AI-Supported Formative Feedback Reinforces Student Engagement and Confidence in a Grade 7 Girls' Science Classroom

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Abstract

This action research study examined how AI-supported formative feedback reinforces student engagement and confidence in a Grade 7 girls' science classroom through structured opportunities for feedback, reflection, and revision. Grounded in research emphasizing the importance of timely, specific, and actionable formative feedback (Hattie & Timperley, 2007; Shute, 2008; Wiliam, 2016), the study explored the use of AI-driven learning checks through the FlintAI platform across biology and physics units over a ten-week period. Data were collected through pre- and post-intervention surveys, semi-structured interviews, structured classroom observations, and AI-generated performance summaries. Findings suggest that the immediacy and structure of the AI-supported feedback process reinforced student engagement and confidence by reducing uncertainty, clarifying learning expectations, and creating structured opportunities for reflection and revision. Classroom observations also suggested increases in behavioural and emotional engagement over time, including greater participation, more sustained on-task behaviour, and increased willingness to engage in discussion, and less frustration with the platform. Students further reported using actionable feedback to revisit and refine their thinking, suggesting deeper cognitive engagement with the material. Separately, AI-generated performance summary data indicated growth in the depth, coherence, and conceptual integration of students' scientific reasoning. Although limitations related to sample size and continuity restrict generalizability, the findings highlight the potential of AI to complement effective teaching practice by functioning as a structured cognitive partner that supports engagement, confidence, and deeper scientific reasoning.

Glossary

AI-Supported Formative Feedback: The use of artificial intelligence tools to provide immediate, personalized, and task-focused feedback designed to support student learning.

Behavioural Engagement: Observable student participation in learning tasks, including on-task behaviour, participation in discussion, task initiation, and task-persistence.

Cognitive Engagement: The degree to which students invest effort in understanding content deeply, including elaboration, revision, reasoning, and concept application and integration.

Emotional Engagement: Students' affective responses to learning tasks, including interest, confidence, frustration, and anxiety.

FlintAI: An education-focused artificial intelligence platform adopted by St. Mildred's Lightbourn School, designed to provide structured, privacy-protected AI learning support.

Formative Feedback: Non-evaluative feedback intended to clarify learning goals, identify gaps in understanding, and provide actionable next steps to support improvement (Wiliam, 2016)

Learning Checks: Short, structured formative assessments delivered at the end of key lessons, providing immediate AI-generated feedback and opportunities for revision.

Triangulation: The use of multiple data sources or methods within a study to enhance credibility and trustworthiness of findings (Mertler, 2020).

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Formative feedback is widely recognized as a critical component of effective teaching because timely, specific, and actionable feedback helps students understand their progress, refine their thinking, remain engaged in the learning process, and build confidence in their understanding (Hattie & Timperley, 2007; Shute, 2008; Wiliam, 2016). However, delivering frequent and individualized formative feedback remains challenging for classroom teachers, particularly in classrooms where the need to support multiple learners simultaneously limits opportunities to provide immediate and individualized support.

Recent advances in artificial intelligence (AI) have created new opportunities to address this challenge. AI-enabled educational tools can provide students with immediate, personalized feedback, allowing teachers to offer feedback more frequently while giving students opportunities to reflect on and revise their thinking as they learn. These opportunities for reflection and revision may also support sustained engagement with learning tasks. Within this evolving landscape, educators are increasingly exploring how artificial intelligence can complement effective teaching practices.

Student confidence represents another important dimension of learning in STEM education, particularly for girls. Research suggests that girls often experience heightened levels of anxiety around assessment in STEM subjects, which can influence their willingness to participate, take risks, and persist when faced with challenging concepts. In this context, formative feedback plays an important role for girls in STEM, as it can help them gauge their understanding, reduce uncertainty, and build confidence in their ability to succeed.

This action research project emerged from both professional reflection and institutional context. The International Coalition of Girls' Schools (ICGS) 2025–2026 research theme, "Navigating the AI Frontier," encouraged educators to explore meaningful applications of artificial intelligence in teaching

and learning. This focus aligned with St. Mildred's-Lightbourn School's (SMLS) adoption of FlintAI, a school-approved artificial intelligence platform designed to support student learning while maintaining data privacy.

Furthermore, reflecting on my own teaching practice, I recognized that my existing system for delivering formative feedback was often delayed, infrequent, and difficult to personalize for each learner. Given the established importance of formative feedback and the emerging potential of AI-supported learning tools, this study examined whether integrating AI-generated feedback into classroom practice could reinforce student engagement and academic confidence by encouraging students to reflect on and revise their thinking. This led to the following research question: How does AI-supported formative feedback reinforce student engagement and confidence in a Grade 7 girls' science classroom?

