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A complexity-informed, feedback loop approach for systems analysis IT education at undergraduate and postgraduate levels

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Advancements in technology, complex student profiles and wide-ranging student learning needs impact feedback effectiveness. This conceptual study explored approaches to providing feedback among agents in a complex adaptive system (CAS), namely, students, staff, and learning technologies in systems analysis IT undergraduate and postgraduate courses across a 2.5-year timeframe. Pedagogical action research enabled iterative cycles of intervention and reflection. Quantitative and qualitative techniques facilitated data collection and analysis to understand feedback mechanism impacts on student outcomes. We identified a multi-faceted whole-of-course approach to facilitating feedback by categorising feedback loops across four levels: learner, instructional, staff, and system. Learner-level feedback consists of peer-to-peer and individual feedback mechanisms that support experiential learning. Instructional-level feedback involves intentional feedback provided by teaching staff to learners to guide progress. Staff-level feedback occurs via internal loops within the teaching team to improve instructional consistency, quality, and responsiveness to student learning needs. System-level feedback comprises course-based or institutional mechanisms that inform ongoing curriculum and learning design. This approach guides the understanding of the dynamic, reciprocal nature of feedback interactions in complex IT teaching environments, whilst applying graduate attributes and modelling industry practices, enabling educators to adapt to changes in teaching practices, learning needs and the IT industry.

Keywords: complex adaptive systems (CAS), feedback loops, information technology, systems analysis education

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Introduction and research aims

The teaching and learning landscape in STEM higher education is constantly evolving. Advances in technology have disrupted the traditional learning environment, impacting pedagogical approaches to learning delivery and authenticity. Students face ongoing challenges with comprehension, engagement, problem solving, and knowledge transfer across contexts. Evolving student profiles further complicate learning, with many balancing work and study commitments. A positive learning culture is required where students can ask questions and engage in intellectual discourse with peers and staff (Sorensen & Baylen, 2009). This culture is further strengthened by an evidenced-informed teacher presence supporting feedback (Morris et al., 2021) and engagement (Anderson, 2004).

To address the challenges within systems analysis information technology (IT) undergraduate and postgraduate courses, we have deconstructed the learning process to identify pain points and adapted our practices to include feedback loops at macro, meso, and micro levels (Fanghanel, 2007). Feedback loops allow students to establish improved concept understanding, achieve learning outcomes, demonstrate authentic learning, and transfer skills across scenarios (Carless, 2019; Nicol & Macfarlane-Dick, 2006).

This holistic feedback approach positions the classroom as a complex adaptive system (CAS) characterised by interconnected agents, adaptive and emergent learning environments, flexible teaching strategies, and alternative assessment models to capture emergent learning outcomes (North & Macal, 2007). STEM education exhibits these CAS characteristics through multiple interconnected agents, adaptation and feedback mechanisms, emergence, and decentralised and distributed controls (Holland, 2006). Our research aims to investigate effective feedback approaches among the agents (students, staff, learning technologies) within this CAS. The scope of this conceptual study includes systems analysis IT undergraduate and postgraduate courses across a 2.5-year timeframe.

Feedback is a “process through which learners make sense of information from various sources and use it to enhance their work or learning strategies” (Carless & Boud, 2018, p. 1315; Carless, 2019). Feedback can be formative (Shute, 2008) or summative, and typically encompasses four levels: task, process, self-regulation and self level (Hattie & Timperley, 2007). Task-level feedback refers to the extent to which tasks are understood and actioned. Process-level feedback refers to the steps needed to be actioned when attempting a learning task. Self-regulation feedback is concerned with the learner’s ability to manage their learning including attempting learning activities, assessments and actioning feedback (Nicol & Macfarlane-Dick, 2006). At the self level, feedback is personalised to the learner, their role and motivations. Feedback timing can be immediate or delayed (Shute, 2008). Effective feedback provides useful input through elaboration about the learning via its complexity, specificity and length (Shute, 2008) and is best embedded in feedback loops across the learning journey (Van der Kleij, 2013). Feedback loops interconnect three main components of the complex adaptive system in focus, namely students, staff and learning technologies.

