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Exploring the Role of Reflective Learning in Fostering Self-Directed Learning among Engineering Students

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Abstract

Engineering education increasingly emphasizes the cultivation of self-directed learning (SDL) as a core graduate capability. Reflective learning, which enhances metacognitive awareness and learner autonomy, has been shown to support SDL in experiential contexts, yet its role in mathematically intensive technical courses remains underexplored, particularly within African universities. This study examined how reflective learning journals support emerging self-directed learning behaviors among undergraduate engineering students enrolled in a Digital Signal Processing (DSP) course at a public university in East Africa. Guided by constructivist learning theory, Schön's reflective practice, and Garrison's SDL model, the study employed a qualitative case study design. Sixteen students from two engineering programs in Biomedical and Electrical completed weekly reflective journals across 12 weeks of a 15-week semester. Data were analyzed thematically using a reflexive framework. Findings revealed that reflective journaling enabled students to articulate their understanding of key course concepts, surface learning gaps, and plan purposeful learning actions that signal emerging SDL behaviors such as self-monitoring and strategy selection. Students described strategies such as revisiting prior materials, engaging with online resources, and using computational tools, demonstrating growing autonomy and self-regulation. Differences across cohorts were shaped more by depth of engagement and prior experiences than academic level. Therefore, embedding structured reflection within technical courses can strengthen metacognitive awareness and learner autonomy without displacing disciplinary rigor. These insights contribute to engineering education scholarship by highlighting the pedagogical value of reflection in analytically demanding contexts and offering practical guidance for integrating reflective practices to promote SDL in diverse and resource-constrained environments.

Keywords: reflective learning; self-directed learning; engineering education; digital signal processing; metacognition

1. Introduction

Engineering graduates are increasingly expected to demonstrate autonomy, adaptability, and the capacity for lifelong learning in response to rapidly evolving technological, economic, and professional demands [1], [2]. Contemporary engineering practice requires graduates not only to apply disciplinary knowledge, but also to independently identify knowledge gaps, seek out new information, and adapt learning strategies in unfamiliar contexts. These expectations have intensified calls for engineering education to deliberately cultivate self-directed learning (SDL) within undergraduate curricula as a core graduate capability rather than an incidental outcome of study.

SDL is commonly defined as a process in which learners take responsibility for diagnosing their learning needs, formulating goals, identifying appropriate resources and

strategies, and evaluating learning outcomes [3], [4]. While SDL has been widely recognised as essential for lifelong learning, research suggests that its development cannot be assumed, particularly within technically intensive courses where instructional priorities often emphasise content coverage, procedural fluency, and summative assessment performance [5], [6]. In such contexts, students may succeed academically while remaining dependent on instructor guidance and externally imposed learning structures.

Reflective learning has been identified as a pedagogical approach with potential to support SDL by fostering metacognitive awareness, learners' capacity to monitor, evaluate, and regulate their own learning processes [7], [8]. Through reflection, students are encouraged to make their thinking visible, interrogate conceptual understanding, and plan purposeful learning actions. Prior research in engineering education has shown that reflective activities can enhance conceptual understanding, promote deeper learning, and support professional identity development, particularly in design-based and experiential learning contexts such as capstone projects, internships, and service learning [9], [10].

However, reflective practices remain relatively underexplored in mathematically intensive core courses, such as Digital Signal Processing (DSP), where abstract concepts, symbolic representations, and cumulative knowledge demand present distinct learning challenges. This gap is especially pronounced in African higher education contexts, where large class sizes, resource constraints, and highly structured curricula may limit opportunities for formative feedback and learner-centred pedagogies [11], [12]. As a result, there is limited empirical evidence on how reflective learning might support SDL within technically demanding courses that form the backbone of engineering programmes.

Responding to this gap, this study examines the role of reflective learning journals in fostering SDL among undergraduate engineering students enrolled in a DSP course at a public university in East Africa. Specifically, the study explores how students use reflection to articulate conceptual understanding, recognise learning gaps, and adopt intentional strategies for improvement. By foregrounding students' reflective accounts, the study contributes contextually grounded insights into how reflective practices can be meaningfully integrated into core technical courses to support emerging SDL behaviours. This study serves as a foundational effort to introduce reflective learning practices within the College of Engineering and to inform future pedagogical integration of reflection across technical courses.

