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Scaffolding Feedback Literacy: Designing a Feedback Analytics Tool with Students

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Abstract

Feedback is essential in learning. The emerging concept of feedback literacy underscores the skills students require for effective use of feedback. This highlights students' responsibilities in the feedback process. Yet, there is currently a lack of mechanisms to understand how students make sense of feedback and whether they act on it. This gap makes it hard to effectively support students in feedback literacy development and improve the quality of feedback. As a specific application of learning analytics, feedback analytics (analytics on learner engagement with feedback) can offer insights into students' learning engagement and progression, which can in turn be used to scaffold student feedback literacy. This study proposes a feedback analytics tool, designed with students, aimed at aiding students to synthesize feedback received from multiple sources, scaffold the sense-making process, and prompt deeper reflections or actions on feedback based on data about students' interactions with feedback. We held focus group discussions with 38 students to learn about their feedback experiences and identified tool features. Based on identified user requirements, a prototype was developed and validated with 16 students via individual interviews. Based on the findings, we envision a feedback analytics tool with the aim of scaffolding student feedback literacy.

Notes for Practice

- Scaffolding student feedback literacy is crucial for enhancing the effectiveness of feedback.
- Feedback analytics can offer insights into students' sense-making and action-taking processes, which can in turn be used to scaffold student feedback literacy.
- A feedback analytics tool, PolyFeed, with its key functions, such as "Annotate Feedback," "Create Work Plan," and "View Summary," showed potential to be effective in supporting student feedback literacy.
- It is essential to involve students in the design of learning analytics tools to ensure that these tools effectively address their nuanced needs, consider the challenges they face, and provide support in the feedback process.

Keywords

Feedback literacy, learning analytics, feedback analytics, feedback traceability, feedback management

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1. Introduction

Feedback is an integral component of education, playing a crucial role in the teaching and learning process. It has evolved from a traditional, unidirectional form of communication to a more dialogic feedback approach, emphasizing a two-way interaction

between educators and learners (Rowe, 2017). This shift highlights the active role that learners must adopt in the feedback process (Boud & Molloy, 2013). This bi-directional exchange enables feedback to be tailored to individual needs, enriching the learning experience. However, various studies have reported that students often struggle to interpret and act on feedback and generally express dissatisfaction and a lack of engagement with the feedback process (O'Donovan et al., 2021; Price et al., 2010). These challenges can be attributed to students' lack of *feedback literacy*, which refers to the skills, understandings, and mindsets that enable students to effectively use feedback (Carless & Boud, 2018). This concept emphasizes the crucial roles and responsibilities that students have in the feedback process and posits that meaningful engagement with feedback is a collective endeavour, not just the educator's responsibility (Carless & Boud, 2018). Hence, there is a pressing need to support and build student feedback literacy to enhance feedback effectiveness. Yet, a significant hurdle in the current feedback process is *traceability*—the capacity to monitor how and when students engage with, interpret, and act on feedback (Winstone, 2019). Without knowing how students interact with feedback, educators may struggle to provide quality feedback and help students develop feedback literacy.

Learning analytics (LA) has emerged as a promising solution to several challenges in education, including feedback traceability (Jin et al., 2022). Specifically, LA systems can capture live-time learning behaviours and prompt self-reflections on learning progress. Current LA tools tend to focus on delivering data-driven feedback on learners' engagement with learning activities or materials (such as page viewing and time on tasks). Although receiving and using feedback from educators is an important part of learning, insufficient attention has been paid to understanding how students make sense of feedback and act on it (Winstone, 2019). This is important for both learners and educators because the information on student engagement with and uptake of feedback can allow learners to develop important learning skills and teachers to understand the impacts of provided feedback and ways to improve it. Without consideration of students' experiences with feedback as an interactive process, the design of LA tools can be constrained within a "feedback as telling" paradigm, potentially leading to diminished learner agency and a lack of productive action (Carless & Boud, 2018). It is thus important to ground LA on effective feedback principles (Tsai, 2022) and involve students in the LA design process (Jivet et al., 2018) to understand their needs, particularly ways to support their feedback literacy.

To address the challenges related to feedback traceability and feedback literacy development, we propose "feedback analytics," an application of LA with a focus on capturing, analyzing, and presenting how students interact with feedback. Through purposefully engaging students in a process of making sense of feedback and presenting them with data on their own engagement with feedback, we expect to scaffold the development of feedback literacy among learners. The present study aims to design and validate a student-facing feedback analytics tool involving students in the process. This study employs focus group discussions to understand students' experience with feedback, so as to identify their feedback literacy skills and ways to scaffold these skills using LA. Based on these discussions, the researchers identified tool requirements and developed a high-fidelity tactile prototype, which was subsequently validated through individual interviews with students. Informed by the findings, we propose a feedback analytics tool that aims to address the challenge of feedback *traceability* and scaffold the development of *student feedback literacy*.

2. Literature Review

2.1 Feedback and Feedback Literacy

Feedback has long been recognized as a crucial element in education, offering learners insights into their performance and areas for improvement (Hattie & Timperley, 2007). Traditional models of feedback were often unidirectional, focusing on the transmission of information from the educator to the student (Boud & Molloy, 2013). However, recent literature increasingly recognizes that effective feedback should be dialogic in nature (Sutton, 2009). Dialogic feedback promotes a two-way communication process between educators and learners, enabling the feedback process to be more attuned to individual needs. In this dialogic approach, it is essential for students to take an active role. This participation allows them to deeply engage in the feedback dialogue, which in turn builds trust and motivates further engagement with feedback (Sutton, 2009; Yang & Carless, 2013). Yet, existing literature consistently points out students' challenges in engagement with feedback, stemming from difficulties in interpreting and applying feedback to subsequent work, leading to a reliance on educators for more explicit and prescriptive guidance (e.g., detailed, clear, actionable feedback) (O'Donovan et al., 2021; Price et al., 2010). These challenges may be attributed to students' lack of feedback literacy, which encapsulates the capabilities, attitudes, dispositions, and mindsets students need to make effective use of feedback (Carless & Boud, 2018). For feedback to be effective, it is crucial that students possess a certain degree of feedback literacy for them to be proactive and self-directed in their engagement with and use of feedback (Carless & Boud, 2018).