The motivation for this study stems from a need to address the challenges described above whilst facilitating impactful learning. Viewing STEM education through a CAS lens encourages more responsive, holistic approaches. For example, by embracing diversity and differentiation within the feedback loop, educators can design flexible and differentiated learning pathways for learners of different backgrounds and capabilities. By encouraging adaptability and resilience, educators create environments that allow for experimentation, iteration, and learning from failure, mirroring the scientific and engineering processes in STEM itself. By promoting collaboration and networks, learning is enhanced when students, teachers, and external partners interact, share ideas, and co-create knowledge. By supporting emergence through inquiry and problem-based learning, students can engage with open-ended, real-world problems which offers opportunities to develop new knowledge and skills organically, rather than being rigidly prescribed.

Methods

This paper presents a conceptual analysis of feedback loops designed to promote effective learning in systems analysis IT undergraduate and postgraduate courses. Pedagogical action research was applied, enabling iterative cycles of intervention and reflection within the teaching context (Norton, 2019). A mixed methods approach was adopted for data collection and analysis, integrating both quantitative measures and qualitative insights to capture a comprehensive understanding of how feedback mechanisms impact student outcomes (Creswell & Creswell, 2023).

Student cohorts were included across multiple study periods. Table 1 summarises cohort size, teaching team size, assessment engagement, and pass rates.

Table 1: Cohort descriptors for each course across study periods (SP)

Attribute	Undergraduate				Postgraduate		
Cohort study periods	SP5 2023	SP2 2024	SP5 2024	SP2 2025	SP2 2023	SP2 2024	SP2 2025
Cohort size	226	101	209	76	22	71	43
Teaching team size	7	4	7	4	1	3	2
Engagement:							
Capstone submission rate	222/226	91/101	196/209	75/76	21/22	69/71	40/43
%	98.23	90.10	93.78	98.68	95.45	97.18	93.02
Course pass rate (%)	95.13	86.14	91.38	98.68	95.45	97.18	88.37

In this study, quantitative data explored the effectiveness of the feedback mechanisms, whilst qualitative data enabled us to understand the reasoning regarding the effectiveness of these feedback mechanisms and associated teaching team experiences. Both methods were well suited to this conceptual and exploratory study, as they allowed the researchers to explore approaches to effectively providing feedback among the agents interacting in this complex adaptive system.

Data analysis of qualitative responses (i.e. thematic analysis of survey feedback) commenced with coding to uncover distinct themes (Braun & Clarke, 2006; Tracy 2020) and was framed by student and staff perspectives to uncover views about the course, assessment, teaching delivery and general perceptions. No conflicting narratives were discarded. Only unusable narratives were discarded. Coding was performed manually over two iterations. Qualitative student perspectives and staff teaching reflections were triangulated with quantitative survey responses to validate data from multiple perspectives and provide data credibility. Participant statements from surveys were represented as is, with spelling errors corrected and the use of [] to denote missing words.

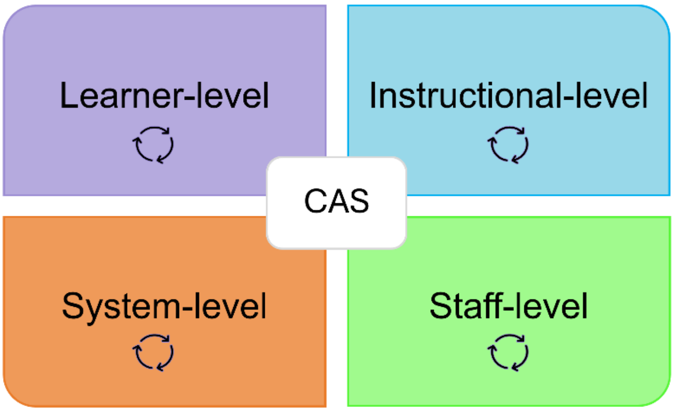
Data was collected in accordance with the University of South Australia's A-34 Policy on Access to UniSA students, staff and data, which states that evaluation data gathered internally can be included in external publications without formal ethics approval, provided the data was gathered online or in writing. Students provided data voluntarily, anonymously and were informed that "*Data collected through this questionnaire will be used to inform improvements at UniSA and could also be used in external publications and presentations. Individual responses will remain confidential, and no individuals will be identified.*"

Action research engages practitioners in a continuous cycle of inquiry. It offers opportunities for reflective practice, which allows for immediate and deferred actions and reflections via feedback mechanisms (Clegg et al., 2010; Timperley, 2009). Our iterative reflective practice identified opportunities to plan and explore different feedback mechanisms. These newly designed feedback mechanisms were implemented. We then reflected on the changes (i.e. the feedback loops) and if these feedback mechanisms needed adjustments. The study focused on the micro (educator) and the meso (IT, systems analysis, STEM education) domains.