Literature Review

A substantial body of research identifies formative feedback as one of the most powerful influences on student learning. Hattie and Timperley (2007) argue that effective feedback clarifies learning goals, identifies gaps between current and desired performance, and provides guidance on how to close those gaps. Similarly, Wiliam (2016) emphasizes that formative assessment is not a supplemental instructional strategy but a central component of effective teaching. When implemented effectively, formative feedback helps students monitor their understanding, revise their thinking, and remain actively engaged in the learning process.

Research consistently identifies several characteristics that make feedback effective. Feedback should be timely, allowing students to address misunderstandings before they become entrenched. It should also be task-specific, focusing on the task rather than the learner's ability. Finally, it should be actionable, providing clear guidance for improvement (Hattie & Timperley, 2007; Shute, 2008).

Immediate feedback also reduces uncertainty and cognitive load, allowing students to revise their thinking while the learning context remains fresh (Shute, 2008).

Additionally, formative feedback plays an important role in shaping students' motivation and engagement. When feedback is framed as guidance for improvement rather than evaluation, students are more likely to interpret mistakes as opportunities for learning rather than indicators of failure (Shute, 2008). This perspective aligns with Dweck's (2006) work on mindset theory, which suggests that students who view challenges as opportunities for growth are more likely to persist in the face of difficulty. In particular, opportunities to revise work in response to feedback can encourage sustained cognitive engagement, as students remain actively involved in refining their understanding.

These dynamics are particularly relevant for girls in STEM education, where higher levels of anxiety around assessment and participation are often reported, even when performance is equal to or stronger than that of boys (Beilock et al., 2010). Classroom environments that normalize revision and provide supportive feedback may, therefore, play an especially important role in reinforcing confidence and engagement for girls in STEM subjects.

While the benefits of formative feedback are well established, implementing it consistently in classroom practice can be challenging. Providing individualized, timely feedback to every student requires significant time and attention from teachers. Artificial intelligence has, therefore, emerged as a potential tool for supporting formative assessment by facilitating more immediate and individualized feedback at scale.

Recent research suggests that AI-enabled educational tools can provide immediate and personalized feedback, allowing students to revise their responses in real time (Okonkwo & Ade-Ibijola, 2021). When used appropriately, AI systems can support reflection, self-regulation, and persistence by guiding students through repeated cycles of feedback and revision. Importantly, scholars emphasize that

AI should function as a support tool within effective instructional practice rather than replacing the teacher (Chiu et al., 2023; Okonkwo & Ade-Ibijola, 2021).

One useful way of conceptualizing this role of AI is through Papert's (1980) idea of computers as objects to think with. Rather than simply providing answers, effective AI tools can act as cognitive partners that encourage learners to articulate their reasoning, test ideas, and refine their understanding; thereby supporting deeper cognitive engagement with the learning task. More recent research on AI-supported learning environments similarly emphasizes the potential of conversational AI systems to prompt reflection, build on prior knowledge, and sustain students' engagement in iterative problem solving (Vasconcelos & dos Santos, 2023).

Taken together, this literature highlights three key ideas. First, formative feedback is central to effective teaching and learning. Second, timely and personalized feedback can reinforce student engagement and confidence by encouraging students to reflect on and revise their thinking. Third, artificial intelligence may offer new opportunities to deliver this type of feedback more consistently within classroom environments. Building on these insights, this study explored how AI-supported formative feedback reinforces student engagement and confidence by providing students with structured opportunities to reflect on feedback and revise their work.

Research Context

St. Mildred's-Lightbourn School (SMLS) is an independent K–12 girls' school located in Oakville, Ontario, Canada. At the time of the study (November 2025), the school enrolled approximately 550 students aged four to eighteen. SMLS emphasizes personalized learning, student engagement, and the development of confidence in girls through real-world educational experiences.

This action research project was conducted over a ten-week period in a Grade 7 science class consisting of 19 students during the second and third terms of the school year (November 2025–January

2026). The timetable provided four 80-minute science periods per eight-day cycle, which equated to between two and three science classes per week.

I also taught the participating students in mathematics and health and physical education. This concurrent teaching relationship provided deeper familiarity with students' learning habits and classroom dynamics, supporting the interpretation of changes observed during the intervention.

Following an initial introductory period and completion of the first unit on the scientific method, the intervention was introduced. Students were informed about the purpose of the study and the nature of their participation.

To ensure ethical research practice, parents received an information letter outlining the purpose of the project, the data collection methods, and the steps taken to protect student privacy. Participation was voluntary, and parents were informed that students would not be academically disadvantaged if they chose not to participate. All data collected were treated confidentially and reported anonymously.