The concept of feedback literacy has been explored through multiple frameworks, each providing a distinct lens to understand the multifaceted nature of student engagement with feedback. Carless and Boud (2018) define feedback literacy as encompassing the understanding, capacities, and dispositions needed to interpret and implement feedback. Their framework includes four core features: *appreciating feedback*, *making judgments*, *managing affect*, and *taking action*. In more recent

research, Molloy and colleagues (2020) expanded upon this concept through a large-scale survey and qualitative study, culminating in a more comprehensive framework for feedback literacy. They proposed a set of seven aspects: (1) *committing to feedback as improvement*, (2) *appreciating feedback as an active process*, (3) *eliciting information to improve learning*, (4) *processing feedback information*, (5) *acknowledging and working with emotions*, (6) *acknowledging feedback as a reciprocal process*, and (7) *enacting outcomes of processing of feedback information*. In comparison with the four features proposed by Carless and Boud (2018), the framework by Molloy and colleagues (2020) adds depth by identifying the dispositions, beliefs, and approaches to feedback. This framework places particular emphasis on the importance of self-regulation skills, highlighting the connection between self-regulation skills and the development of the aforementioned aspects. As an example, aspects (4) and (7) require students to relate feedback to their own learning progress and make appropriate judgments on ways to act on the feedback. This underscores the role of self-regulated learning (SRL) in the feedback process, which is a concept that describes the cognitive, motivational, and emotional facets that empower learners to manage, monitor, and regulate their learning (Panadero, 2017). The intrinsic link between feedback literacy and SRL is evident when delving into the nuances of both concepts. For example, students' emotional resilience (managing affect), as an affective dimension of SRL, is one of the capabilities that students need in order to properly deal with feedback; students' ability to evaluate (making judgment) their own work and feedback information, which is related to the judgmental dimension of SRL, enables them to self-evaluate their performance and decide which learning strategy or tactic to implement (taking action). Therefore, SRL plays a crucial role in promoting uptake of feedback since it directly impacts the development of feedback literacy.

While numerous studies have explored components of student feedback literacy (Han & Xu, 2020; Li & Han, 2022), how we can scaffold the development of these components remains unclear. This is partly due to the challenge of effectively tracking how students interact with feedback (Jin et al., 2022; Winstone, 2019); how they interpret, internalize, and act upon the feedback they receive; and how that feedback ultimately affects their learning. This limitation hampers effective teaching support and development of student feedback literacy. In light of this, we propose to use LA to capture and analyze student interactions with feedback, thereby presenting "feedback analytics" (Winstone, 2019) (analytics on learner engagement with feedback) to prompt self-reflections among students and scaffold their feedback literacy.

2.2 LA and Feedback

In recent years, LA has emerged as a promising technology-enhanced approach to facilitating the feedback process (Carless & Boud, 2018; Yang & Carless, 2013) and tracking feedback's impact (Winstone, 2019). It leverages extensive learning data to provide insights into student engagement within a technologically enhanced learning environment. This engagement data, including click streams and forum discussions, along with academic performance and sensory data, plays a critical role in generating feedback to students. The majority of existing LA feedback tools predominantly focus on delivering automated feedback (Knight et al., 2020; Sedrakyan et al., 2020; Whitelock et al., 2015; Zheng et al., 2022) or assisting educators in crafting personalized feedback (Lim, Dawson, et al., 2021). Using diverse online engagement data and performance data available within the platforms (e.g., learning management systems), these tools aim to enhance students' overall experience with feedback, focusing on improving feedback content, frequency, and timeliness. Further expanding on the capabilities of LA-based feedback, it holds the potential to support a wide array of educational objectives, including feedback adoption, reflection, self-regulation, and motivation and engagement enhancement (Pardo et al., 2019; Lim, Gentili, et al., 2021). Recent advancements in artificial intelligence (AI) have demonstrated the potential to facilitate the dialogic feedback process through human-to-chatbot interactions, offering flexibility in timing and location to improve the learning experience and real-time engagement (Kim et al., 2021). In this vein, Dai and colleagues (2023) explored the feasibility of employing ChatGPT for feedback generation by assessing the quality of feedback generated by ChatGPT, laying the groundwork for its incorporation into LA feedback tools. This research revealed ChatGPT's capability to generate feedback that is more detailed and readable than that provided by human educators, though it cautioned that such feedback might not offer a reliable assessment of student performance (Dai et al., 2023). However, it implied ChatGPT's potential to assist educators in delivering more readable and consistent feedback, potentially enhancing students' sense-making process. Despite these technological advancements, little attention is paid to the sense-making process of feedback or the support students may need to turn feedback into action (Winstone, 2019), thus leaving a gap in the understanding of feedback effectiveness, specifically the extent to which feedback is used by learners to enhance learning.

