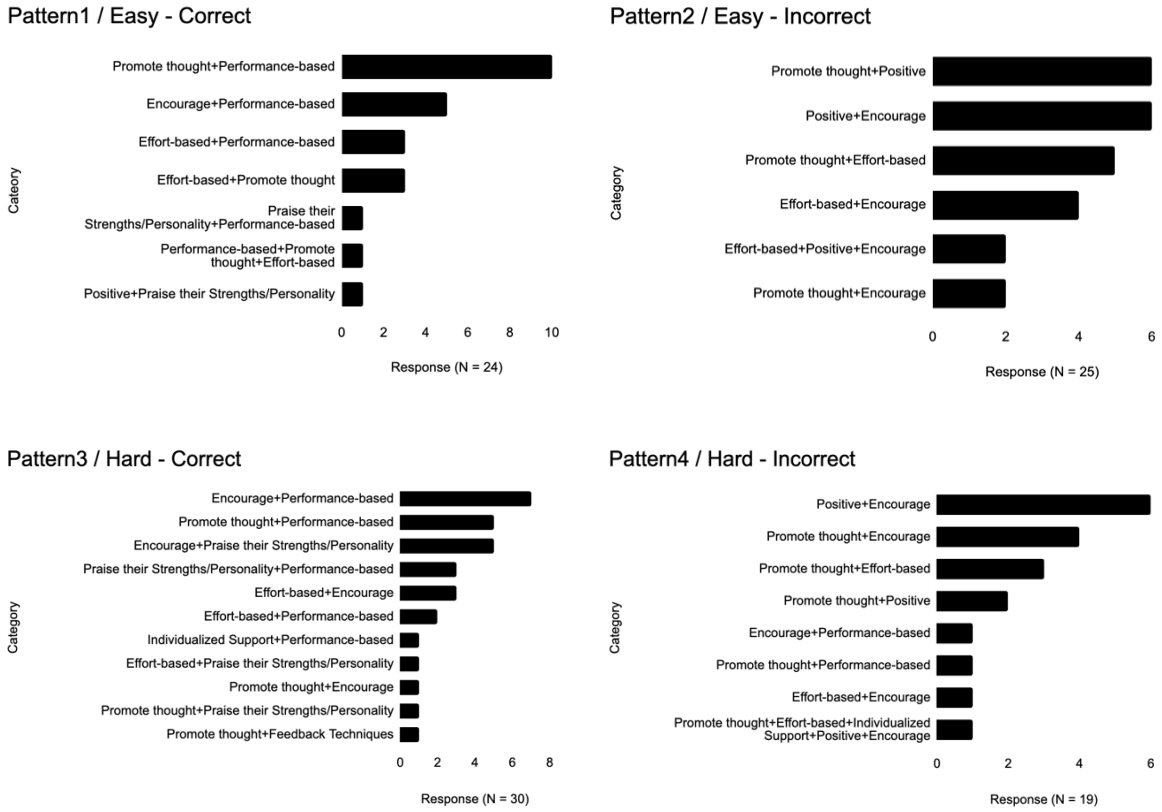
As described above, we also asked teachers to generate effective feedback messages for each of the four scenarios depicted in the storyboards. Specifically, we asked them, "If you were the teacher in this scenario, what kind of feedback would you give to the student in scene 5?" We categorized the collected responses based on the feedback categories from the Affinity Diagramming process (Table 2). The analysis showed that *performance-based feedback* was frequently observed when students answered the problem successfully (Patterns 1 and 3), but it was less popular when students answered the task incorrectly (Patterns 2 and 4). Across all patterns, but particularly on Patterns 2 and 4, the *promote thought* feedback was frequently mentioned. This finding illustrates that teachers would scaffold reflection and help students reconsider their reasoning toward the correct answer.

Further, the analysis revealed that teachers often combine multiple types of feedback in their feedback messages (Figure 2). In particular, for Patterns 1 and 3 (in which students successfully solved the problem), teachers tended to combine performance-based feedback with other types of feedback (e.g., *encourage* +

performance-based, effort-based + performance-based in Pattern 1, and *promote thought + performance-based* in Pattern 3). This trend suggests that even when students provide correct answers, teachers are inclined to offer diverse feedback aimed at deepening learners' understanding, rather than merely evaluating correctness. For example, they use *performance-based feedback* along with *promote thought* feedback, such as: "Well done! Can you tell me how you knew that you should put the number 60 here?" and "You got it correct. How did you come up with the answer?" Our finding is aligned with the work by Shute (2008) that points out that effective feedback should go beyond simple right-or-wrong information but rather include elaborative information that promotes learners' thinking and problem-solving processes.

