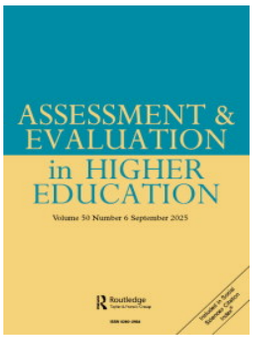
Feedback-seeking behaviour as a self-regulation strategy in higher education: a pedagogical approach



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Feedback-seeking behaviour as a self-regulation strategy in higher education: a pedagogical approach

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ABSTRACT

Feedback-seeking is a critical skill in higher education, where students are expected to actively engage with and initiate the feedback process. However, limited research explores how feedback-seeking can be explicitly taught. This study examines a systematic pedagogical approach to teaching feedback-seeking behaviour (FSB) in first-year STEM (Science, Technology, Engineering, and Mathematics) higher education, grounded in the self-regulation of learning (SRL) framework. Integrating FSB into the academic writing process, the pedagogical approach focuses on feedback monitoring and feedback inquiry from peers and teachers. Using a longitudinal design, data were collected from 96 students across 16 groups, including drafts, reflections, feedback questions, and students' evaluations of the pedagogical approach. Findings reveal that teaching FSB systematically enables students to: 1) engage in targeted feedback inquiry, 2) monitor and identify gaps in their work, such as vague descriptions, and 3) develop strategic prioritization skills, balancing areas for improvement with project goals in collaborative settings. This study contributes to FSB research by offering a structured model that transforms feedback practices into tools for active learning and self-regulation.

KEYWORDS

Feedback seeking behavior; feedback literacy; STEM higher education; self-regulation of learning

Introduction

Recent research increasingly emphasizes learning as a collaborative process where different actors, e.g. students and teachers, contribute and share responsibility (Fraile, Gil-Izquierdo, and Medina-Moral 2023). This shift towards active learning has influenced feedback practices, traditionally characterized by a uni-directional flow of information. In these traditional frameworks, a single knowledge-holder provides feedback, while the 'less knowledgeable' recipient receives the feedback and is expected to implement it. Such practices are often laden with power dynamics, creating a hierarchical relationship between the feedback provider and the receiver (Jeffery and Halcomb-Smith 2020). However, emerging perspectives advocate for a more equitable approach, positioning students as not only active partners in but also leaders of the feedback process (Henderson et al. 2021). In order to create this, there has been recent calls for integrating feedback-seeking behaviour (FSB) into the higher education curriculum, particularly for first-year undergraduate students (Young and Carless 2024).

While the integration of FSB into curricula remains underexplored, drawing on established frameworks can provide valuable insights into its potential. Self-regulated learning (SRL) offers a

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promising lens through which to understand and implement FSB. SRL refers to a process where learners take an active role in their education by setting goals, monitoring their progress, and adapting strategies to achieve desired outcomes (Zimmerman 2002). This approach emphasizes autonomy and control, allowing students to manage their learning processes effectively. Research has shown that self-regulated learners who actively seek feedback not only enhance their academic performance but also create autonomy and lifelong learning skills (Huisman et al. 2019). By applying the principles of SRL, feedback can transition from a passive process to one of active engagement, creating opportunities for deeper learning and personal growth (Nicol and MacFarlane-Dick 2006).

This study integrates FSB into project-based learning, an instructional approach in which students actively engage with real-world problems and challenges to acquire deeper knowledge. By teaching FSB, the study achieves a dual purpose: enhancing students' engagement with feedback while fostering their autonomy as learners. This study examines the implementation of this pedagogical strategy over the course of a 14-week program. The longitudinal design offers valuable insights into how FSBs can be supported and sustained through structured, self-regulated learning activities. This research contributes to the growing body of literature on FSB and SRL by presenting a practical, evidence-based model for transforming feedback practices in undergraduate STEM (Science, Technology, Engineering, and Mathematics) higher education.

Conceptual framework

This study draws on Self-Regulation of Learning (SRL) in FSB. I first introduce recent research on feedback seeking strategies as part of feedback literacy focusing on challenges found in previous studies that investigated FSBs. I then introduce the pedagogical approach to FSB, which is based on SRL.

Feedback literacy: uni- and multi-directional feedback practices

Feedback literacy, defined as the ability to understand, engage with, and use feedback effectively, is a critical skill in higher education. Traditionally, feedback literacy has been conceptualized as a passive process, where students receive feedback from teachers or peers and attempt to implement changes (Henderson et al. 2021). However, emerging research emphasizes FSB, which repositions students as active participants in the feedback process (Gan, Wei, and Yu 2025). In disciplines such as medicine, FSB is already recognized as a vital skill for improving performance (Ginsburg et al. 2024). In STEM higher education, however, FSB has received comparatively less attention, despite evidence indicating that students who actively engage with feedback tend to achieve better outcomes (Lundstrom and Baker 2009).