The impact of feedback is not merely confined to improvements in subsequent works. It is a multifaceted element impacting various aspects (e.g., cognitive, affective, relational, change values, intentional/unintentional), often creating plural ripples (Henderson et al., 2019). In this context, capturing the multifaceted impacts of feedback is crucial so as to evaluate the extent to which feedback is effective in helping students move toward learning goals (Zimbardi et al., 2017a). LA-based feedback tools (or "feedback analytics," a term proposed in this paper) can track feedback impact by analyzing students' *digital footprints* (Winstone, 2019; Zimbardi et al., 2017a). However, tracking students' interactions with feedback and its impact poses significant challenges due to the intricate and intangible nature of feedback impact. Current LA feedback tools predominantly

gauge student engagement with feedback by focusing on metrics such as the frequency of opening feedback files (Bikanga Ada & Stansfield, 2017) and the duration of student engagement with feedback (Zimbardi et al., 2017b). For example, Zimbardi and colleagues (2017a) developed a feedback analytics capture system, UQMarkup, to assist educators in the marking process. It facilitates the delivery of timely, detailed, and context-specific feedback, allowing for inline comments in audio, typed, or handwritten annotation. The system also aims to track student engagement with feedback, measuring both the time and the duration of their interaction. However, such analytics provide a surface level of information regarding students' engagement with feedback and fail to address the need to understand how students make sense of feedback and act on it. Additionally, concerns regarding the accuracy, ethics, and privacy of LA tools have frequently been raised, potentially resulting in students' resistance to using these tools, even after extensive efforts to design and develop them (Tsai et al., 2021). These limitations in existing LA feedback tools, coupled with a lack of educational theories in their design (Tsai, 2022), have arguably hindered a holistic understanding of the impact of feedback and its potential to scaffold feedback literacy. For example, FEATS, as introduced by Winstone (2019), aims to track feedback impact by capturing students' engagement with feedback based on their personal reflections. Their simple visualizations may not capture the full feedback impact due to its limitations in tracking students' repeated mistakes, consistent strengths, or areas of confusion, given that a single piece of feedback can encompass multiple elements. This approach potentially overlooks the initial stages of the feedback sense-making process, which could result in not effectively supporting students in taking productive actions, especially if they misinterpret the original feedback. Therefore, it necessitates a more nuanced approach to understanding students' current feedback sense-making process. This calls for the involvement of students in the design of a student-facing feedback analytics tool that is grounded in theories of effective feedback, with a special focus on feedback literacy.

Thus, we based our research on the following questions:

- RQ1: What can students' experiences with feedback reveal about their feedback literacy?
- RQ2: How may a feedback analytics tool scaffold feedback literacy from students' points of view?

This study foregrounded students' experiences with feedback, considering their insights to be central to the research process. The study was structured in two main phases. Phase 1 (Section 3) sought to understand students' feedback literacy based on how they usually interacted with feedback (Part A) and identify user requirements based on the functionalities that students would like to see in a feedback analytics tool (Part B). Phase 2 (Section 4) sought to design a prototype based on the findings of Phase 1 and validate it. Specifically, Phase 1—Part A is designed to addresses RQ1, while Phase 1—Part B and Phase 2 are designed to addressed RQ2.

3. Phase 1: Eliciting Requirements for the Feedback Analytics Tool

3.1 Method

Phase 1 employed a qualitative research approach, facilitated through semi-structured focus group interviews. A total of 38 higher education students (28 females, 10 males), including undergraduate ($n = 16$), postgraduate ($n = 18$), and PhD ($n = 2$) students from diverse disciplines (science, engineering and computer science, arts and humanities, and medicine and health sciences), participated in the study. In total, eight focus group interviews were conducted, each lasting approximately one hour. The interviews were structured in two parts, as described above (interview questions can be accessed at https://bit.ly/45dtYp0). Part A includes three main questions, focusing on students' perspectives regarding educators' feedback practices, students' current practices of using feedback, and the challenges faced in the feedback process. Part B involved a brainstorming activity where the researcher asked participants: "We'd like to develop a feedback management tool to help students to manage and make use of received feedback. Are there any functions or features you would like to see in the feedback tool?" Following this, students were invited to brainstorm and vote on the top five features they deemed essential for a future tool. A digital whiteboard platform, Miro, was used to facilitate the brainstorming process.

3.2 Analysis

A thematic analysis was adopted to analyze the qualitative data, using the NVivo software. The overall coding scheme consists of 34 codes. It was developed to analyze data collected in Phase 1—Part A. These codes were categorized into three levels of themes, with the top-level themes being *student feedback literacy*, *feedback characteristics*, *agent characteristics*, and *learning design*.

The *student feedback literacy* theme was used to understand students' feedback literacy skills based on their experiences with feedback. It was further dissected into five primary components, *appreciating and committing to feedback*, *eliciting feedback*, *managing emotions*, *processing feedback*, and *taking action and enacting outcomes*, grounded in the review of two student feedback literacy frameworks (Carless & Boud, 2018; Molloy et al., 2020), discussed in Section 2.1. Given the overlaps and complementary aspects of these two frameworks, aspects (1), (2), and (6) (Molloy et al., 2020) were consolidated