Findings

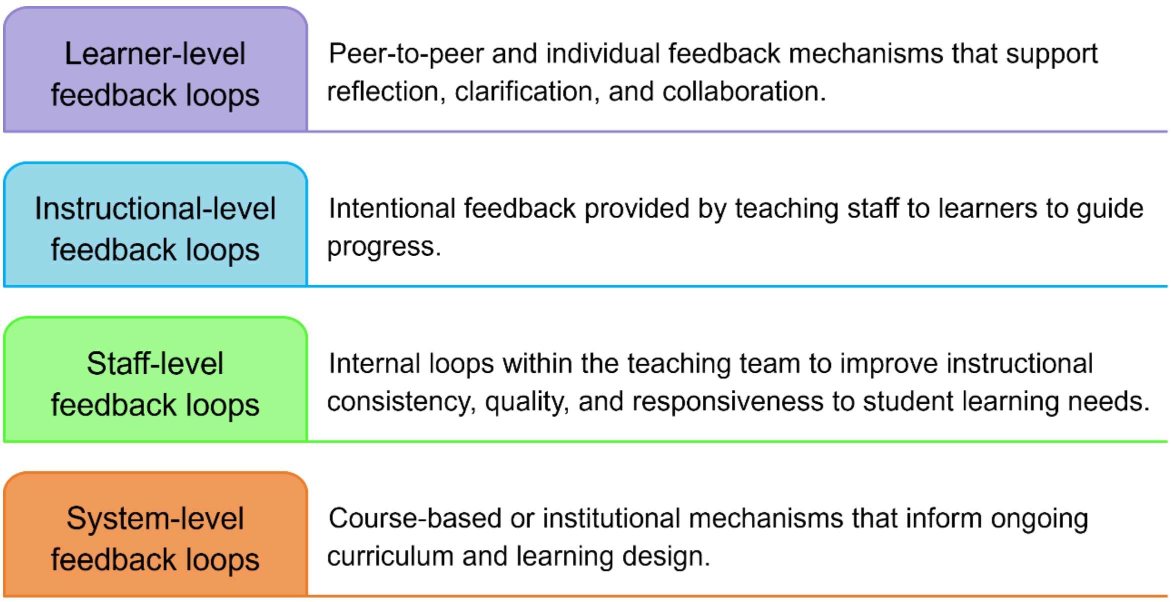
From our critical analysis and reflections, we propose a structured conceptual approach to facilitating feedback in systems analysis IT undergraduate and postgraduate courses. Feedback loops are categorised across four levels: learner, instructional, staff, and system, as shown in Figure 1.

Figure 1: Feedback loops applied in systems analysis IT undergraduate and postgraduate courses



The timing of feedback can be immediate or delayed. However, these feedback loops also provide mechanisms that cater to synchronous or asynchronous modes of learning, which acknowledge the complexity of systems that include multiple interconnected agents. Figure 2 presents the four feedback loop levels with definitions, illustrating their role in enhancing both student learning and instructional design.

Figure 2: Definition and role of feedback loop levels



Learner-level feedback loops

Learner-level feedback loops develop dialogue and collaborative critique that strengthen conceptual understanding, metacognitive awareness, and adaptive problem-solving, while enhancing learning and engagement. Examples include:

1. Students receive structured critique, peer review and revise documents.
2. Students perform self-assessments using rubrics and H5P knowledge checks (a free and open-source content collaboration framework which provides students the opportunity to self-review their learning).
3. Students provide real-time feedback on course learning experiences.

Instructional-level feedback loops

Instructional-level feedback loops provide immediate course correction and feedback that support active engagement, guide skill development, scaffold learning, and clarify expectations, enabling students to revise their artefacts and progress in their learning. We provide three examples used in our courses.