The Action

This action research project examined the use of AI-supported formative feedback during the biology and physics units of the Grade 7 science curriculum. The intervention used FlintAI (n.d.), an artificial intelligence platform adopted by St. Mildred's-Lightbourn School and designed specifically for K–12 educational environments.

FlintAI was used to deliver formative feedback through short assessments referred to as learning checks. These learning checks were administered at the end of selected lessons throughout the biology unit and during the first four lessons of the physics unit. Each learning check aligned with lesson objectives from the Ontario Grade 7 Science Curriculum (Ontario Ministry of Education, 2022) and assessed student learning across the four Ontario assessment categories: knowledge and understanding, application, thinking and inquiry, and communication.

To address the assessment categories outlined above, the learning checks used a range of question formats. These included: recognition and recall questions, such as multiple choice, true/false, and fill-in-the-blank items, as well as prompts asking students to define key terms, provide examples, and apply their knowledge in short written responses. Open-ended questions were also used to encourage inquiry-based thinking and explanation of scientific reasoning.

After submitting each response, students received immediate AI-generated feedback that provided personalized guidance on their strengths and areas for improvement. When responses were wholly or partially incorrect, students were given an opportunity to revise their answer after reviewing the feedback provided by the system. This iterative process allowed students to reflect on and refine their thinking as they worked to close the gap between their current understanding and the intended learning goal, with FlintAI functioning as a cognitive partner in this process (Papert, 1980).

At the completion of each learning check, FlintAI generated an individualized performance summary outlining each student's strengths, areas for improvement, and suggested next steps for learning. These summaries provided students with a clear overview of their progress and highlighted specific areas where further development was needed.

In addition to the AI-generated feedback, learning checks were reviewed collectively as a class. During these discussions, students were encouraged to ask questions, clarify misunderstandings, and share their reasoning with peers. This teacher-led component reflected research suggesting that artificial intelligence tools are most effective when used to complement rather than replace classroom instruction (Chiu et al., 2023; Okonkwo & Ade-Ibijola, 2021).

Data Collection

Data were collected throughout the ten-week intervention period (November–January), when FlintAI was implemented as a formative feedback tool in the Grade 7 science classroom. Multiple sources of evidence were used to allow for data triangulation and to strengthen the credibility of the

findings. Although both quantitative and qualitative data were collected, the study placed greater emphasis on qualitative insights, particularly those reflecting student voice.

Four sources of data informed the analysis: pre- and post-intervention surveys, semi-structured interviews, AI-generated performance summaries from the learning checks, and a system of structured classroom observations adopted from Fredricks et al. (2004) (see Appendix A), along with a formalized coding framework (see Appendix B). Together, these sources allowed changes in student engagement and confidence to be examined.

Students first completed a pre-intervention survey designed to establish baseline data regarding their prior experience with artificial intelligence tools, including FlintAI, as well as their attitudes toward AI in education. The survey also explored students' preferences regarding feedback timing and frequency, their perceptions of formative feedback, and their self-reported levels of engagement and confidence in science. The survey used a mixed-format design including Likert-scale items, multiple-choice questions, multi-select items, and short answer questions. Following the intervention period, students completed a post-intervention survey that revisited these baseline measures and examined their perceptions of the FlintAI learning checks, including the clarity, usefulness, and perceived personalization of the feedback they received. Most relevant to this study, the post-intervention survey asked students to rate the extent to which the intervention influenced their engagement and confidence in science.

Semi-structured interviews were conducted both before and after the intervention to deepen understanding of students' experiences and to capture student voice. The interview questions mirrored those used in the surveys so that responses could be compared across data sources while also allowing students the opportunity to elaborate on their perspectives. It also gave students an opportunity to voice any limitations and areas for improvement in the system.

In addition to survey and interview data, individual and whole-class performance summaries generated by FlintAI for each learning check were analyzed. These summaries provided insight into student strengths, areas for improvement, and overall patterns in conceptual understanding. FlintAI also categorized student responses using performance designations of “developing,” “proficient,” and “excellent,” which represented differing levels of demonstrated understanding on the learning check. Examining these summaries across the intervention period allowed trends in students’ reasoning and conceptual understanding to be identified, providing indicators of students’ cognitive engagement with the scientific concepts being studied. Changes in student confidence were examined primarily through survey responses and interview data.