into one code—*appreciating and committing to feedback*. This consolidation expands the *appreciating feedback* dimension (Carless & Boud, 2018), highlighting the awareness of the purpose of feedback in learning and the active role learners need to play in the feedback process, thereby embracing feedback as a means for personal growth. Aspect (3) complements aspect (4) (Molloy et al., 2020) because it necessitates that students interpret and evaluate feedback by engaging in a meaningful dialogue and actively *making judgment* (Carless & Boud, 2018) on feedback, drawing upon their understanding of assessment criteria and standards. This resulted in the formation of two codes: *eliciting feedback* and *processing feedback*. Aspect (5) (Molloy et al., 2020) builds on the *managing affect* (Carless & Boud, 2018) dimension because it requires students to be open to any comments without displaying negative emotions and to demonstrate volition in approaching appropriate others to elicit suggestions and continue dialogue. This has led to the code *managing emotions*. Lastly, aspect (7) (Molloy et al., 2020) informed the code *taking action and enacting outcomes*. This code aligns with the dimension of *taking action* (Carless & Boud, 2018), reflecting students' ability to identify strategies to act on feedback in order to achieve their own goals, highlighting both the implementation of actions and the achievement of outcomes. For each of the five codes, students' responses were further coded into *demonstrated* and *lacking*. This facilitated the identification of whether students demonstrated any of the five aspects based on their descriptions of experiences using feedback and the challenges with feedback.

The themes of *feedback characteristics* (Ryan et al., 2023; Hattie & Timperley, 2007; Lim, Dawson, et al., 2021), *agent characteristics* (Jin et al., 2022), and *learning design* (Jin et al., 2022) were used to analyze additional causes of challenges perceived by students in the feedback process. These themes were derived from students' responses and existing literature, which are elaborated upon in the detailed coding scheme. Three rounds of inter-rater reliability (IRR) tests between two researchers were conducted, resulting in Cohen's Kappa 0.67, 0.78, and 0.87, respectively (a range between 0.81 and 1.00 is deemed "almost perfect agreement," McHugh, 2012). Following that, the main coder carried out the coding process for all focus group transcripts. In the following section, quotes from Phase 1 participants were labelled as FG (focus group), with a number to differentiate groups, followed by R (respondent), with a number assigned to distinguish between individuals. For example, FG1R2 indicates respondent 2 from focus group 1.

The voting of top five desirable features based on the brainstorming activity in Phase 1—Part B generated 55 ideas, which were subsequently consolidated by the researcher into 10 function categories in an affinity diagram.

All the numbers cited for the codes throughout Sections 3.3 and 4.3 indicate the frequency with which a particular code was applied to the data (e.g., $f = 20$). Additionally, the quotes presented in Sections 3.3 and 4.3 underwent minor editing to enhance readability while remaining faithful to the participants' responses. Edits involved the removal of filler words (e.g., "like" and "um"), without altering the original meanings, and the insertion of explanations or corrections in square brackets, especially when the quotes are from participants whose first language was not English.

3.3 Findings

3.3.1 Demonstrated Feedback Literacy versus Lack of Feedback Literacy

As shown in Table 1, the analysis unveiled that, out of 114 references (i.e., units of data coded) to *student feedback literacy*, 71 references revealed students who "demonstrated" certain aspects of feedback literacy, indicating a generally good level of overall feedback literacy among students. However, 43 references revealed them "lacking" in certain aspects, highlighting the areas that need improvement.

Appreciating and committing to feedback This code was used to capture instances where students demonstrated ($f = 30$) or lacked ($f = 4$) appreciation for feedback as a valuable source of information, perceived feedback as an interactive and reciprocal process, or embraced feedback for personal growth. For example, student FG2R2 said, "I find it really helpful to revisit feedback … I might take bits of feedback and put it into my notes so I can revisit it later when I'm working on another assignment. I'm ensuring that I'm following the feedback that's been previously given to me." On the other hand, a few instances were observed where students perceived feedback as not being a valuable source of information for their learning and were not aware of the role that they should play in the feedback process. For example, FG3R5 stated: "The feedback you get doesn't help build your skill set; it's pointing out the shortcomings of your knowledge, so there's nothing really to gain from that."

Table 1. Number of References Coded for Feedback Literacy Based on Students' Experiences with Feedback

Code	Demonstrated	Lacking
Student feedback literacy	71	43
Appreciating and committing to feedback	30	4
Eliciting feedback	27	2
Managing emotions	2	24
Processing feedback	17	9
Taking action and enacting outcomes	20	8

Eliciting feedback This code was used to capture instances where students demonstrated ($f = 27$) or lacked ($f = 2$) the ability to seek feedback and clarify confusions with their educators. For example, student FG6R4 was aware of the educators' time limitations and resource constraints due to large student cohorts, noting, "It's not that they don't want to give you more individual, specific feedback; it's just that it takes a lot of time to mark hundreds of assignments. So, you can always ask; that's usually how I overcome feedback that's hard to understand. So, I haven't had too much trouble." On the other hand, there were a few instances where students experienced difficulties in engaging in dialogue with educators to seek further feedback or clarify confusions: "I'd like to discuss [about feedback with tutor], but I often find that avenue closed off; I feel a bit unsure of what to do. I don't know whether it was just a miscommunication on their end or whether it is something I need to change" (FG7R2).

Managing emotions This code was used to capture instances where students demonstrated ($f = 2$) or lacked ($f = 24$) the ability to handle feedback-related stress or disappointment. The notable discrepancy indicates that emotional management is a common obstacle to the effective use of feedback for many students. This emotional struggle potentially hinders students from making effective use of feedback (Carless & Boud, 2018). For instance, student FG3R1 confessed, "For me, if I receive negative feedback, I feel frustrated. When the teacher gives me negative feedback without any positive comments, I will be more frustrated. I think it discourages me from improving or completing the next assignment or task."