1. Instructors provide real-time verbal feedback during formative in-class activities.
2. Instructors use tools (such as OneDrive) for project-based learning activities to enable the provision of asynchronous feedback.
3. Instructors provide written and verbal feedback on summative checkpoint tasks and assignments.

Staff-level feedback loops

Staff-level feedback loops enable rapid course adaptation informed by in-class dynamics and student understanding, supporting iterative and responsive course design that promotes consistency, fairness, and continual professional development across the teaching team. Examples include:

1. Tutors provide feedback to the course coordinator on tutorial pain points.
2. Staff review major activity or assessment outcomes.
3. Staff record teaching reflections, challenges, and engagement levels in a shared platform.

System-level feedback loops

System-level feedback loops facilitate data-informed curriculum improvements that enhance teaching effectiveness, maintain equitable collaborative learning experiences, and support the longitudinal evolution of courses through accountability and quality assurance. Examples include:

1. Learning management system (LMS) data (e.g., quiz performance, reading engagement, onTask+ analytics) is analysed by instructors or auto-detection flags.
2. Feedback from previous cohorts allows for analysis of recurring issues.
3. Course review processes involving external moderation allow instructors to reflect on teaching approaches and learner outcomes.

Discussion

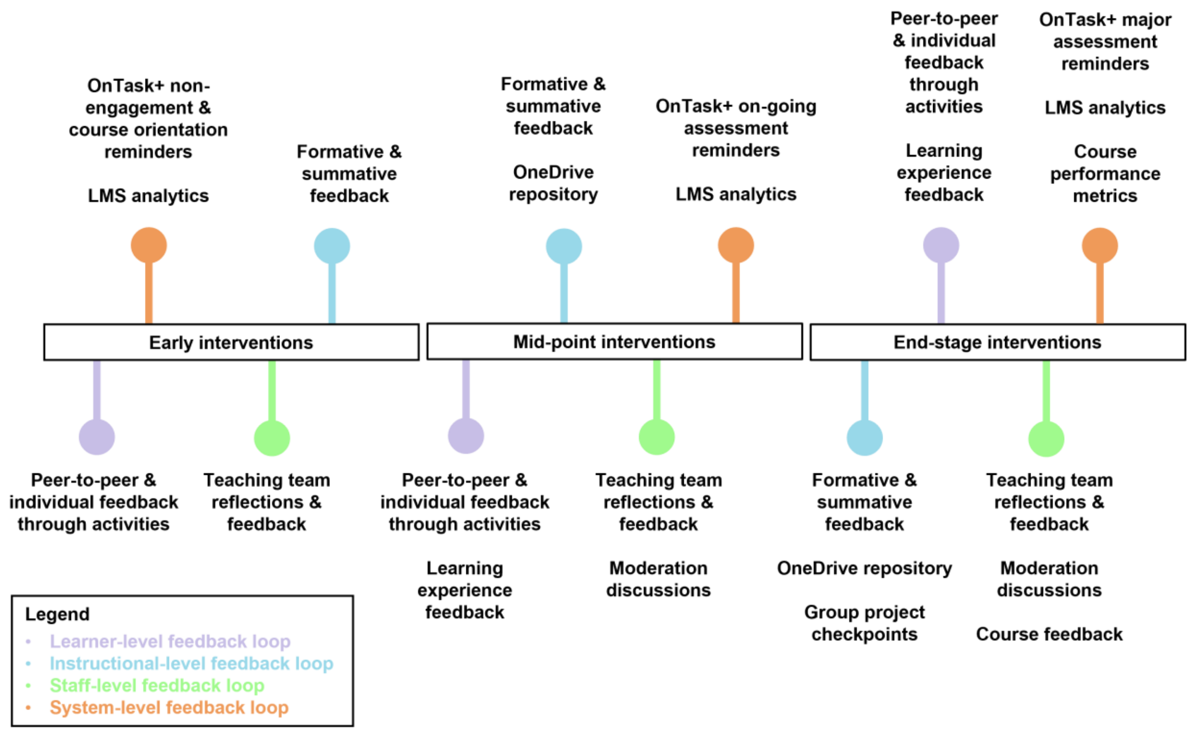
This study examined the role of feedback loops in student engagement and learning as illustrated in Figure 3. To support deeper engagement, scaffold student learning and develop proficiency, we used formative and summative methods including in-class activities, quizzes, checkpoint and participation tasks, digital and paper-based artefacts, peer review, and presentations. To gauge understanding and adjust our teaching accordingly, we encouraged open communication with learners, using real-time classroom check-ins, anonymous and voluntary minute papers and end-of-course surveys. We actively listened to feedback and used these collective reflections to inform improvements, creating a learning environment where multiple perspectives were valued.