Structured classroom observations were conducted during three learning checks: Learning Check 1 (LC1) (see Appendix C), Learning Check 5 (LC5) (see Appendix D), and Learning Check 9 (LC9) (see Appendix E). These observations occurred at the beginning (LC1), midpoint (LC5), and end (LC9) of the intervention period in order to capture changes in student engagement over time. The observation protocol was explicitly informed by the Fredricks et al. (2004) engagement framework, with a particular focus on behavioural and emotional dimensions of engagement as defined within this model.

Behavioural engagement indicators were operationalized through observable student actions, including the number of reminders required to begin tasks, time required to complete learning checks, frequency of peer discussion, number of student questions directed toward the teacher or peers, requests to leave the classroom, voluntary use of notes, and willingness to participate in whole-class discussions. Emotional engagement indicators, also derived from this framework, included visible signs of frustration or disengagement, as well as student comments or reactions toward the AI system.

Observations were recorded using a structured observation framework aligned with these indicators and were subsequently coded according to the behavioural and emotional engagement categories outlined by Fredricks et al. (2004).

Data Analysis

The data collected throughout this action research project revealed several patterns that informed the analysis process. The triangulation of evidence drawn from surveys, semi-structured interviews, AI-generated performance summaries, and classroom observations strengthened the credibility and trustworthiness of the findings (Mertler, 2020). Engagement was interpreted across cognitive, behavioural, and emotional dimensions (Fredricks et al., 2004), while changes in student confidence were examined through patterns in student survey responses and interview data.

Following Mertler's (2020) inductive analysis framework of organize, describe, and interpret (pp. 305–311), the data were organized by source and reviewed across the intervention period to identify recurring patterns and changes over time. Survey responses were analyzed using frequency comparisons, while interview transcripts, performance summaries, and classroom observations were reviewed for recurring themes related to student engagement, confidence, revision behaviours, and scientific reasoning.

Through this inductive analysis process, several themes emerged regarding the role of AI-supported formative feedback in reinforcing student engagement and confidence. These themes included the influence of immediate and structured feedback on student engagement and confidence, the ways actionable feedback encouraged students to review and revise their thinking, and the progression of scientific reasoning as an indicator of increasing cognitive engagement over the course of the intervention.

Discussion of Findings

Immediate and Structured AI-Supported Feedback Reinforces Student Engagement and Confidence

Pre-intervention survey data indicated that students entered the study with moderate to high levels of engagement and confidence in science. Twelve of the total 19 students reported already feeling engaged and 12 of 19 students reported already feeling confident. No students reported feeling low in

engagement or confidence. All 19 students in the class agreed that immediate formative feedback supported their learning. These data suggested that the class represented an already stable and academically motivated group.

Following the intervention, students largely affirmed the value of the AI-supported learning checks. Twelve of 19 students reported that having learning checks was preferable to not having them, and 16 students identified the immediacy of the feedback as helpful. Additionally, 13 students reported applying the feedback they received from FlintAI to later lessons and assignments, suggesting that students were actively engaging with the feedback rather than passively receiving it.

Student voice from interview data provided further insight into how the immediate nature of the feedback supported engagement. Student R noted “it gives results right away”, and Student Q said “it gives me feedback right away and that helps me a lot,” while student Student F stated “something that helped me learn was how fast it helped me out.” These responses suggest that the immediacy of the feedback reduced uncertainty and allowed students to respond while the learning context remained fresh in mind.

Student R connected the structure of the learning checks to an improved ability to summarize key information after each lesson. She noted that the learning checks “kind of summarize everything we’ve learned for the day and allow me to know what I should be focusing on moving forward.”

Importantly, several students linked the learning check process to improved confidence and reduced stress. They described the learning checks as lowering the stakes of assessment. Student K said “they take some of the stress out of evaluation” and that they “just see it as practice.” Others connected improved understanding to confidence, with Student M explaining that “because FlintAI has helped me understand better, I now feel more motivated and confident.” Student Q said, “I feel more confident and engaged because of FlintAI,” while Student O highlighted that the system “encourages me” and “it does feel personalized.”

Not all student experiences were positive, however. Student C remarked “nothing has helped me learn in FlintAI,” while Student E stated that the system “doesn’t feel like it really knows me.” These responses suggest that while the immediacy and structure of the feedback supported many students, the perceived level of support it was providing varied.

Classroom observation data further supported these patterns of engagement and confidence across the intervention period. During the first learning check (LC1), students required frequent reminders to begin tasks, off-task discussion was common, and several students displayed visible frustration or disengagement during the learning check process. By the midpoint and final learning checks (LC5 and LC9), however, students demonstrated greater independence in initiating tasks, more consistent participation in whole-class discussions and fewer visible signs of frustration. These data also revealed increases in on-task peer discussion and more stable emotional responses to the feedback process over time. These behavioural and emotional shifts suggest that as students became more familiar with the structured feedback-and-revision process, they engaged with the learning checks more confidently and consistently.