Processing feedback This code was used to capture instances where students demonstrated ($f = 17$) or lacked ($f = 9$) the ability to analyze and interpret feedback effectively, thereby to make effective judgment about the quality and relevance of the feedback to their work. For instance, student FG7R1 could discern between constructive and unhelpful feedback and make effective judgment about their work based on their interpretation of the feedback given. The student elaborated, "It obviously depends on how constructive it [feedback] is. If it's sort of helpful feedback … then I'll go to the rubric and have a look. I'll think, 'Okay, I can see where I missed that.' Or 'Okay, that sentence probably doesn't make sense or needs a bit more work'" (I7R1). In contrast, some students encountered difficulties in effectively analyzing and making sense of feedback, leading to difficulties in making evaluative judgments about their own work. For instance, student FG3R4 stated, "The challenge for me might be that after I receive the feedback and take some action, I'm still not sure if I'm on the correct track."

Taking action and enacting outcomes This code was used to capture instances where students demonstrated ($f = 20$) or lacked ($f = 8$) the ability to translate feedback into action. These abilities include applying feedback to enhance their work (current and future) and regulate their learning by employing different learning strategies, such as setting goals, planning, and monitoring the progress of implementing feedback. As an example, student FG4R2 not only reflected on their work but also put feedback into practice for future assessments: "I'd reflect on what needs to be improved and why I didn't do well. After that, I try to apply the feedback to my practice. For example, if my lecturer pointed out some linguistic errors in my assessment, I'd add them to my checklist for the next one. This helps me ensure I don't make the same mistake." On the other hand, challenges in applying feedback for improvement were also observed, as illustrated by student FG6R1: "Very often I understand the lecture content but I don't understand … how to use the feedback."

3.3.2 Challenges with Feedback Process

When discussing their perceived challenges in the feedback process, students identified challenges related to external factors, extending beyond their own factors, namely feedback literacy skills. The most frequently mentioned issues are related to *learning design* ($f = 42$) and *feedback characteristics* ($f = 42$). From students' perspectives, issues with *learning design*, such as abstract marking rubric, inconsistent feedback, and poor assessment design, act as barriers to using feedback effectively. For example, students expressed that the design of assessments did not enable them to apply feedback to future scenarios because "[one] assignment often won't be related to future assignment[s] so we can't do anything with [feedback] because it's not applicable to the future ones" (FG4R6). Additionally, students highlighted the challenge of receiving inconsistent feedback from different educators, leading to confusion. The code *feedback characteristics* describes the features that students believe to be useful for accepting and enacting feedback. Particularly, students stressed the importance of receiving actionable, detailed, and clear feedback, expressing a preferences for constructive feedback over generic and vague comments: "There would just be a question mark. So it wouldn't be very clear what section they're talking about or which part was wrong. It can be really confusing since it doesn't clarify anything at all" (FG8R3). Finally, the *agent characteristics* code focuses on the qualities and attitudes of the educators that support the feedback process. Students highlighted the challenges posed by unapproachable or unresponsive educators in seeking additional feedback. As one student stated, "When they're not very approachable or they just don't respond to your emails or the forum, it's really hard to get any more feedback" (FG7R1).

3.3.3 Students' Requirements for the Feedback Tool

As shown in Table 2, out of 10 main categories of features identified across all focus groups, six functions were selected for the student-facing feedback analytics tool (reasons for excluded features are provided in Table 2). The selected functions

Table 2. Prioritized Brainstorming Ideas for Feedback Tool Features

Function Categories	Descriptions	Features in Prototype	Votes
Resources & examples	Additional resources to aid student understanding, e.g., sample answers or varied examples of assessments that scored at different levels	*Excluded* (features for the educator-facing tool; will be considered in next phase)	27
Communication	A channel to easily contact educators or request explanations on specific parts of the feedback	Rating educators' feedback, *explain further*	22
Annotation & categorization	Identifying and categorizing key points from feedback	Annotation of feedback (highlight and label)	18
Marking rubric–related	A desire for providing more detailed marking rubrics, e.g., a more specific and detailed marking rubric	*Excluded* (features for the educator-facing tool; will be considered in next phase)	12
Integration & accessibility	A unified place for students to easily access feedback from multiple units	Ability to extract feedback information from various sources (e.g., Moodle feedback, Google Doc comments, email feedback)	11
Peer data	A way to connect with other peers by viewing the most common mistakes or strengths	*View summary* (e.g., comparison data across cohorts)	11
Marking mechanism	Features related to learning design, e.g., more detailed marking or provision of feedback before submission	*Excluded* (features for the educator-facing tool; will be considered in next phase)	10
Feedback monitoring & progress tracking	Ability to track feedback over time and see comparison data across assignments	*View summary* (e.g., data visualizations for summary data on their own progress regarding their interactions with feedback)	9
Feedback design	A desire for quality feedback, e.g., more specific and detailed feedback	*Excluded* (features for the educator-facing tool)	8
Feedback use	Enabling students to create to-do lists or action plans	Add to-do list feature	6

serve to scaffold student feedback literacy. Among these, the *communication* function category received the most votes, highlighting the need for a clear channel for feedback dialogue. Functions proposed under this category aim to encourage dialogue between educators and students, facilitating opportunities for students to clarify confusion and seek help. This not only fosters improved educator-student relationships but also assists students in managing emotions in the feedback process. The *annotation and categorization* category was also considered crucial to aiding students in analyzing and organizing feedback effectively. Functions of this category include helping students analyze and categorize comments for their specific needs, such as identifying strengths, weaknesses, confusing points, and actionable items, thus scaffolding students to make sense of feedback and derive effective judgment. The desire for an intuitive and universally accessible tool was reflected through the votes on the *integration and accessibility* category. Functions in this category allow students to access and manage feedback from multiple courses in one place, promoting their active engagement with the tool. This enhances their appreciation of feedback, allowing them to perceive feedback as a valuable information source and proactively engage with it. Students expressed a desire to view *peer data* to understand the common strengths and weaknesses across cohorts. Functions in this category offer valuable insights by revealing the common strengths and weaknesses within cohorts, allowing students to feel a connection with their peers. This understanding could motivate them to formulate actions by providing cohort data for peer comparison. Students also expressed interest in having a feature that would allow them to create to-do lists or action plans (*feedback utilization* category) that could be monitored and tracked within the tool (*feedback monitoring and progress tracking* category). Functions proposed in both of these categories could support goal-setting, planning for future improvements, and monitoring ongoing progress, thereby bolstering students' proactive use of feedback.