Learner-level feedback

At the learner-level, students reported on their progress through stand-up meetings, retrospectives, a project team health monitor, and peer comments via a OneDrive project deliverable. H5P knowledge checks and collaborative tools enabled timely and transparent feedback, with 88.90% of students agreeing that regular feedback enhanced their learning (End-of-course survey, 2025; see Table 3 in Appendix 1 – Survey design). These strategies were recognised in the anonymous and voluntary end-of-course experience questionnaire best aspect comments such as: *"provided valuable feedback for our team's progress", "insightful feedback",* and "*clear expectations*".

The overall impact of learner feedback was positive with appreciation expressed through unsolicited student emails. For example, *"I would not have been able to achieve this grade without your ongoing support throughout that course"; "This will undoubtedly prove invaluable as I continue my studies and advance in my career"; "Your willingness to address our questions and provide additional support has made a significant difference in my learning experience."* The learner-level feedback loop supports the development of the following graduate attributes: *is prepared for life-long learning in pursuit of personal development and excellence in professional practice, can work both autonomously and collaboratively as a professional* and *communicates effectively in professional practice and as a member of the community.*

Figure 3: Feedback loop interventions applied within course deliveries



Instructional-level feedback

Instructional-level feedback was an important mechanism for students to receive input on their work-in-progress, particularly when learning new concepts or extending their application. Providing formative feedback through OneDrive documents was beneficial as students understood complex concepts and resolved potential group conflicts. For example, the instructor provided feedback to one group of students, stating "*Read the relevant text [part] of the textbook chapter. Provide one example per requirement type applied to this case study*" within their group portfolio document. The instructional-level feedback loop supports the development of the following graduate attributes: *can work both autonomously and collaboratively as a professional* and *communicates effectively in professional practice and as a member of the community.*

Staff-level feedback

At the staff level, tutors were provided with key teaching resources (such as weekly teaching guides and marking moderation meeting recordings) through a shared OneDrive or LMS folder. They reported improved communication between the teaching team, reduced email traffic, and confidence and clarity in their marking, resulting in more consistent, timely, and constructive feedback to students. We identified that the teaching quality, and subsequent student learning experiences, were positively impacted through staff-level feedback mechanisms.

System-level feedback

At the system-level, OnTask+ interventions were incrementally implemented to enhance engagement and timely completion of course requirements. Table 2 in Appendix 1 shows the impact with and without these interventions, noting that SP2 2023 is the baseline without an intervention applied. Initial emails targeted students who had not accessed the course website during weeks 1 to 3, subsequent emails addressed students who had not completed the orientation quiz, and final reminders went to students who had not submitted assessments the day before they were due.

Across SP5 2023 to SP2 2025, OnTask+ emails corresponded with improved engagement and assessment submission. Without interventions, non-attempts and non-submissions were higher (e.g., orientation quiz: non-attempts ranged between 27.03%–45.54%). With targeted reminders (see the sample email template below which was sent out to students who had not yet logged into the course website in week 2), course website non-access declined from 15 → 4 → 1 student across weeks 1 to 3, and orientation quiz non-attempts ranged from 11.84%–20.57%). Later interventions for the major assessment were particularly effective, with Assignment 2.1 and 2.2 non-submissions reduced to just 1 student each (1.32%) following day-before due date reminders.

> Sample Email Template:
>
> **Subject***: [COURSE_ACRONYM] Week 2 - You have not logged into the [COURSE_NAME] course website*
>
> **Body:**
> *Dear [STUDENT_NAME],*
>
> *According to my records, it appears that you have not yet accessed the course website for [COURSE_NAME].*
>
> *We are now at the end of week 2 of the course where two lectures have been delivered, the first assignment has been released and discussed and workshop activities begin next week.*
>
> *If you are having difficulties getting started or accessing materials, please let me know.*

It is really important that you engage in the course and associated activities as a matter of priority as this is an intensive course.