Ashford and Cummings (1983) define FSB as 'the conscious devotion of effort toward determining the correctness and adequacy of behaviours for attaining valued end states' (p. 466). FSBs encompass two key dimensions: feedback monitoring, which involves observing and learning from the environment, and feedback inquiry, which entails actively soliciting feedback from peers or teachers (Papi et al. 2019). Both forms of FSB enhance student engagement and learning, yet their cultivation and sustainability in higher education contexts remain underexplored.

Understanding what works and what does not work in students' FSB is crucial for designing effective pedagogical interventions. Therefore, the next section will review studies related to FSB, providing insights into both the successes and challenges associated with fostering these behaviours.

Feedback-seeking behaviour: monitoring and inquiry

Although few studies explicitly address pedagogical methods for teaching FSB, existing research highlights effective practices for students. For example, Li and Han (2024) found that students

who actively sought detailed and specific feedback in their feedback inquiries experienced greater benefits, particularly when they clearly articulated their expectations to feedback providers. In contrast, brief or ambiguous feedback was associated with reduced student engagement.

When it comes to challenges related to feedback monitoring specifically, it is recommended that students conduct this while checking rubrics. However, Zhou et al. (2023) identified that students often struggle to decode writing rubrics, relying on exemplars or peers to understand expectations. This reliance can hinder personalized FSB, particularly in the later stages of projects, when deadlines dominate focus. Zhou et al. (2023) also noted that students preferred peer feedback during initial drafts but relied more on teacher feedback as their work progressed, driven by concerns about the quality and legitimacy of peer feedback.

Perceived costs and value significantly influence FSBs, particularly feedback inquiry. Ashford and Cummings (1983) identified these costs as self-presentation costs (fear of appearing incompetent), ego costs (discomfort with negative feedback), and effort costs (the time and energy required to seek and act on feedback). Papi et al. (2019) further noted that students with a growth mindset—who view their abilities as improvable—are more likely to seek feedback despite these costs. In contrast, those with a fixed mindset may engage in superficial FSB, prioritizing appearances over genuine improvement. Arguably, engaging with meaningful FSB processes has the potential to foster a growth mindset, as students encouraged—or even required—to actively seek and implement feedback can develop a more positive and improvement-focused perspective.

This study addresses these challenges and implements key recommendations by embedding structured feedback-seeking activities into group-project-based learning. These activities are intentionally designed to create a low-risk, supportive environment that mitigates perceived costs while enhancing the perceived value of feedback-seeking. By integrating feedback-seeking as a core element of self-regulated learning within the curriculum, this approach seeks to empower students to engage meaningfully with feedback.

The role of self-regulation of learning in FSB

Self-regulation of learning (SRL) offers a valuable lens for understanding how students can develop more effective FSB. SRL involves learners taking control of their educational processes by setting clear goals, monitoring their progress, and reflecting on their outcomes (Zimmerman 2002). Within higher education, FSB can be viewed as a self-regulatory skill—one that enables students to identify areas for improvement, locate relevant resources (including feedback), and apply that feedback to enhance their learning.

Evidence suggests that students who engage in feedback as part of a self-regulated learning strategy are more likely to improve their performance (Nicol and MacFarlane-Dick 2006; Taras 2001). Moreover, self-regulated learners tend to regard feedback as a resource for growth rather than a critique of their abilities, which can alleviate the anxiety often associated with feedback (Dweck 1999). Building on these insights, this study incorporates key SRL principles outlined by Nicol and MacFarlane-Dick (2006) into a pedagogical intervention aimed at teaching first-year undergraduate STEM students to seek feedback more effectively in the context of academic writing.

A pedagogical approach to feedback seeking behaviour

In this section, I outline a pedagogical approach designed to foster self-regulated learning through structured activities that encourage students to actively seek and engage with feedback throughout the academic writing process of their project reports. Grounded in Nicol and MacFarlane-Dick (2006) seven principles of good feedback practice, which draw on SRL, the

approach promotes student autonomy and improves performance. Nicol and Macfarlane-Dick's principles emphasize clarifying performance standards, facilitating self-assessment, providing high-quality information, encouraging dialogue, promoting positive motivational beliefs, offering opportunities for improvement, and informing teaching practices. These principles serve as the foundation for this model, which reimagines feedback as a dynamic, multidirectional process involving active student participation.

The model is structured into self-regulation phases, each aligned with specific feedback-seeking activities (feedback monitoring and feedback inquiry) and clearly defined roles for teachers and students. Table 1 summarizes these phases and their associated tasks.

As can be seen in Table 1, students engaged in FSB through two primary sources: peer feedback and teacher feedback. In the initial phases, students identified areas for improvement and formulated specific feedback-seeking questions, which were addressed in structured peer feedback meetings. These meetings were attended by both communication and technical teachers, who monitored the discussions ensuring feedback was relevant and covered all major issues in the drafts. Later in the process, after revising their drafts based on peer input, students prepared targeted questions for their teachers, who then provided feedback during scheduled meetings. In the following is a detailed description of feedback-seeking activities.