4. Phase 2: Designing and Validating the Feedback Analytics Tool

4.1 Method

4.1.1 Prototype Design

Based on the requirements identified in Phase 1—Part B (see Table 2) and guided by relevant literature (Winstone, 2019; Ryan et al., 2023), three primary functions—*annotate feedback*, *create work plan*, and *view summary*—were identified as essential features for the feedback analytics tool, named *PolyFeed*. A prototype was developed using Figma, which presents a browser extension that allows students to synthesize feedback from multiple sources on a single platform.

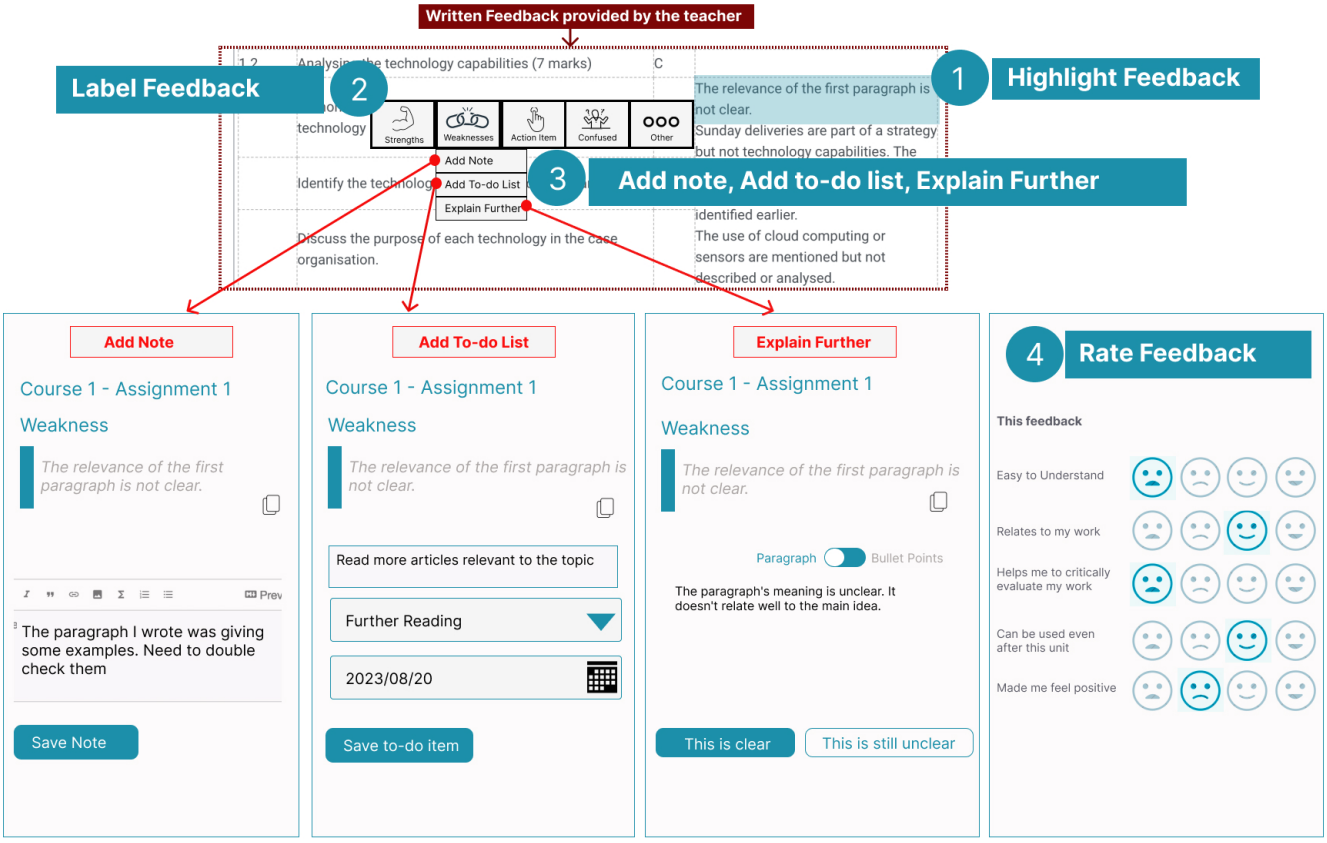

Figure 1. Main Features of PolyFeed

In PolyFeed, the *annotate feedback* function allows students to highlight and label the feedback as *strengths*, *weaknesses*, *action points*, *confusion*, and *other* (with the option to define their labels) (Figure 1, Steps 1 and 2). Following this, students can choose to add a personal note (Figure 1, Step 3—*add note*) and seek clarification on feedback if needed (Figure 1, Step 3—*explain further*). The latter will be supported by ChatGPT. The *create work plan* function extends the annotation feature, allowing students to create to-do lists; categorize action items as *further reading, further practice, contact tutor, ask classmate, refer to learning resources, explore online*, and *other* (with the option to define their labels); and set deadlines for these actions (Figure 1, Step 3—*add to-do list*). At the end of this process, students may choose to rate educators' feedback (Figure 1, Step 4). Lastly, the *view summary* function provides an overview of students' strengths, weaknesses, and planned actions based on their annotations, facilitating progress tracking within and across courses (see selected examples in Figure 2). Figure 2, Step 1, shows the patterns of completion for students' to-do lists, which are created based on identified strengths and weaknesses. Figure 2, Step 2, compares individual students' to-do list completion progress (the top bar) with that of peers in different performance groups. Figure 2, Step 3, illustrates common strengths and weaknesses identified in the feedback that an individual student receives across different courses, with the node size indicating frequency (i.e., repeated strengths or weaknesses). Figure 2, Step 4, visualizes common strengths among students in different performance groups in the same course. Figure 2, Step 5, provides a summary of a student's strengths in a particular course, grouped according to different assignments. Figure 2, Step 6, is similar to Figure 2, Step 3, but focused on the frequency of a student's weaknesses across assignments in one course. Figure 2, Step 7, presents a heat map summarizing the to-do list items created across courses, with numbers indicating actions per category (e.g., for course 1, the student has created two action items in the *further reading* category).

Figure 2. PolyFeed Dashboard Elements

Figure 2, Step 8, shows the progress a student makes in implementing the to-do list items created for each assignment in a particular course.

4.1.2 Validation Session Design