2. Research Questions

This study addressed the following research questions

a) How do engineering students use reflective learning journals to articulate their understanding of concepts in a Digital Signal Processing (DSP) course?
b) In what ways do reflective journal entries help students identify and address gaps in their learning?

c) How do students describe the strategies they adopt to enhance self-directed learning through reflection within a technical course context?

3. Positionality Statement

This study was conducted by two engineering educators with a shared interest in improving teaching and learning in engineering education within a developing country context. One researcher served as the instructor of record for the Digital Signal Processing course and has over a decade of experience teaching engineering courses in this classroom context. His role provided deep contextual understanding of course structure, curricular demands, and student learning challenges.

The second researcher is an engineering graduate from the same institution who is currently pursuing graduate studies in engineering education. She brings lived experience as a former student in similar instructional environments where structured reflection wasn't emphasized, informing her sensitivity to students' learning experiences and engagement with reflective practices.

Throughout the analysis, the researchers engaged in reflexive memoing and ongoing analytic discussions to critically examine assumptions, interpretations, and positional influences during theme development

4. Theoretical Framework

This study is grounded in constructivist learning theory, which conceptualises learning as an active process of meaning-making shaped by prior knowledge, experience, and reflective engagement [13]. From a constructivist perspective, understanding is not transmitted directly from instructor to student but is constructed through interaction with content, tasks, and reflective opportunities. Reflection plays a critical role in this process by enabling learners to examine assumptions, integrate new information, and reorganise existing knowledge structures.

Schön's theory [7] of reflective practice provides a foundational lens for understanding how reflection supports learning through deliberate consideration of experience. Reflection allows learners to move beyond procedural engagement toward deeper conceptual understanding by making sense of successes, difficulties, and unexpected outcomes. In educational contexts, reflective writing has been shown to support metacognitive processes, including planning, monitoring, and evaluation processes that are central to effective learning in complex domains [8], [14].

To explicitly conceptualise learner autonomy, the study further draws on Garrison's model [3] of self-directed learning, which frames SDL as the integration of three interrelated dimensions: self-management (control of learning resources and context), self-monitoring (metacognitive awareness and reflection), and motivation (learner willingness to assume responsibility for learning). Within this framework, reflection

functions as a key mechanism through which learners monitor understanding, identify gaps, and make informed decisions about learning strategies.

By integrating constructivist learning theory, reflective practice, and Garrison's SDL model, this study conceptualises reflective learning journals as pedagogical tools that mediate the development of SDL within a technical course context. This integrated framework informs both the study design and analysis by guiding attention to how students' reflections reveal conceptual sense-making, metacognitive awareness, and intentional learning actions.

In this study, SDL-related behaviors were inferred from reflective evidence of (i) *self-monitoring* (naming misconceptions, uncertainty, or confidence), (ii) *self-management* (planning learning actions, selecting resources, organizing study), and (iii) *motivation* (expressed commitment, persistence, or value placed on improvement). These indicators sensitized interpretation while preserving inductive theme development.

5. Methodology

5.1 Course Context

The study was conducted in a Digital Signal Processing (DSP) course offered to Year 3 and Year 4 engineering students at a public university in East Africa. The course serves students from multiple engineering programmes and covers core DSP topics, including discrete-time signals and systems, sampling and reconstruction, convolution, frequency analysis, and transform methods. These topics are widely recognised as conceptually demanding due to their abstract mathematical representations and reliance on cumulative prior knowledge [15].

To support learning in this challenging context, reflective learning journals were introduced as a structured instructional activity. Students were provided with guiding prompts that encouraged them to reflect on (a) key concepts learned, (b) areas of difficulty or confusion, and (c) strategies they planned to adopt to improve understanding. Importantly, reflective journaling was framed as a learning tool rather than an assessment of correctness, with the intention of creating space for honest self-evaluation and metacognitive engagement. In addition to journaling, tutorials and class discussions were used to address common learning gaps identified during instruction, although only voluntarily submitted weekly journals were included as research data.