In the goal setting and planning phase, students begin by reflecting on criteria provided by the teacher, analysing examples, and setting personalized writing goals (Weeks 1–2). Teachers provide examples of reports for analysis, negotiate criteria with the class, and showcase prior feedback to clarify expectations. This stage sets the foundation for self-regulated learning by fostering clarity and encouraging students to envision successful outcomes.

The performance phase focuses on students finalizing and submitting their first drafts (Weeks 3–4). This milestone provides a basis for subsequent evaluation and feedback-seeking activities.

The evaluation phase emphasizes students' reflection on the strengths and weaknesses of their drafts (Week 5), preparing them for the evaluation and performance phase, where they

Table 1. A pedagogical model for implementing FSB in higher education.

Self-regulation phase	Feedback-seeking phase	Actor performing the task	What is being performed	Week
Goal setting and planning	Feedback monitoring	Teacher	Provide examples of reports, well-defined criteria, class negotiation of criteria, examples of prior feedback	Week 1
		Students	Reflect on criteria, analyze examples, envision successful writing, and set goals accordingly	Week 2
Performance		Students	Finalizing and submitting their first draft	Week 3–4
Evaluation		Students	Reflect on draft strengths and weaknesses	Week 5
Evaluation + Performance	Feedback inquiry	Students	Identify improvement areas in their drafts, and draft questions for peers	Week 6
		Peers	Respond to feedback-seeking inquiries	Week 7
		Students	Respond to peer feedback in a meeting attended by two students' groups and the teachers, revise based on received feedback	Week 8
		Students	Finalizing and submitting their second draft	Week 9–11
Evaluation + Performance		Students	Analyze their draft, identify further improvement areas, and prepare questions for teachers	Week 12
		Teachers	Respond to feedback-seeking inquiries during a meeting	Week 14
Evaluation		Students	Reflect on progress, what has been learnt and the feedback-seeking pedagogical approach	Week 14

Note: The students submitted their work four weeks after their final interaction with the teachers, during which they had time to refine and finalize their texts.

engage in feedback inquiry (Weeks 6–8). During this period, students identify areas for improvement and draft written questions for peers, which are discussed in a peer feedback group meeting attended by both communication and technical teachers. Prior to the meeting, teachers review the drafts and monitor discussions to ensure that feedback is relevant and addresses key areas for improvement. Students then incorporate peer feedback into their revisions.

The performance phase resumes as students finalize and submit their second drafts (Weeks 9–11), incorporating insights gained from peer interactions. Subsequently, in the evaluation and performance phase (Week 12), students analyse their drafts, identify unresolved issues, and prepare focused questions for teacher feedback. Teachers respond to these inquiries during scheduled meetings in Week 14, providing targeted guidance to address specific challenges.

The final evaluation phase (Week 14) involves reflective activities where students assess their progress, reflect on lessons learned, and evaluate the FSB pedagogical approach. This closing stage emphasizes metacognitive awareness and solidifies the iterative learning process embedded in the FSB model.

In addition to drawing on Nicol and Macfarlane-Dick's framework, this pedagogical model incorporates key insights from the literature on FSB. For example, Papi et al. (2019) emphasize the importance of fostering a growth mindset, where students view feedback as an opportunity for improvement rather than as a threat. By embedding feedback-seeking into a supportive and low-risk environment, this model helps students overcome the perceived costs associated with FSB, such as the fear of exposing weaknesses (Ashford and Cummings 1983). Moreover, Zhou et al. (2023) highlight the need for timely and legitimate feedback, which is addressed in this model by integrating both peer and teacher feedback at various stages of the writing process. In the next sections, I explain the context in which this pedagogical approach was implemented.

Context

The participants in this study were STEM first-year undergraduate students in their first term of study, tasked with writing their first assignment: a report on a project they conducted in groups of 5-6 students. The projects were situated in the field of Engineering, offering students an opportunity to explore technical applications of IoT (Internet of Things), while developing their academic writing skills. Given that these students were at the beginning of their academic journey, research suggests that introducing a pedagogical approach to FSB at this stage is both timely and beneficial (Young and Carless 2024).

The course included 96 students, divided into 16 groups. The course was co-taught by a communication teacher and a technical teacher. The communication teacher, who also served as the researcher, focused on facilitating students' writing development and FSBs. The technical teacher guided the technical aspects of the projects. Communication lectures formed a core component of the course, introducing students to key concepts such as feedback literacy. These sessions provided foundational knowledge to support students in engaging actively with the FSB model.