Actionable AI-Supported Feedback Encourages Cognitive Engagement Through Revision and Reflection

While the immediacy and structure of the feedback supported engagement and confidence, student responses indicated that the actionable nature of the feedback did the same. Students consistently described the feedback as helpful in identifying specific areas for improvement. Student M explained that FlintAI “tells me what I do best and if there’s small things to improve,” while Student H noted that it helped by “telling me what I need to add more information on.” Student F described using feedback directly to support learning, stating, “I use the areas of improvement to help me learn” and “it helps me see what I need to review.”

Student O highlighted the role of examples in supporting their understanding, noting that the system “uses examples to help fix my mistakes” and provides “really good examples” that could be

applied in group discussions. These responses suggest that feedback supported not only correction, but also the development of more detailed and conceptually grounded responses.

Importantly, students frequently described how the feedback encouraged them to revise and reflect on their work. Student F explained that FlintAI "taught me to check my work before handing it in," while Student K said that "sometimes it can help me add more details." Some students also extended their learning beyond the initial task. Student O said, "I can ask FlintAI to give me follow-up questions on the same topic," suggesting a developing capacity for self-directed learning.

At the same time, student feedback highlighted important limitations. Some students reported that feedback could be repetitive. Student E noted "after I edit my responses it still gives me the same feedback over and over again." Student E also described the feedback as "too wordy" and that it should "just say what needs to be said simple and easy." Additional concerns included performance summaries being too general and occasional technical issues such as the website malfunctioning.

Growth in Scientific Reasoning Reflects Increasing Cognitive Engagement

Analysis of student performance data across the FlintAI learning checks revealed a progression in the depth and sophistication of students' reasoning over the course of the intervention. During the first learning check (LC1) (see Appendix F), students generally demonstrated strong foundational understanding, with most performing at a "proficient" level. However, many written responses lacked depth, precision in scientific terminology, and clear cause-and-effect reasoning. Explanations often reflected recall of information rather than extended reasoning. The *Areas of Improvement* section of the LC1 class summary states "Students could strengthen their short answer writing skills. Many provided incomplete or unclear explanations about viruses, often needing multiple prompts to develop complete responses."

For example, when explaining why viruses are considered "on the edge of life," Student F wrote: "viruses fit into some categories like sensitivity and movement but they can't reproduce." While this

student correctly identified some characteristics associated with living things, her explanation left out several key scientific ideas, including the fact that viruses require a host cell to reproduce, and that they do not grow in the way animal and plant cells do.

By the midpoint of the intervention (LC5) (see Appendix G), student responses began to demonstrate greater elaboration and more consistent use of cause-and-effect reasoning. Although precision in scientific terminology remained an area for growth, students increasingly attempted to explain ideas more thoroughly and coherently. The *Areas of Improvement* section of the LC5 class summary stated that "The most common area for growth involves distinguishing between temperature and thermal energy. Many students struggled to identify that temperature measures particle movement rather than the amount of thermal energy."

This growth can be observed in Student F's responses. When asked why a 40°C metal cup feels warmer than a 40°C Styrofoam cup, she explained that "the material of the cup affects how quickly that energy is transferred to your hands." Her response demonstrated a clearer understanding of differing rates of thermal energy transfer based on material type. Compared to her LC1 response, the explanation was more organized, concise, and logically sequenced. However, the response still lacked more precise scientific terminology, such as the terms conductor and insulator, which would have strengthened the explanation further.

The most significant shift appeared during the last learning check. By LC9 (see Appendix H), 11 of 15 students present on the day achieved an "excellent" designation, and whole-class summaries described student explanations as "clear, detailed, and articulated in students' own words". At this stage students were increasingly able to connect concepts across contexts and apply scientific understanding to real-world situations.

Student F's final responses further illustrate this progression. When asked why human bodies are not crushed by atmospheric pressure, she explained that the body contains fluids and air that push

outward with the same force that the atmosphere pushes inward, comparing the interaction to a "tug-of-war where both sides are equally strong." This explanation not only demonstrated accurate scientific reasoning, but also showed the student's ability to apply an analogy to communicate a complex scientific principle.

Importantly, growth in scientific reasoning occurred despite a shift into more abstract and conceptually demanding physics content, a transition that research suggests students often perceive as more difficult than biology-related learning (Sabari & Gafoor, 2018). While natural instructional progression likely contributed to this development, the repeated feedback-and-revision process appeared to reinforce increasingly sophisticated reasoning and sustained cognitive engagement over time.