5.2 Research Design

This study adopted a qualitative case study design to explore how reflective learning journals foster self-directed learning (SDL) in a mathematically intensive Digital Signal Processing (DSP) course. A case study approach was appropriate given the focus on understanding students' meaning-making processes rather than measuring predefined outcomes [16].

The study was guided by constructivist learning theory, Schön's reflective practice, and Garrison's SDL model. These frameworks informed the design of reflective prompts, the interpretation of student reflections, and the thematic analysis of data. This integration provided pedagogical scaffolding for iterative reflective engagement within the course, which was later synthesized in the data-derived conceptual model.

5.3 Participants and Cohort Demographics

Although 85 students were enrolled across both cohorts, 16 students volunteered to participate in the study, completing weekly reflective journals across 12 weeks of a 15-week semester accounting for 19% of the class enrolment. Table 1 summarizes the demographic distribution of the two cohorts and indicates the number of students who voluntarily submitted reflective journals for research analysis. The distribution of volunteers broadly reflected the program composition of the cohort. Participation was voluntary, and the study was not designed for demographic representativeness.

Table 1: Cohort Demographics (Enrolled Students) and volunteer participants

Cohort	Number of Students	Female Students	Male Students	Volunteer Participants (n=16)
EEE4 (Year 4 electrical & electronic engineering)	73	21	52	12 (8 males, 4 females)
BME3 (Year 3 biomedical engineering)	12	5	7	4 (1 male, 3 females)
Overall Enrolment	**85**	**26**	**59**	**16**

5.4 Data Collection

Data consisted of weekly reflective journal entries submitted by participants over 12 weeks. Prompts encouraged students to articulate key DSP concepts, identify challenges, evaluate confidence, describe learning strategies, and connect learning to future practice. Although class discussions and informal group interactions formed part of the instructional context, only students' weekly reflective journal entries were collected and analyzed as research data in this study.

The reflective journal prompts were intentionally designed to elicit evidence of conceptual understanding, learning challenges, confidence evaluation, and planned learning strategies, supporting analytic attention to patterns of conceptual articulation, gap identification, and strategy adoption.

Data collection was conducted by the tutorial assistant rather than the course instructor. The tutorial assistant collected handwritten reflective journals at the end of each class session while the instructor was not present and responded to any student questions or concerns related to the reflections. Students were informed about the study through a brief in-class announcement and written instructions explaining the purpose of the reflections and the voluntary nature of journal submission for research use. Participation was voluntary, reflections were not graded for correctness, and all journal entries were anonymized prior to analysis.

Although reflective journals were not graded for correctness, engagement was supported through structured weekly prompts aligned with course topics. Students were encouraged to identify learning challenges and outline strategies for improvement in subsequent weeks. Recurring learning difficulties identified through reflections informed brief tutorial clarifications at cohort level, enabling students to revisit concepts and adjust learning strategies. This approach supported authentic reflection and self-monitoring rather than performance-oriented responses.

Ethics and consent. The reflective journaling activity was originally implemented as a pedagogical initiative intended to support student learning within normal course delivery rather than as a research intervention. As such, formal institutional ethics approval was not required at the time of implementation. When the decision was later made to analyse the journals for research purposes, students were informed that submission of journals for research analysis was voluntary and separate from course requirements, and that participation would not affect grading or course standing. Students provided informed consent for the use of their reflections in anonymized form. All data were de-identified prior to analysis and reported only in aggregated or anonymized form. This approach was intended to reduce perceived pressure, support honest student reflection, and mitigate instructor influence on participation or responses.

5.5 Data Analysis and Trustworthiness

A reflexive thematic analysis approach [17] was employed. Analysis involved iterative cycles of:

- Familiarization with the data,
- Initial coding of meaning units,
- Development of candidate themes, and
- Refinement through researcher reflexivity.

Consistent with reflexive thematic analysis, theme development was led by interpretive engagement with the dataset; the independent coding process was used as a structured check on coding consistency and to support transparent discussion of coding decisions, rather than to claim objectivity.