The integration of structured feedback-seeking activities required adjustments in instructional priorities. Previously, more emphasis was placed on grammar and paraphrasing, but student feedback indicated these were less relevant, particularly with the rise of AI-assisted writing tools. To ensure deeper engagement, the course shifted focus to feedback monitoring and inquiry, encouraging students to critically assess and refine their work through iterative feedback cycles.

The following research questions guide this project:

1. What are the students' practices at each stage of the feedback-seeking pedagogical model?
2. What are the perceived challenges and benefits of feedback-seeking in project-based collaborative projects?

Methods

This research investigates the practices of students at each stage of a guided model of FSB, going beyond studies that focus solely on reported practices or perceptions of challenges. By examining students' actions and reflections, the study evaluates the pedagogical model's effectiveness from the students' perspective, providing a nuanced understanding of how FSB can be implemented in teaching.

Data were collected from students' written assignments and reflective submissions, capturing a comprehensive view of their engagement with the feedback-seeking process. As Table 2 shows, collected data included: written observations, questions for feedback seeking from peers and teachers, and reflective data.

Table 2. Overview of data.

Type of Data	Amount of Data
Students' observations on three documents (previous course feedback, detailed criteria, and sample reports)	16 texts (500–1000 words each)
Students' goal setting for their writing	16 texts (500–1000 words each)
Students' questions for feedback seeking from peers	16 sets of questions (each set ~6 questions)
Students' reflections on strengths and weaknesses of drafts	16 texts (~500 words each)
Students' questions for feedback seeking from teachers	16 sets of questions (each set ~6 questions)
Students' reflections on the pedagogical approach	16 texts (~200 words each)

Engagement in the feedback-seeking process was required to pass the course but was not given a specific mark. Since students worked in groups, participation varied, though all were expected to contribute to discussions and peer feedback activities. To support engagement, structured feedback meetings were held, with teachers monitoring discussions to ensure major issues were addressed. Students who did not fully participate were required to complete a compensation assignment, independently providing and justifying feedback on sample work. However, no students needed to complete this assignment, suggesting that the structured group format effectively encouraged participation.

This study was conducted in accordance with ethical standards and received approval from Chalmers University of Technology, ensuring compliance with institutional and ethical guidelines. All student participants provided written informed consent prior to their involvement in the study, as detailed in the manuscript. The consent process was transparent and voluntary, with students informed of their rights and the purpose of the research.

Thematic deductive analysis was applied to identify major themes across each stage of the FSB model (Braun and Clarke 2006). This method enabled a detailed examination of patterns across students' questions and reflections, uncovering key areas of engagement and development. The analysis highlighted four major themes: areas of improvement, areas of strength, challenges associated with the FSB model, and benefits derived from its implementation. Each of these themes includes subthemes that offer deeper insights into how students interacted with the pedagogical approach and are elaborated upon in the following sections.

Results

In this section I present findings related to how the students approached feedback monitoring and feedback inquiry, which include students' observations, questions and then reflections on their drafts. The second section of the findings looks into students' evaluations of the pedagogical model.

Feedback monitoring

Students' observations from exemplary reports, examples of feedback from previous runs of the course, and course criteria are reported in this section along with their reflections on their drafts and how they incorporated their observations in their drafts.

Students' observations on feedback monitoring materials

A prevalent issue was the lack of specificity and vague descriptions, which left readers unclear about critical details. 12 out of 16 groups identified this as a key concern. For example, Group 9 observed, 'Statements like 'radar can be used to detect objects' are too broad. The report needs to specify how radar measures distance or the type of objects it can detect'. Similarly, Group 12 emphasized the need for detailed steps and justifications in the methodology, noting that 'the report simply stated 'practical issues' as a reason for not placing the radar at a specific angle without explaining what those issues were'.

Another common problem was the inadequate theoretical background, affecting the clarity and context of the reports. Seven groups noted insufficient theoretical depth. Group 4 remarked, 'The theory section is too brief, especially regarding IoT applications. It would benefit from more examples to show how IoT devices interact and what kind of data they collect'. Group 13 added, 'The introduction should lay out why the study is important. In our example, the report failed to connect the purpose of using radar technology to real-world energy-saving applications'.

Poor explanation of results and data analysis was also frequently noted. Six groups identified gaps in methodological transparency and reproducibility. Group 6 highlighted, 'In the stationary tests section, the report discusses issues with surface water detection but doesn't explain why water was hard to detect. This leaves the reader guessing'. Similarly, Group 11 pointed out, 'Graphs are included without figure descriptions, making it difficult to interpret the data. Reports should ensure that each figure has a clear explanation, especially when used to support conclusions'.

Students also highlighted the overlooking of ethical and privacy concerns, particularly in IoT contexts. Four groups raised concerns about data privacy and ethical considerations. Group 10 commented, 'The report discusses radar data collection but fails to address privacy concerns. In the context of IoT, it's crucial to consider who has access to the data and how it's used'. Group 14 noted, 'Ethical implications were mentioned briefly, but there was no in-depth discussion on data privacy or the potential for misuse'.