Conclusion

The findings from this action research study suggest that AI-supported formative feedback can reinforce student engagement and confidence in a Grade 7 girls' science classroom when implemented through structured opportunities for feedback, reflection, and revision. Although students entered the study with relatively high baseline levels of engagement and confidence, the introduction of regular AI-supported learning checks appeared to reinforce cognitive, behavioural, and emotional engagement over the course of the intervention. Across survey, interview, classroom observation, and performance summary data, students increasingly demonstrated greater independence in engaging with learning tasks, more consistent emotional responses to feedback, and a growing willingness to revisit and refine their thinking.

Importantly, the findings suggest that the immediacy and structure of the feedback process helped reduce uncertainty and clarify learning expectations, while the actionable nature of the feedback encouraged students to actively revise and elaborate on their responses. Over time, students' written explanations became increasingly detailed, coherent, and conceptually integrated, suggesting deeper

cognitive engagement with the scientific material. While some growth in engagement, confidence, and reasoning would naturally be expected across two instructional units, the convergence of multiple data sources suggests that the AI-supported formative feedback reinforced these developments by supporting sustained reflection, revision, and engagement with the learning process.

Several limitations must be considered when interpreting these findings. First, this study was conducted within a single class of 19 students in an independent school setting, which limits the ability to generalize results across broader educational contexts. Continuity of the intervention also presented challenges. Regular student absences meant that not all students participated in every learning check or data collection point. Researcher continuity was another consideration. As both classroom teacher and researcher, and with additional coaching responsibilities outside of class time, my own occasional absences disrupted the consistency of the intervention and observation process. While efforts were made to maintain structure across the intervention period, these interruptions reflect the realities of everyday school life.

Despite these limitations, this project offers meaningful implications for classroom practice. AI-supported formative feedback does not replace the teacher; rather, when thoughtfully integrated, it can function as a structured cognitive partner that strengthens the immediacy, personalization, and opportunities for revision that characterize effective formative feedback. In this way, AI-supported feedback can help reinforce student engagement and confidence while supporting deeper reflection on learning. Moving forward, I plan to refine the design of these learning checks by simplifying feedback language and optimizing question volume while maintaining the feedback-and-revision structure that supported student engagement. I also intend to continue exploring the use of AI-supported formative feedback across additional science units and potentially other courses that I teach.

As artificial intelligence continues to shape the educational landscape, this research reinforces the importance of intentional implementation and the continued role of the teacher. When aligned with

sound pedagogical principles and grounded in reflective practice, AI-supported formative feedback can reinforce student engagement and confidence. Importantly, it does so not by replacing the teacher, but by strengthening the learning processes that effective teaching already supports.

Reflection Statement

This action research journey has been one of the most meaningful and professionally enriching experiences of my career. It has provided an opportunity not only to examine and refine my own practice, but also to engage deeply with ideas around student engagement and confidence, feedback, and the evolving role of AI in education.

I would like to begin by expressing my sincere gratitude to my research advisor, Debbie Hill, whose enduring support and thoughtful guidance were instrumental throughout every phase of this project. From the early stages of planning and design, through implementation, analysis, and writing, Debbie consistently challenged my thinking while providing encouragement and clarity at each step of the process.

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I would also like to thank my teaching partner, Clare Staszkiel, whose willingness from the outset to adopt this AI-supported approach with her own students added an important dimension to this work. While data from her class were not included in the formal analysis, the opportunity to observe and reflect on a parallel cohort provided valuable insight.

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willingness to engage in thoughtful dialogue about this work and offer guidance throughout has been greatly appreciated.

To my students, I extend my deepest thanks. Your openness, curiosity, and willingness to engage with something new made this work possible. Your energy and honesty shaped this project in ways that could not have been anticipated, and it has been a privilege to learn alongside you.

Finally, I would like to thank my wife for her patience and support, particularly during the writing phase of this project. Balancing this work alongside family life, especially with a toddler and a newborn, was not without its challenges. Your understanding and encouragement meant more than I can fully express.

References

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences, 107*(5), 1860–1863. https://doi.org/10.1073/pnas.0910967107

Chiu, T. K. F., Moorhouse, B. L., Chai, C. S., & Ismailov, M. (2024). Teacher support and student motivation to learn with Artificial Intelligence (AI)-based chatbot. *Interactive Learning Environments, 32*(7), 3240–3256. https://doi.org/10.1080/10494820.2023.2172044

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House.