To enhance analytic rigor, two independent coders conducted the initial coding using a shared coding framework. As a transparency check, both coders independently coded an initial subset of the dataset in a single round, and inter-coder agreement was calculated

using percentage agreement. This process yielded an agreement of 84%, indicating substantial consistency in code application. Discrepancies were discussed through an iterative consensus process, leading to refinement of code definitions and alignment in interpretation. Following this calibration step, the refined coding framework was applied to the full dataset. This approach strengthened the trustworthiness of the analysis by combining reflexive thematic interpretation with systematic checks for coding consistency. A summary of the coding framework and inter-rater reliability process is provided in Appendix B.

Theoretical concepts related to metacognition and self-directed learning were used as sensitizing lenses during interpretation, supporting analytic attention to patterns of conceptual articulation, gap identification, and strategy adoption without predetermining thematic categories.

6. Findings

Analysis of students' reflective journals revealed three interrelated themes: (1) articulation of conceptual understanding, (2) identification of learning gaps, and (3) adoption of intentional learning strategies. Together, these themes illustrate how reflective journaling supported metacognitive engagement and emerging self-directed learning behaviours within a technically intensive DSP course.

6.1 Articulation of Conceptual Understanding

Students frequently used reflective journals to articulate their understanding of DSP concepts by explaining ideas in their own words, summarising mathematical relationships, and linking abstract representations to system behaviour across most participants. Rather than reproducing lecture notes, many students demonstrated active sense-making as they reflected on topics such as sampling, convolution, frequency representation, and transform methods.

For example, one student explained their understanding of sampling and reconstruction as follows:

> *"From module one, I understood the basic elements of digital signal processing systems, the steps of digitisation from A/D conversion, and the need to balance between sampling rate and bit depth in order to maintain signal fidelity." (Student 3, Year 3)*

Similarly, students reflected on transform-based analysis by articulating how theoretical constructs support system interpretation:

> *"I learned that the Z-transform is essential in analysing discrete-time signals because it allows us to determine system properties like stability and causality through the region of convergence." (Student 7, Year 4)*

These excerpts indicate that reflection provided a space for students to consolidate conceptual understanding by translating formal mathematical ideas into coherent explanatory narratives. Such articulation reflects active knowledge construction rather than surface-level engagement.

6.2 Identification of Learning Gaps

A prominent feature across the reflections was students' explicit identification of learning gaps, reported across both cohorts. Many students openly acknowledged concepts they found difficult, particularly those involving abstract reasoning, such as frequency interpretation, convolution, correlation, and the Z-transform.
One student noted challenges related to frequency concepts:

> *"I did not understand the concept of frequency in continuous-time and discrete-time signals, especially how angular frequency differs from frequency measured in hertz." (Student 2, Year 3)*

Another student reflected on difficulties with convolution and system analysis:

> *"The content became complex to digest, especially the difference between convolution and correlation. I realised that I could apply formulas but did not fully understand what was happening conceptually." (Student 5, Year 4)*

These reflections demonstrate metacognitive monitoring, as students critically evaluated their own understanding rather than assuming mastery based on task completion. The willingness to explicitly name areas of confusion suggests that reflective journaling supported honest self-assessment, a core component of self-directed learning.

6.3 Planning and Adoption of Learning Strategies

Beyond identifying learning gaps, students frequently described intentional strategies they planned to adopt to improve their understanding with variation in depth and specificity across participants. These strategies included revisiting course materials, engaging with online resources, practising additional problems, and using computational tools to visualise signals.

For instance, one student explained:

> *"To address my learning gaps, I decided to engage with online content such as YouTube videos and revisit previous course units so that I can strengthen my foundation in DSP concepts." (Student 4, Year 3)*

Another student described using practical tools to support understanding:

> *"I plan to engage in Python practice to help me visualise systems and better understand concepts like convolution and system response." (Student 9, Year 4)*

These excerpts illustrate how students moved from recognising difficulties to planning concrete learning actions, reflecting key dimensions of SDL such as goal setting, strategy selection, and self-regulation. Importantly, these strategies were self-initiated rather than instructor-directed, indicating growing learner autonomy.

Across the dataset, reflective journals functioned as more than descriptive accounts of course content. They provided a structured space through which students articulated understanding, monitored learning progress, and planned actions to address identified challenges.