The validation serves to (a) evaluate the tool's usability and (b) understand students' perceptions of the support offered by PolyFeed in scaffolding feedback literacy. The validation sessions were conducted individually with 16 participants (nine females, seven males), comprising undergraduate ($n = 8$), postgraduate ($n = 5$), honours ($n = 1$), and PhD ($n = 2$) students from diverse disciplines (similar to Phase 1). We created four scenarios to validate the features described earlier using a figma prototype. In the first three scenarios, participants were exposed to three different modes of digital written feedback—Moodle feedback, Google Doc comments, and email feedback—illustrating PolyFeed's ability to extract relevant information from various sources. The Think Aloud method was adopted to capture participants' thinking processes throughout each scenario. At the end of each scenario, participants were asked to rate their experience with the proposed workflows using 5-point Likert scale statements (see Table 3 in Section 4.3.1). In the fourth scenario, participants were asked open-ended questions to evaluate the presented feedback analytics (see Figure 2 for examples). Suggestions from participants for improving the presented features and dashboard elements were also collected using open-ended questions. Upon completing the four scenarios, participants were asked to share their overall perceptions of the tool, focusing especially on its potential to enhance their feedback literacy.

4.2 Analysis

A thematic analysis was adopted to analyze the qualitative data collected in the validation session. We extracted the *student feedback literacy* codes from the coding scheme developed in Phase 1 (see Section 3.2) and added a new theme: *suggestions for improvements*. In this paper, we only present the findings related to *student feedback literacy* due to the scope defined by the research questions. One round of IRR between the same researchers was conducted, resulting in Cohen's Kappa 0.97 ("almost perfect agreement," McHugh, 2012). Quotes from Phase 2 participants were labelled as VIP (validation interview participant), with a numerical value assigned to distinguish between individuals (e.g., VIP1 and VIP2).

4.3 Findings

4.3.1 Usability of the Tool

Table 3 summarizes user ratings for the proposed workflows for each scenario. For each statement used to evaluate the scenarios, students also provided their reasons for selecting a particular rating. 80% of the participants mainly agreed with all the statements except for S1.4, S3.2, S3.3, S4.2, and S4.3, indicating general approval of the workflow's user-friendliness. More than 65% agreed (6% somewhat agree and 62% strongly agree) to provide backward feedback (i.e., feedback on educators' feedback) to their educators (S1.4). However, students raised concerns regarding the efficacy of backward feedback due to educators' workload or negligence. 31% of the participants were hesitant about the *explain further* function supported by ChatGPT (S3.2). They voiced concerns related to privacy, the potential for hallucinations caused by plausible yet factually incorrect or unrelated responses, and accuracy associated with the use of large language models (LLMs, e.g., ChatGPT). Similarly, 75% agreed (19% somewhat agree and 56% strongly agree) that they would like to annotate the feedback that is clarified by PolyFeed using ChatGPT (S3.3). However, misinterpretation by ChatGPT was a significant concern for students. The clarity of data visualization (S4.2) also received mixed responses. Main concerns raised by students were the difficulties in interpreting the graphs and unfamiliarity with the dashboard visualizations. Additionally, 25% of the students found comparison graphs demotivating (S4.3). In this regard, students expressed their concerns about increased stress and a preference for motivation through actual educators' feedback.