Flint. (n.d.). *Flint—AI for schools*. https://www.flintk12.com

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81–112. https://doi.org/10.3102/003465430298487

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Okonkwo, C. W., & Ade-Ibijola, A. (2021). Chatbots applications in education: A systematic review. *Computers & Education: Artificial Intelligence, 2,* 100033. https://doi.org/10.1016/j.caeai.2021.100033

Ontario Ministry of Education. (2022). *The Ontario curriculum: Grades 1–8: Science and technology, revised 2022*. Queen's Printer for Ontario. https://www.dcp.edu.gov.on.ca/en/curriculum/science-technology

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. Basic Books.

Sarabi, M. K., & Abdul Gafoor, K. (2018). *Student perception on nature of subjects: Impact on difficulties in learning high school physics, chemistry and biology* (ERIC Document No. ED617654). ERIC. https://files.eric.ed.gov/fulltext/ED617654.pdf

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research, 78*(1), 153–189. https://doi.org/10.3102/0034654307313795

Vasconcelos, M. A. R., & dos Santos, R. P. (2023). Enhancing STEM learning with ChatGPT and Bing Chat as objects to think with: A case study. *Eurasia Journal of Mathematics, Science and Technology Education, 19*(8), em2309. https://doi.org/10.29333/ejmste/13313

Wiliam, D. (2016). *Leadership for teacher learning: Creating a culture where all teachers improve so that all students succeed*. Solution Tree Press.

Appendix A

Classroom Observation Coding Framework

Classroom observations conducted during selected learning checks were coded to capture behavioural and emotional indicators of student engagement. These indicators were adapted from the engagement framework described by Fredricks et al. (2004).

Classroom observations were used primarily to examine observable behavioural and emotional engagement indicators during the learning check process. Cognitive engagement indicators were analyzed separately through student performance summaries and are therefore not included in this observation coding framework.

Behavioural Engagement Indicators

- Task initiation and persistence (reminders required to begin or remain on task)
- On-task peer discussion
- Off-task peer discussion
- Requests to leave the classroom
- Whole-class participation during learning check take-up
- Variability in task completion time across the class

Emotional Engagement Indicators

- Visible frustration
- Visible disengagement
- Positive comments about FlintAI
- Negative comments about FlintAI

Appendix B

Behaviour Coding Scale

Observed behaviours were coded using a four-point ordinal scale.

Score	**Behaviour Frequency**
0	No instances observed
1	Low (1 - 3 instances)
2	Moderate (4 - 8 instances)
3	High (9+ instances)

Appendix C

Classroom Observations: Learning Check 1

Engagement Category	Indicator	Code
Behavioural	Reminders required for task initiation	3
	Time variability for completion of LC between students	3
	On-task peer discussion	0
	Off-task peer discussion	3
	Requests to leave the classroom	2
	Whole-class participation during “teacher take-up”	1
Emotional	Visible frustration	3
	Visible disengagement	3
	Positive comments about FlintAI	0
	Negative comments about FlintAI	3

Appendix D

Classroom Observations: Learning Check 5

Engagement Category	Indicator	Code
Behavioural	Reminders required for task initiation	1
	Time variability for completion of LC between students	2
	On-task peer discussion	1
	Off-task peer discussion	2
	Requests to leave the classroom	1
	Whole-class participation during “teacher take-up”	2
Emotional	Visible frustration	1
	Visible disengagement	1
	Positive comments about FlintAI	1
	Negative comments about FlintAI	1