I look forward to seeing you in class next week.

Best wishes.

Regards,

[USER_NAME].

Student feedback aligned with these quantitative improvements and provided valuable insights. Several students expressed appreciation such as, "*Thank you for sending me this mail, I was able to remember what I had to do,"* and *"I'll be sure to check out the course website this weekend, sorry for the delay."* These examples suggest that personalised reminders were effective in prompting engagement and were perceived positively by students.

These feedback loops demonstrated that multiple interconnected agents within this CAS can effectively progress learning and teaching goals in systems analysis IT education courses. Prior feedback research focused on learners and their needs, with educators expected to adapt their feedback based on how well students understood and actioned feedback, and with a focus typically on cognitive and physical outcomes (Mandouit & Hattie, 2023; Wisniewski et al. 2020). In comparison to existing feedback models (Lipnevich & Panadero, 2021), our study applied a whole-of-course approach, with multiple feedback mechanisms providing a steady flow of feedback focused on each student's learning needs. This enabled students to self-regulate their learning at task and process levels and increase their self-efficacy (Nicol & Macfarlane-Dick, 2006). Feedback agents typically consist of learners, peers and educators (Panadero & Lipnevich, 2022), however, our whole-of-course feedback approach considers technologies and systems as active agents which may mediate the learning environment of students. Technology is used not only to provide formative quiz-based or adaptive web-based system feedback (Morris et al., 2021), but to provide regular consistent feedback through use of artefact repository tools like OneDrive which makes learning progress visible. The system-level feedback loop supports the development of the following graduate attributes: *operates effectively with and upon a body of knowledge of sufficient depth to begin professional practice* and *is prepared for life-long learning in pursuit of personal development and excellence in professional practice.*

Conclusion

Through this pedagogical action research study, we have presented a novel feedback loop approach that addresses the complexities of a CAS consisting of multiple interconnected agents and have applied it to dynamic IT teaching environments. This approach showcases the reciprocal nature of feedback interactions amongst interconnected agents, such as learners, staff and systems, whilst also providing opportunities for learners to develop and apply graduate attributes, and model industry practices.

This work contributes a whole-of-course multi-faceted feedback approach, recognising the importance of providing feedback opportunities for these agents to also continuously adapt to the rapidly evolving CAS environment.

This study is limited in scope to a conceptual exploration of a whole-of-course multi-faceted feedback approach. Further research is needed to extend the contributions to disciplines beyond systems analysis IT education as the unique features of those CAS contexts need to be understood individually, holistically and appropriately applied.

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Disclosure of the use of AI-assisted technologies during writing

No AI-assisted technologies were used during the writing process.

About the authors

Kathy Darzanos holds a Bachelor of Computer and Information Science (Honours) and a Professional Certificate in University Teaching. She is a Senior Lecturer at Adelaide University actively engaged in Higher Education (HE) research and the scholarship of teaching and learning (SoTL) through dissemination of practice, membership of HE professional bodies, and as a HE journal reviewer. She is the lead Academic Integrity Officer Coordinator for the School of Computer Science and Information Technology and a Teaching Squares facilitator at Adelaide University. She was also a former leader of a SoTL Community of Practice in the STEM academic unit at the University of South Australia.

Kathy believes in creating a positive student learning culture, developing inclusive learning environments and supporting students in their first year or transition to university, at the undergraduate and postgraduate level.

She is a co-investigator in a UniSA Unstoppable Teaching and Learning Development Grant (2025-2026) for a project titled Ethical Professionalism: A Values Focus, that aims to progress the development of a value sensitive design-based learning tool to improve ethical professionalism and data literacy among students.

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Her research explores technology ethics, the design of information systems and the social impact of emerging technologies. Her doctoral thesis applied value sensitive design and explored privacy expectations and data flows in the context of personalised search. She was a member of the Australian Computer Society's Professional Ethics Committee and was a co-convener of a community-based AI Ethics Book Club.

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Appendix 1: System-level feedback

Table 2: Comparison of student engagement with and without OnTask+ intervention.

SP2 2023

Course delivered using the standard teaching and learning approaches. OnTask+ not used. This study period represents a baseline for comparison purposes.