Structural issues, such as a disjointed structure and lack of cohesion, were another area of concern. Ten out of 16 groups identified problems with structure and organization. Group 5 observed, 'The report's introduction jumps straight into the problem without providing a clear background. A good report should guide the reader through each section, building on the previous one'. Group 15 reflected, 'The results and discussion sections were disjointed. It seemed like two different parts written by different people. The report would benefit from a more cohesive writing style'.

Insufficient attention to methodological details was frequently raised as a barrier to reproducibility. Six groups noted gaps in explaining experimental procedures. Group 3 remarked, 'It's important to describe every step taken during the experiments. Our example report listed different settings for the radar but did not explain why some configurations were excluded'. Similarly, Group 1 emphasized, 'The method needs to be comprehensive so others can replicate the experiment. Simply stating that certain lenses were used without explaining their impact on the results is not sufficient'.

Finally, common language and formatting issues detracted from professionalism. Nine groups reported concerns about formatting, consistency, and language use. Group 8 noted, 'There were several instances of inconsistent terminology throughout the report, making it hard to follow. Consistency is key to maintaining a professional tone'. Group 2 pointed out, 'There were spelling mistakes in the abstract and inconsistencies in how equations were presented. These small errors can detract from the report's overall quality'.

These findings, summarized in Table 3 below, demonstrate how feedback monitoring enabled students to identify areas to 'monitor' in their reports, ranging from specificity and theoretical depth to structure, ethics, and formatting.

Table 3. Frequency of feedback concerns observed during feedback monitoring.

Aspect Observed	Number of Groups (out of 16)
Structure and Organization	10
Formatting and Presentation	9
Clarity and Specificity	12
Theoretical Depth	7
Methodological Detail	6
Ethical and Privacy Considerations	4

Students' reflections on drafts after feedback-monitoring

Students' reflections reveal a balance of strengths and weaknesses in their approach to drafting and refining their reports, closely aligning with the key observations noted in the analysis of their feedback monitoring. One commonly identified strength was the technical depth and clarity in specific sections of their reports. Seven out of 16 groups highlighted the effective integration of radar technology. For instance, Group 7 noted, 'The Acconeer radar module allowed us to achieve precise measurements, especially in distance detection tests'. This strength was particularly evident in areas involving signal processing and radar range measurements.

Additionally, the use of visuals was widely noted as a strength. Nine out of 16 groups remarked that figures and diagrams helped clarify complex data. Group 9 reflected, 'The inclusion of figures helped to clarify complex data, especially in our section on antenna gain and directivity'. Similarly, eight groups praised their structural coherence, with Group 8 stating, 'Our method section was clearly structured, which made it easier for readers to follow our experimental setup'.

However, several weaknesses were also acknowledged, mirroring the broader observations from the feedback monitoring phase. Six out of 16 groups identified insufficient theoretical depth as a recurring issue. Group 10 recognized that 'the theory section could be more detailed, especially regarding beamwidth and reflectivity', while Group 6 admitted, 'We need to strengthen the connection between our theoretical discussions on IoT and its practical applications'.

Time management challenges were another recurring theme, affecting the overall polish of the drafts. Five groups admitted that limited time impacted the coherence and refinement of their work. Group 3 stated, 'Limited time led to an unpolished draft, which impacted the overall coherence of our report'. Similarly, four groups noted that limited experimental results hindered their ability to refine sections of their reports. Group 11 explained, 'Our lack of experimental results was due to prioritizing other assignments, which limited the time available for refining the report'.

These reflections demonstrate students' ability to critically evaluate their work, recognizing areas of strength, such as technical clarity and effective visual aids, while identifying gaps in theoretical depth and time management that impacted the comprehensiveness and polish of their drafts. Table 4 below summarizes the distribution of student reflections on their drafts.

Table 4. Frequency of reflections on drafts after feedback-monitoring.

Aspect Reflected Upon	Number of Groups (out of 16)
Technical Depth and Clarity	7
Use of Visuals	9
Structural Coherence	8
Insufficient Theoretical Depth	6
Time Management Challenges	5
Limited Experimental Results	4

Feedback inquiry

Feedback inquiry from peers

The following Table 5 summarizes the distribution of feedback-seeking questions from students during peer feedback sessions.

Table 5. Frequency of feedback inquiry from peers.

Feedback Topic	Number of Groups (out of 16)
Structural Clarity and Organization	8
Technical Accuracy and Depth	6
Language and Tone	7
Scope and Relevance	5

The thematic analysis of student feedback-seeking questions highlights key areas where groups sought input from their peers to improve their drafts. These questions demonstrate a focus on structural clarity, technical depth, language, and scope, with each group contributing distinct perspectives. One significant area of inquiry was structural clarity and organization, with 8 out of 16 groups questioning whether their reports were coherent and well-structured. For example, Group 8 asked, 'Is the text overall coherent and logically structured?'. Similarly, Group 1 inquired, 'Is the formatting used in the report optimal?'. These questions indicate a shared concern for ensuring the logical flow and readability of their work.