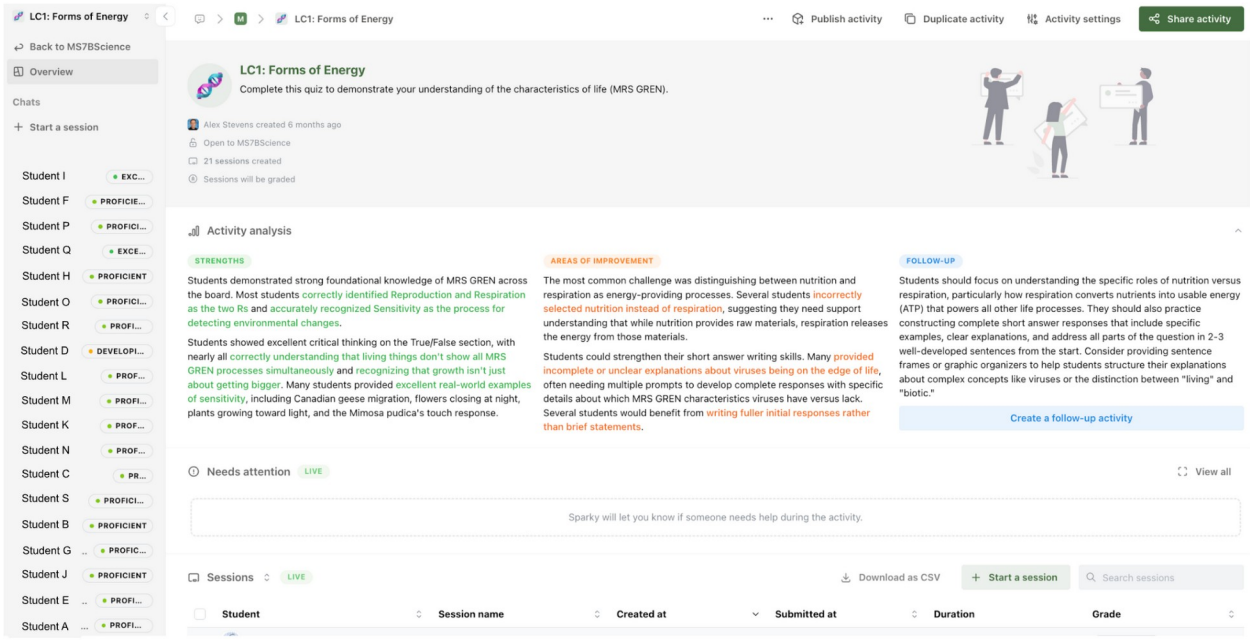
Appendix E

Classroom Observations: Learning Check 9

Engagement Category	Indicator	Code
Behavioural	Reminders required for task initiation	0
	Time variability for completion of LC between students	1
	On-task peer discussion	2
	Off-task peer discussion	1
	Requests to leave the classroom	1
	Whole-class participation during “teacher take-up”	3
Emotional	Visible frustration	1
	Visible disengagement	1
	Positive comments about FlintAI	1
	Negative comments about FlintAI	1

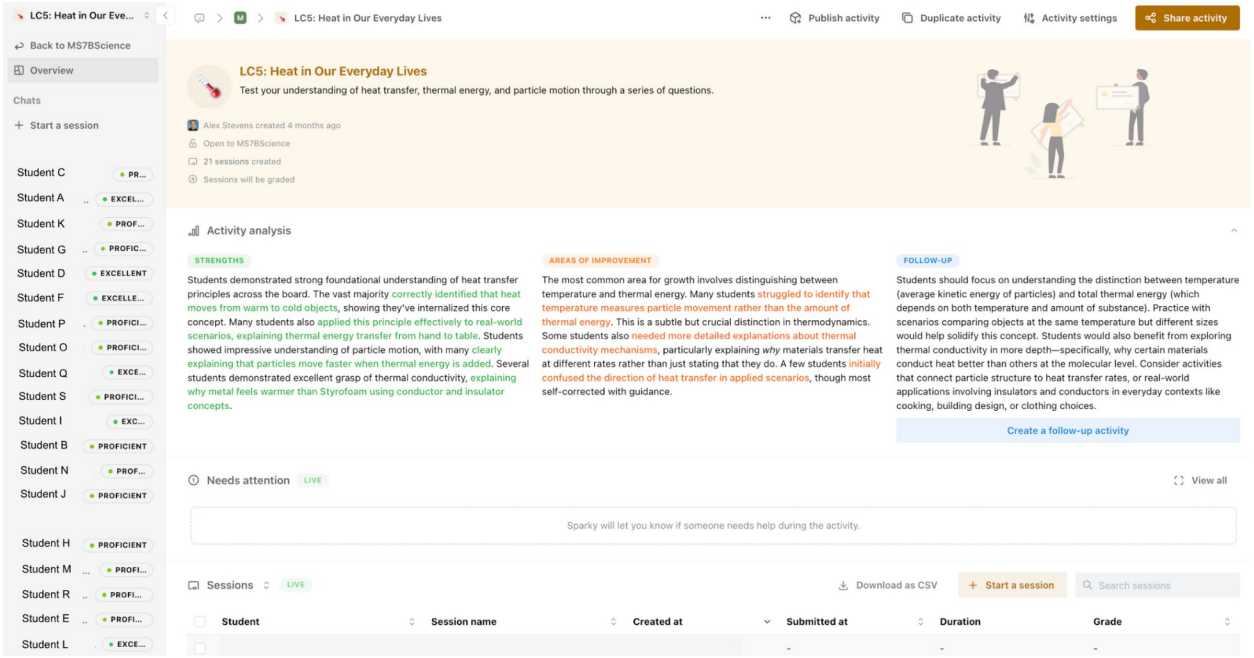
Appendix F

Performance Summary: Learning Check 1



Appendix G

Performance Summary: Learning Check 5



Appendix H

Performance Summary: Learning Check 9