6.4 Integrative Synthesis: Reflective Learning Processes Supporting Emerging Self-Directed Learning

Figure 1 presents an integrative synthesis of the findings, illustrating how structured reflective journaling functioned within the Digital Signal Processing (DSP) course to support emerging self-directed learning behaviours. As shown, repeated engagement with structured reflection prompts (Reflection 1 through n) supported an iterative reflective learning process in which students articulated their conceptual understanding, identified learning gaps, and planned and adopted learning strategies.

These reflective learning processes were underpinned by metacognitive processes of monitoring, evaluation, and planning, enabling students to make their learning visible and regulate it more intentionally over time. Through this iterative process, students demonstrated emerging self-directed learning behaviours, including increased self-monitoring, more intentional strategy selection, and greater learner autonomy. The model is data-derived and does not propose a causal sequence; rather, it offers a conceptual synthesis of how reflective journaling supported learning regulation within a mathematically intensive engineering course.

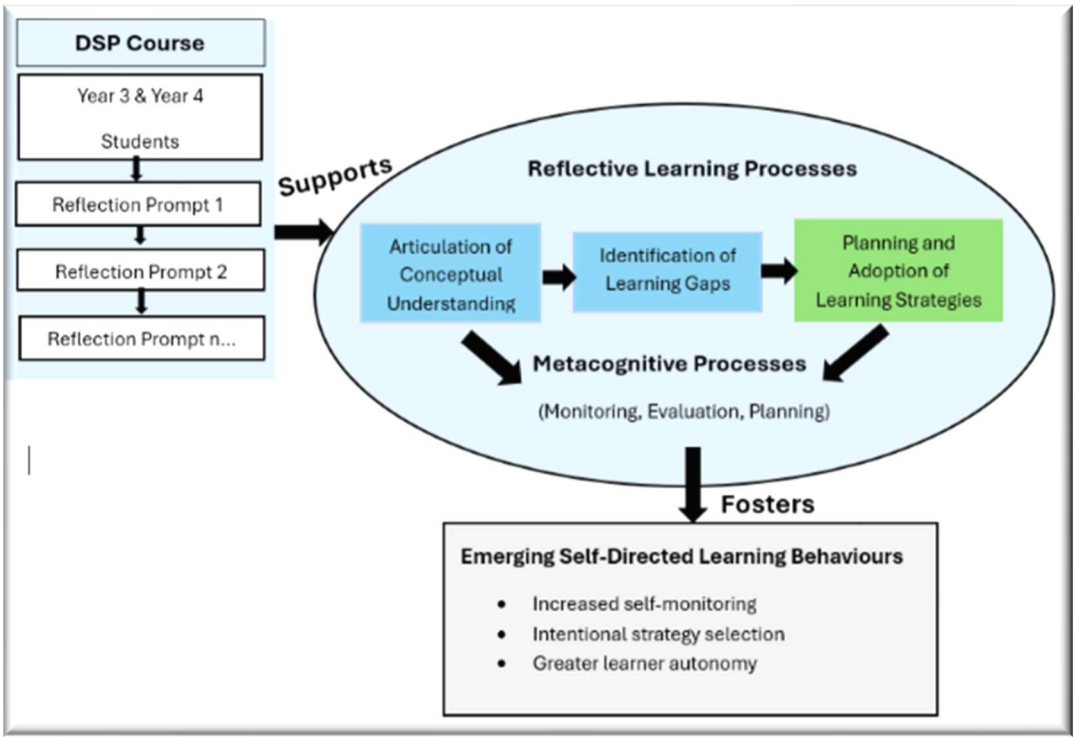

Figure 1: Data-derived conceptual synthesis of reflective learning processes supporting SDL

7. Discussion

The conceptual model in Figure 1 provides a unifying lens for interpreting how instructional design, reflective learning processes, and metacognitive regulation connect to the emerging self-directed learning behaviors identified in this study. Taken together, these reflective practices signal emerging self-directed learning behaviors and highlight the pedagogical value of reflective journaling within a mathematically intensive engineering course.

Building on this synthesis, the discussion interprets how reflective learning journals supported students' articulation of conceptual understanding, identification of learning gaps, and planning and adoption of learning strategies, and considers how these processes align with constructivist learning theory, Schön's reflective practice, and Garrison's model of self-directed learning [7], [3].