Another prominent theme was technical accuracy and depth, with six groups focusing on the adequacy of their theoretical explanations and whether additional technical topics should be included. Group 5 posed the question, 'Should the theory section discuss more topics such as beamwidth and reflectivity?'. Similarly, Group 8 asked, 'Is the method section descriptive enough? Is it unclear somewhere where we need to explain more?'. These questions reflect a desire to deepen the technical rigor of their work and clarify key sections.

Language and tone also featured prominently in the questions, with seven groups aiming to ensure their writing adhered to academic standards. Group 1 asked, 'Is the language used in the text formal, neutral, and scientifically written? If not, which parts are lacking in this area?'. This highlights the importance students placed on presenting their work professionally and effectively.

Finally, scope and relevance were areas of concern for five groups. Groups sought input on whether their projects were appropriately framed. Group 5 inquired, 'How should we expand our scope section? What can we add?'. Similarly, Group 8 questioned, 'Are our research questions narrow enough? Do we have too many?'. These questions illustrate efforts to refine the boundaries and focus of their reports.

Feedback inquiry from teachers

The following Table 6 summarizes the distribution of feedback-seeking questions from students when engaging with teachers:

Table 6. Frequency of feedback inquiry from teachers.

Feedback Topic	Number of Groups (out of 16)
Clarity of Introduction and Scope	7
Methodological Transparency	6
Adequacy of Theoretical Framework	5
Scientific Rigor and Academic Standards	4

Students' FSBs when engaging with teachers revealed distinct patterns centered on clarity, depth, and alignment with project objectives. A recurring theme was the need for clearer articulation in report sections, with seven out of 16 groups questioning whether their introductions provided sufficient context and whether their purpose and scope were well-defined. For instance, Group 1 sought clarification on whether their introduction adequately conveyed the relevance of their radar-based pothole detection system to road safety, emphasizing, 'What we have done must come across more clearly to complement the paper'. Similarly, Group 4 questioned whether their scope sufficiently addressed the technical feasibility of their tank-level rain gauge project, highlighting their concern about balancing technical depth with practical applications.

Questions about methodological transparency were also prevalent, with six out of 16 groups raising concerns about how their experimental methods were conveyed. Group 8, working on gesture recognition using radar, inquired whether their explanation of test setups and data collection methods was clear, specifically asking, 'Does the 3.2 section make clear how the gestures are performed and how the gestures have been divided into positions?'. Similarly, Group 5 asked whether their presentation of calibration experiments, which included three side-by-side images, effectively conveyed their findings or required an alternative approach. These inquiries underscore students' proactive efforts to align their methodology with academic standards and ensure comprehensibility.

Students also frequently sought feedback on the adequacy of their theoretical frameworks, with five out of 16 groups inquiring whether their background sections effectively connected technical details with broader implications. For example, Group 3 asked whether their fall-detection project covered all necessary theoretical components, such as a detailed explanation of radar reflection and signal anomalies. Group 2, focusing on IoT applications for a white cane project, questioned whether their background section effectively connected technical details with broader implications. These questions demonstrate a strong interest in bridging theory with practical relevance.

Concerns about scientific rigor and academic standards were another prominent theme, raised by four out of 16 groups. Group 6 asked whether their referencing adhered to IEEE standards throughout their report, reflecting a desire to maintain professional documentation practices. Meanwhile, Group 11 sought advice on whether their results section adequately interpreted experimental data and how to address potential margins of error. These questions highlight students' focus on ensuring both the accuracy and credibility of their work.

Reflections on drafts after feedback inquiry

Table 7 summarizes the distribution of student reflections after engaging in feedback inquiry:

Table 7. Frequency of reflections on drafts after feedback inquiry.

Reflection Theme	Number of Groups (out of 16)
Clarity and Structure	9
Inconsistencies in Writing Style	6
Time Management and Depth of Analysis	7
Data Presentation and Visualization	5
Adherence to Professional Standards	4

Students' reflections on their drafts revealed a balanced perspective, highlighting both accomplishments and areas in need of improvement. A prominent strength noted by 9 out of 16 groups was clarity and structure in their reports. Group 4 emphasized, 'The experiments are replicable from the details and pictures in the method', showcasing their commitment to ensuring

transparency and accuracy in their documentation. Similarly, Group 5 highlighted their adherence to academic conventions, stating, 'We have an appropriate structure for a technical report', and commended the logical flow between sections.

Despite these strengths, students were candid about the challenges they faced. Inconsistencies in writing style due to multiple contributors were identified by 6 out of 16 groups. Group 6 observed that 'clashing writing styles' were evident in their draft, necessitating revisions to unify the tone and format. Group 5 identified informal terms, such as 'eyeballed', that needed to be replaced with more precise language to align with the scientific rigor required for their reports.