Figure 2

Frequency of Feedback Type: Combinations in Each Pattern



One limitation of this study is that the feedback strategies reported by teachers in the survey might not necessarily reflect real, effective feedback that they give to students in the classroom. Also, hile we asked teachers to describe what they would do in the given scenarios, the self-reported data were not empirically validated in terms of their impact on student learning. Future work should examine how these teachers' self-reported feedback strategies translate into classroom practice and evaluate their actual impact on student learning outcomes in K-12 classroom settings.

Our study offers a preliminary insight into how human teachers and AI could work together in classrooms. Specifically, our study shows that teachers would uniquely offer tailored feedback that would complement common feedback given by AI-based systems. Although this is rather a small aspect of the entire human-AI collaboration in classrooms that one could imagine, we argue that our results give nuanced and important insights into a critical aspect of human-AI collaboration in classrooms (Vincoli et al. 2025).

References

Aleven, V., & Koedinger, K. R. (2002). An effective metacognitive strategy: Learning by doing and explaining with a computer-based cognitive tutor. *Cognitive Science, 26*(2), 147-179.

Aleven, V., McLaughlin, E. A., Glenn, R. A., & Koedinger, K. R.(2017). Instruction based on adaptive learning technologies. In R. E.Mayer & P. Alexander (Eds.), *Handbook of research on learning and instruction* (2nd ed., pp. 522-560). New York: Routledge.

Belland, B. R. (2014). Scaffolding: Definition, current debates, and future directions. In J. Spector, M. Merrill, J. Elen, & M. Bishop (Eds.), *Handbook of research on educational communications and technology* (pp. 505-518).

Burgess, A., Van Diggele, C., Roberts, C., & Mellis, C. (2020). Feedback in the clinical setting. *BMC Medical Education, 20*, 460.

Graesser, A. C., Lu, S., Jackson, G. T., Mitchell, H. H., Ventura, M., Olney, A., & Louwerse, M. M. (2004). AutoTutor: a tutor with dialogue in natural language. *Behavior Research Methods, Instruments, & Computers, 36*(2), 180–192.

Eriksson, E., Björklund Boistrup, L., & Thornberg, R. (2016). A categorisation of teacher feedback in the classroom: A field study on feedback based on routine classroom assessment in primary school. *Research Papers in Education, 32*(3), 316–332.

Holstein, K., McLaren, B. M., & Aleven, V. (2018). Informing the design of teacher awareness tools through causal alignment analysis. In J. Kay & R. Luckin (Eds.), Rethinking learning in the digital age: Making the learning sciences count. 13th International Conference of the Learning Sciences (ICLS) 2018, Volume 1 (pp. 120-127). International Society of the Learning Sciences.

Holtzblatt, K., & Beyer, H. (2015). Consolidation and ideation. In Contextual design (pp. 95-120).

Karumbaiah, S., Borchers, C., Shou, T., Falhs, A.-C., Liu, P., Nagashima, T., Rummel, N., & Aleven, V. (2023). A spatiotemporal analysis of teacher practices in supporting student learning and engagement in an AI-enabled classroom. *In Artificial Intelligence in Education: 24th International Conference, AIED 2023, Tokyo, Japan, July 3–7, 2023, Proceedings* (pp. 450-462).

Kochmar, E., Vu, D. D., Belfer, R., Gupta, V., Serban, I. V., & Pineau, J. (2020). Automated personalized feedback improves learning gains in an intelligent tutoring system. *In Artificial Intelligence in Education: 21st International Conference, AIED 2020, Ifrane, Morocco, July 6–10, 2020, Proceedings, Part II* (pp. 140-146).

Ma, W., Adesope, O. O., Nesbit, J. C., & Liu, Q. (2014). Intelligent tutoring systems and learning outcomes: A meta-analysis. *Journal of Educational Psychology, 106*(4), 901-918.

Sato, S., Platz, M., & Nagashima, T. (2024). Which leads to more effective learning in intelligent tutoring software, effort-based or performance-based feedback? In *Proceedings of the Annual Meeting of the Cognitive Science Society,* 46(0)

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research, 78*(1), 153-189.

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist, 46*(4), 197-221.

Vincoli, M., Scholz, N., & Nagashima, T. (2025). Multidimensional student agency in learning with AI: a conceptual framework and design implications. *In International Conference on Artificial Intelligence in Education* (pp. 218-232). Cham: Springer Nature Switzerland.

Wang, Z., & Han, F. (2022). The effects of teacher feedback and automated feedback on cognitive and psychological aspects of foreign language writing: A mixed-methods research. *Frontiers in Psychology, 13*, 909802.

Wisniewski, B., Zierer, K., & Hattie, J. (2020). The power of feedback revisited: A meta-analysis of educational feedback research. *Frontiers in Psychology, 10*, 3087.

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