7.1 Reflection as a Mechanism for Conceptual Sense-Making in DSP

The first key finding indicates that reflective journaling supported students' ability to articulate and consolidate conceptual understanding in DSP. By explaining concepts such as sampling, convolution, and transform-based analysis in their own words, students engaged in active meaning-making rather than passive reproduction of content. From a constructivist perspective, this process reflects learners' active construction of knowledge through reflection on experience and engagement with abstract material.

This finding extends prior research on reflection in engineering education, which has largely focused on design-based or experiential learning contexts [9], [10]. The present study demonstrates that reflective practices can also play a meaningful role in analytical, mathematically intensive courses, challenging assumptions that reflection is less relevant in such settings. In DSP, where conceptual understanding often develops incrementally and abstractly, reflective writing appeared to provide a cognitive space for students to integrate mathematical formalisms with conceptual interpretation.

7.2 Metacognitive Awareness and the Identification of Learning Gaps

A central contribution of this study is the evidence that reflective journaling supported students' metacognitive awareness through explicit identification of learning gaps. Students frequently acknowledged difficulties with abstract concepts such as frequency interpretation, convolution, and Z-transform properties. This willingness to articulate uncertainty reflects self-monitoring, a core dimension of SDL in Garrison's model [3]. Rather than viewing difficulty as failure, students used reflection to diagnose limitations in understanding, suggesting a shift toward more sophisticated learning orientations. This finding aligns with research highlighting the importance of metacognition in supporting learning in STEM disciplines [8], [14]. In the context of DSP, where procedural competence can mask conceptual misunderstanding, reflective journaling appeared to surface misconceptions that might otherwise remain hidden.

7.3 Reflection and the Development of Intentional Learning Strategies

Beyond recognising learning gaps, students' reflections revealed the adoption of intentional strategies aimed at improving understanding. These strategies included revisiting course materials, engaging with online resources, practising additional problems, and using computational tools to visualise signals. Such actions reflect self-management and self-regulation, key components of SDL [3], [4].

Importantly, these strategies were largely self-initiated rather than instructor-directed, indicating growing learner autonomy. This finding supports prior work suggesting that reflective activities can prompt learners to take ownership of their learning processes [5] and extends this insight to a core technical engineering course.

The results suggest that reflection can function as a bridge between recognising difficulty and taking purposeful action, thereby supporting the development of lifelong learning capacities.

7.4 Student Preparedness and Engagement with Reflection

Consistent with reviewer expectations, the findings also offer insight into students' preparedness and attitudes toward reflective learning. While some students initially expressed uncertainty or difficulty engaging with reflection, many demonstrated

increasing depth over time, suggesting that reflective capacity itself can develop through structured practice. This highlights the importance of scaffolding reflective activities, particularly in contexts where students may have limited prior exposure to reflective learning.

Taken together, these findings suggest that reflective learning can be meaningfully integrated into analytically rigorous engineering courses, extending reflection research beyond predominantly design- and experience-based contexts.

8. Limitations

This study has limitations that should be considered when interpreting the findings. The small sample size (16 participants) limits generalizability, and voluntary participation may have introduced self-selection bias. Reliance on self-reported reflections may not fully capture actual learning behaviors. While inter-rater coding enhanced reliability, thematic interpretation remains subject to researcher reflexivity. These limitations underscore the need for caution in extrapolating results, while also highlighting the value of contextually grounded insights for engineering education practice.

9. Implications for Engineering Education Practice

The findings of this study have several implications for engineering educators and curriculum designers. First, embedding structured reflective journaling within core technical courses can support the development of SDL without displacing essential disciplinary content. Reflection does not need to be confined to design projects or experiential placements; it can be meaningfully integrated into analytically rigorous courses such as DSP.

Second, the design of reflective prompts matters. For example, a weekly prompt could ask: *What DSP concept felt most unclear this week, what specifically confused you, and what one action will you take before next class to address it?* Prompts that explicitly encourage students to articulate understanding, identify learning gaps, and plan learning strategies are more likely to support metacognitive engagement and learner autonomy. Educators should consider aligning reflective activities with learning outcomes related to problem-solving, conceptual understanding, and lifelong learning. Example reflective prompts used in this study are provided in Appendix A to support adaptation by other engineering educators.