Time management and depth of analysis were frequent areas of concern for seven out of 16 groups. Group 11 reflected that 'some concepts, such as subweep parameters, have not been explained', indicating a gap in their theoretical coverage. Group 3 similarly admitted that their discussion lacked depth, stating that it 'has not been fully developed' and required further effort to critically analyze the results. These challenges were often linked to tight deadlines and competing priorities, which hindered the completion of certain sections.

Data presentation and visualization were also highlighted as areas for improvement by 5 groups. Group 7 questioned whether their figures were effectively integrated into the report, reflecting, 'Is having three pictures side by side in the results good, or do we have to reconsider how we best present the results?'. Such reflections demonstrate students' awareness of the importance of clear and engaging visual communication in technical reports.

Adherence to professional standards was another focal point, with four out of 16 groups emphasizing the need for compliance with academic conventions. Group 8 acknowledged that their draft required further verification to comply with IEEE standards, while Group 2 noted inconsistencies in referencing and emphasized the need for improvement. These reflections underscore students' commitment to ensuring their work meets academic and professional expectations.

Overall, these reflections illustrate students' ability to critically evaluate their work, recognizing strengths such as structure and teamwork while addressing weaknesses like coherence, time management, and adherence to standards.

Students' reflections on the pedagogical approach

The following Table 8 summarizes the distribution of student reflections on the pedagogical approach:

Table 8. Frequency of students' reflections on the pedagogical approach.

Reflection Theme	Number of Groups (out of 16)
Recognition of Achievements	9
Challenges in Collaborative Work	7
Value of Student-Led Dialogue	10
Refinement of Questions After Initial Feedback	8
Time Management Challenges	6

Students' reflections on the pedagogical approach revealed an intriguing mix of awareness, challenges, and growth. Many students were not only critical of their shortcomings but also took pride in recognizing their achievements. Nine out of 16 groups acknowledged their ability to produce well-structured sections or employ effective visual aids. This self-recognition often boosted their confidence and encouraged them to ask for further feedback. As one student reflected, 'Seeing that we got the method section right by all standards made me feel like I can focus on polishing the discussion without being overwhelmed'.

The collaborative nature of the task presented unique challenges, with 7 groups reporting difficulties in distinguishing individual contributions within group work. This made it awkward for some students to ask for feedback on parts they did not personally draft. One student candidly noted, 'It's tricky to ask about another person's section because you don't want to seem like you're criticizing their work unfairly but it is also part of my work so I don't know'. This sensitivity highlights the nuanced social dynamics in FSB on collaborative projects, underscoring the need for explicit training in collaborative feedback etiquette.

A key insight from student reflections was the value of student-led dialogue, with ten groups emphasizing how engaging in teacher-led tutorials encouraged them to ask additional questions they had previously overlooked. 'It's like magic', one student said. 'When the teacher started answering all the questions that we asked, I wanted to ask even more'. Many groups reported continuing to refine their questions after receiving initial feedback, a theme identified in eight groups. One student explained, 'The tutorials didn't just give us answers, they made us think about how to ask better questions next time and helped us look at our texts in a different way'. This phenomenon highlights the value of blending structured feedback-seeking practices with spontaneous, interactive moments that trigger new insights.

Despite these successes, time management remained a persistent challenge for six groups. Students acknowledged that juggling multiple priorities often limited their ability to fully incorporate feedback or refine their drafts. One group humorously noted, 'Deadlines are like speed bumps—they slow you down just enough to notice the dents but not enough to fix them all'. This suggests that while feedback-seeking activities were beneficial, they also added an extra burden to the curriculum.

These reflections underscore the dynamic interplay between structured activities and natural, dialogic interactions in fostering effective FSB. By integrating these elements into the curriculum, the pedagogical approach encourages students to take ownership of their learning, transitioning from passive recipients of feedback to proactive agents in their academic development.

Discussion

The findings of this study highlight the multifaceted nature of FSB as a SRL strategy in STEM undergraduate higher education. By systematically integrating FSB into the curriculum, students were not only able to refine their academic writing but also develop critical lifelong learning skills. The thematic analysis underscores the importance of providing structured opportunities for FSB while recognizing the inherent challenges associated with this practice.

RQ1: what are the students' practices at each stage of the feedback-seeking pedagogical model?

During the feedback monitoring phase, students primarily identified issues related to clarity and specificity, structure and organization, and formatting and presentation, suggesting a strong focus on communicative aspects rather than technical content. Fewer students recognized gaps in methodological detail, theoretical depth, or ethical considerations, indicating that while they could pinpoint structural weaknesses, higher-order concerns received less attention. This suggests that while feedback monitoring was effective in fostering self-evaluation, further scaffolding may be needed to encourage students to engage more deeply with content-related feedback.