Cohort size = 111

Without intervention

Orientation quiz:	30 non-attempts	27.03%
Assignment 1:	10 non-submissions	9.01%
Assignment 2.1:	6 non-submissions	5.41%
Assignment 2.2:	8 non-submissions	7.21%

With intervention

n/a

SP5 2023

OnTask+ used as an early at-risk indicator, specifically to monitor and track non-engaging students across weeks 1-3.

Cohort size = 226

Without intervention

Orientation quiz:	99 non-attempts	43.81%
Assignment 1:	8 non-submissions	3.54%
Assignment 2.1:	4 non-submissions	1.77%
Assignment 2.2:	10 non-submissions	4.42%

With intervention (OnTask+ email prompts sent to students)

Course website: non-access reduced from 32 →12 → 2 students across weeks 1-3

SP2 2024

OnTask+ used as an early at-risk indicator, specifically to monitor and track non-engaging students across weeks 2-3.

Cohort size = 101

Without intervention

Orientation quiz	46 non-attempts	45.54%
Assignment 1	17 non-submissions	16.83%
Assignment 2.1	10 non-submissions	9.90%
Assignment 2.2	11 non-submissions	10.89%

With intervention (OnTask+ email prompts sent to students)

Course website: non-access reduced from 17 →11 students across weeks 2-3

Table 2 (cont …): Comparison of student engagement with and without OnTask+ intervention.

SP5 2024

OnTask+ used as an early at-risk indicator, specifically to monitor and track non-engaging students across weeks 1-3 and to check orientation quiz non-attempts.

Cohort size = 209

Without intervention

Assignment 1:	19 non-submissions	9.09%
Assignment 2.1:	14 non-submissions	6.70%
Assignment 2.2:	18 non-submissions	8.61%

With intervention (OnTask+ email prompts sent to students)

Course website: non-access reduced from 54 → 25 → 9 students across weeks 1-3

Orientation quiz: non-attempts reduced from 160 to 43 (20.57%)

SP2 2025

OnTask+ fully implemented as an early and ongoing at-risk indicator, specifically track non-engaging students across weeks 1-3, to check orientation quiz non-attempts, and to check non-submissions of all major assessment items.

Cohort size = 76

Without intervention

n/a

With intervention (OnTask+ email prompts sent to students)

Assignment 1:	1 day prior: 38 non-submissions; after: 6 non-submissions	7.89%
Assignment 2.1:	1 day prior: 72 non-submissions; after: 1 non-submission	1.32%
Assignment 2.2:	1 day prior: 61 non-submissions; after: 1 non-submission	1.32%

Course website: non-access reduced from 15 → 4 → 1 student across weeks 1-3

Orientation quiz: non-attempts reduced from 41 to 9 (11.84%)

Appendix 2: Survey design

The survey design is represented in Table 3. Students were asked questions relating to knowledge, skills, attitudes, learning characteristics, teaching, social and cognitive presences, course and program alignment, industry relevance, and course improvements in order to explore the holistic impact of the feedback mechanisms on their learning outcomes and experiences. The survey comprised of a mix of closed-ended questions (multiple choice Likert scales, short-form text responses and multiple selection options) and open-ended questions (long-form text responses). Questions were randomised and survey responses were anonymously and voluntarily sought from each study period's enrolled student cohort. The surveys were administered at three distinct points in the course (at the start, middle and end of the course).

Table 3: Constructs and rationale used in the survey design

Survey Construct	Rationale
Knowledge	To identify to what extent core knowledge concepts were understood and applied.
Skills	To identify to what extent core skills were understood and applied.
Attitudes	To identify to what extent core attitudes were understood and applied.
Learning Outcomes	To identify if students understood their learning goals.
Learning Activities	To identify how students attempted their learning activities.
Learning Experience	To identify different learning experiences of students.
Learning Satisfaction	To identify to what extent students are satisfied with their learning.
Teaching Presence	To understand the effectiveness of different elements of teaching presence.
Social Prescence	To understand the effectiveness of different elements of social presence.
Cognitive Presence	To understand the effectiveness of different elements of cognitive presence.
Course and Program Alignment	To understand the extent to which students can identify connections between this course and their program of study.
Industry Relevance	To understand the extent to which students can identify the relevance between this course and industry.
Challenges	To understand the challenges students encounter with their learning in this course.
Suggestions for Improvement	To identify course improvements from a student's perspective.