Third, reflective journaling represents a scalable pedagogical approach, particularly relevant in resource-constrained contexts. Unlike intensive one-on-one feedback, reflective activities can be implemented with minimal additional resources while still promoting deep learning and self-regulation.

10. Conclusion

This study examined the role of reflective learning journals in supporting self-directed learning among undergraduate engineering students in a Digital Signal Processing course at a public university in East Africa. The findings demonstrate that students' articulation of conceptual understanding, recognition of learning gaps, and adoption of intentional learning strategies are key indicators of emerging self-directed learning behaviors.

By extending reflective learning research into a mathematically intensive engineering course, this study contributes to engineering education scholarship by demonstrating the pedagogical value of reflection beyond traditionally experiential contexts. The findings underscore the potential of reflective journaling as a practical and effective approach for supporting learner autonomy and metacognitive development within core technical curricula.

In an era where engineering graduates must continually adapt to evolving professional demands, fostering self-directed learning within undergraduate education is essential. These findings should be interpreted in light of the small, self-selected sample and the use of reflective self-report data within a single course context. This study demonstrates that reflective learning can function as a pedagogical bridge between conceptual understanding and learner autonomy within analytically demanding engineering contexts. This study offers evidence that reflective learning practices can play a meaningful role in achieving this goal, particularly within diverse and resource-constrained educational settings.

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Appendix A: Reflective Journal Prompts Supporting Self-Directed Learning

The reflective journal prompts used in this study were designed to operationalize key dimensions of self-directed learning by encouraging students to monitor understanding, identify learning gaps, select learning strategies, and plan subsequent actions. The prompts reflect the study's conceptual framing of reflective learning as a mechanism through which metacognitive awareness supports the development of self-directed learning behaviors. The examples below illustrate the structure of prompts used during the course and may be adapted by other engineering educators.

Prompt Purpose	**Example Reflective Prompt**	**SDL**
Concept articulation	In your own words, what was the main DSP concept you learned this week?	Self-monitoring
Identification of learning gaps	What concept or idea remains unclear to you, and why?	Self-monitoring
Strategy reflection	What did you do this week to improve your understanding?	Self-management
Planning next steps	What specific action will you take before the next class to address your learning challenge?	Self-management
Connection to practice	How might this concept be applied in engineering practice or future coursework?	Motivation

Appendix B1: Summary of Coding Framework

The thematic analysis was guided by a coding framework developed through iterative engagement with students' reflective journal entries. Codes were generated inductively from the data and interpreted using sensitizing concepts drawn from metacognition and self-directed learning (SDL). The framework supported consistent interpretation while ensuring that themes remained grounded in students' reflective accounts rather than predetermined categories.

Theme	**Description**	**Example Indicators in Data**	**Related SDL Dimension**
Articulation of conceptual understanding	Students explain DSP concepts in their own words or connect mathematical representations to conceptual meaning	Explaining sampling, convolution, or transform methods conceptually; linking mathematical expressions to system behaviour	Self-monitoring

Theme	Description	Example Indicators in Data	Related SDL Dimension
Identification of learning gaps	Students explicitly identify confusion, uncertainty, or incomplete understanding of concepts	Naming difficulty with frequency interpretation, convolution, or abstract signal representations; recognising misconceptions	Self-monitoring
Planning and adoption of learning strategies	Students describe intentional actions taken or planned to improve understanding	Revisiting lecture materials, consulting online resources, practising additional problems, or using computational tools to support learning	Self-management

Appendix B2: Inter-Rater Reliability Across Coding Rounds

To enhance transparency in the analytic process, inter-coder agreement was examined during early stages of coding. Both coders independently coded an initial subset of reflective journal entries using a shared coding framework. Coding differences were subsequently discussed to refine code definitions and consolidate themes prior to full analysis.

Coding Stage	Data Subset Coded	Purpose	Inter-Coder Agreement
Initial coding stage	Subset of reflective journals	Independent coding to identify differences and refine code definitions	84%
Final analysis stage	Full dataset	Application of refined and agreed coding framework	Maintained above acceptable agreement threshold

This process supported analytic rigor and transparency while remaining consistent with the interpretive principles of reflexive thematic analysis.