In the feedback inquiry phase, students sought different types of feedback from peers and teachers, demonstrating a strategic approach to feedback-seeking. Peer feedback inquiries focused on structural clarity, language and tone, and technical accuracy, reflecting an emphasis on readability and presentation. In contrast, teacher feedback inquiries addressed clarity of introduction and scope, methodological transparency, and theoretical framework adequacy, indicating that students turned to teachers for conceptual and methodological validation. These findings could be

interpreted in two ways: either students developed more effective feedback-seeking strategies over time, or they inherently trusted teachers more for high-stakes feedback. The former is more plausible, given that feedback monitoring did not initially reveal such distinctions, suggesting that students refined their approach as they progressed through the course. Regardless, this highlights the developmental nature of FSB and underscores the importance of sustained exposure to structured feedback-seeking opportunities throughout students' academic journeys.

RQ2: what are the perceived challenges and benefits of feedback-seeking in project-based collaborative projects?

This model of feedback-seeking shifts the locus of power to students, challenging traditional assumptions that teachers are always the primary guides in the learning process (Jeffery and Halcomb-Smith 2020). By taking ownership of their learning, students became more independent, capable of self-regulating, and adept at observing areas for improvement. Through their FSB, students developed a growth mindset (Papi et al. 2019), as reflected in their increased tendency to ask more questions and create additional opportunities to learn.

Despite these successes, the study also revealed persistent challenges in feedback-seeking. Collaborative work often posed difficulties, particularly in delineating individual contributions and addressing face-threatening scenarios. Students expressed hesitation in critiquing peers' sections due to concerns about overstepping boundaries. Additionally, time management emerged as a recurring issue, with several groups admitting that tight deadlines limited their ability to fully engage in the feedback-seeking process. These findings reflect broader challenges in SRL research, where balancing multiple demands can hinder students' ability to engage deeply with learning. Future implementations of this pedagogical approach could incorporate clearer guidelines for peer collaboration and structured support to ensure more equitable participation.

The iterative nature of FSB, as observed in this study, underscores the dynamic interplay between guidance and autonomy. Structured feedback-seeking activities allowed students to identify specific areas of improvement. However, the analysis also highlighted the value of natural, less-structured feedback moments. For instance, students noted that engaging in dialogue often triggered new insights, suggesting the need to complement organized feedback activities with spontaneous, dialogic interactions.

Based on the findings of this study, one potential enhancement to the pedagogical model is to place greater emphasis on the quality of feedback-seeking behaviour. This can be achieved through self-assessment, allowing students to reflect on the effectiveness of their feedback inquiries and monitoring strategies. Additionally, incorporating multiple episodes of feedback monitoring throughout the course, rather than limiting it to the initial stage, would ensure continuous exposure to performance expectations. By reinforcing feedback monitoring at different points in the learning process, students may develop a more refined approach to seeking and utilizing feedback, ultimately enhancing the quality and impact of their FSB.

This study's pedagogical model for FSB has broader implications for higher education. Although implemented in a first-year STEM course, the structured approach to feedback inquiry and monitoring can be adapted to various disciplines and educational levels. The model's emphasis on self-regulated learning, student autonomy, and active engagement with feedback aligns with contemporary educational practices that value learner-centered approaches. Future research could explore how this model functions in different academic contexts, further supporting its relevance to higher education in general.

Limitations and future research

This study has several limitations. While students engaged with technical feedback during meetings with the technical teacher, no observations or recordings were collected from these

interactions. Consequently, the study cannot fully assess how students sought and applied feedback on scientific content. Future research should examine how FSB evolves across both technical and writing-focused interactions to provide a more comprehensive understanding of student engagement with different feedback types.

Additionally, future studies could explore how students' FSB align with teachers' assessments of their academic writing. Comparing students' feedback priorities with teacher evaluations would help identify gaps in self-assessment and determine whether students focus on the most critical areas for improvement. Tracking feedback-seeking trends alongside teacher evaluations could refine pedagogical strategies and support the development of more targeted interventions to improve students' self-assessment skills.

Conclusion

The findings of this study highlight the critical role of feedback-seeking in fostering self-regulation and improving learning in STEM undergraduate education. Students demonstrated significant progress in their ability to engage with feedback actively, but challenges such as time management and the complexities of collaborative work persist. Addressing these challenges requires a dual approach: structured feedback-seeking activities to provide clear guidance and natural, dialogic feedback opportunities to encourage deeper engagement.

Future pedagogical strategies should focus on enhancing students' time management skills and providing practical tools for integrating theoretical concepts into applied projects. Furthermore, fostering an environment that normalizes constructive peer critique and reduces the perceived costs of FSB can help mitigate challenges associated with collaborative work. By prioritizing both organized and natural feedback interactions, educators can empower students to use feedback as a powerful tool for academic and professional growth.

Disclosure statement

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