Table 3. Percentage Ratings on Usability Statements

Statement	1	2	3	4	5
Scenario One					
S1.1: The current workflow is user friendly.				44%	56%
S1.2: It was easy to highlight and select the labels.			6%	81%	13%
S1.3: It was easy to create a note to the annotated feedback.			19%	81%	
S1.4: I would like to share my thoughts about feedback with teachers.	6%	6%	19%	6%	62%
Scenario Two					
S2.1: The current workflow is user friendly.			19%	13%	68%
S2.2: It was easy to create a to-do list to the annotated feedback.			19%	81%	
Scenario Three					
S3.1: The current workflow is user friendly.				6%	94%
S3.2: I would like to have the *explain further* function supported by ChatGPT to explain some of the feedback information further.	19%	6%	6%	25%	44%
S3.3: I would like to annotate the feedback that has been simplified by ChatGPT.	6%	13%	6%	19%	56%
S3.4: I would like a feature to contact the tutor through this tool to discuss feedback.			13%	6%	81%
Scenario Four					
S4.1: The strength and weakness summaries are easily understandable.				31%	69%
S4.2: The graphs are easily understandable.		19%	31%	44%	6%
S4.3: I found the comparison graphs to be useful or motivating.	6%	19%	25%	13%	38%

1 Strongly Disagree, 2 Somewhat Disagree, 3 Neutral, 4 Somewhat Agree, 5 Strongly Agree

4.3.2 Potential to Scaffold Students' Feedback Literacy

In general, the participants agreed that PolyFeed could be useful for enhancing their feedback literacy. This is illustrated in five aspects, ordering them according to the frequency with which each code was applied: *processing feedback* ($f = 55$), *eliciting feedback* ($f = 48$), *taking action and enacting outcomes* ($f = 44$), *appreciating and committing to feedback* ($f = 35$), and *managing emotions* ($f = 18$).

Processing feedback This theme looked into students' perceptions of PolyFeed in terms of supporting them to assess the quality and relevance of feedback and interpret it to make effective judgments on their work. In particular, the participants mentioned that PolyFeed allows easy access to feedback (by curating multiple sources of feedback across courses in one place), facilitating the sense-making process (using the annotation function), providing opportunities to reflect on learning behaviours, and presenting peer comparison data for self-re-evaluation through the feedback analytics dashboard. For instance, VIP1 and VIP10 appreciated the unified feedback view that PolyFeed offered. VIP1 expressed the convenience of being able to "see all the feedback in one place, [without] going in and out [of Moodle]," while VIP10 noted how feedback became "a more accessible chunk of information, [where] you can kind of spin your interpretation of that." Additionally, VIP10 and VIP14 appreciated the *explain further* function for its ability to transform extensive feedback into succinct bullet points, making it easy for them to interpret feedback, especially for busy students and non-native English speakers: "[I] know some students when

they receive the feedback like the original vision, they will use a translation [tool]. But if you have this one [*explain further* function], maybe [it'll] really help them to find the key point of the whole paragraph." On the other hand, students valued the dashboard's visual comparisons, enabling them to evaluate and reflect on their performance across courses (Figure 2, Steps 3 and 7), on assignments (Figure 2, Step 6), and even with peers (Figure 2, Steps 2 and 4) in the same class by visualizing comparisons of students' strengths, weaknesses, and action plans. For instance, VIP1 underscored the convenience of these comparisons, which enabled them to evaluate their performance in relation to their peers: "we don't know if we're actually doing good or bad, if we're on track; having a comparison against the class is really good."

Eliciting feedback This code looked into how students perceived PolyFeed as an aid in seeking feedback. The participants generally found PolyFeed useful in this aspect. Specifically, a number of features were cited by participants to support this process, including the *explain further* function supported by ChatGPT, short surveys on educators' feedback, and the *contact tutor* category in the *add to-do list* function. The participants indicated that these functions can streamline their feedback clarification process and foster better communication with educators. For example, VIP1 shared their struggles with understanding feedback provided by their educators, especially when direct interactions with educators are challenging. On the other hand, VIP10 highlighted the rarity of discussions with educators post assignment submission and valued the function of short surveys on educators' feedback (Figure 1, Step 4) to enable dialogue between students and educators.

Taking action and enacting outcomes This theme looked into students' perceptions of PolyFeed in helping them apply feedback to improve the current work or future tasks through setting goals, monitoring their progress, and reflecting upon the impact of feedback. In particular, they cited three ways PolyFeed can support them in this process: organizing feedback, formulating actions based on feedback, and tracking and monitoring their progress in implementing feedback. In terms of organizing feedback, PolyFeed allows students to annotate feedback by highlighting and labelling it with different categories (*strength*, *weakness*, *confusing*, *action items*, and *other*) and then creating a note (Figure 1, Steps 1 and 2). According to VIP14, this feature enabled students to organize feedback in a "more structured" way. Moreover, participants found value in the dashboard summaries of strengths and weaknesses (Figure 2, Step 5) and indicated that this feature could encourage students to more actively "turn feedback into action" (VIP12) rather than "reading it and then leaving it" (VIP10). Participants particularly mentioned the graphs depicting completion patterns of action points (Figure 2, Steps 1 and 8), suggesting that it allows them to stay focused and ensure they are on the right track because the visual data could "reveal areas where you might be falling short" (VIP9).

Appreciating and committing to feedback This code looked into how students perceived PolyFeed as a tool that could enhance their awareness of feedback as a valuable source of information and as a reciprocal process, subsequently influencing their attitude toward using feedback actively. The ability to regularly access and overview summary data on their interactions with feedback in PolyFeed made students appreciate feedback not just as a transient comment but as a continuous and valuable source of learning information. VIP5 articulated that PolyFeed "makes feedback more present," illustrating how the platform allows feedback to exist in a space where students can "see it more than once and revisit any time" (VIP5). After interacting with PolyFeed, VIP7 was surprised that they "never thought [that] feedback can be track[ed] down" and the platform made VIP7 more "statistically aware of [the feedback]." As indicated earlier, students found that the function to rate educators' feedback provided an opportunity for them to give feedback to educators about how they perceive the feedback (Figure 1, Step 4). They believed that this function can promote a mutual understanding between students and educators. This reciprocal exchange of feedback opens up "an opportunity for both educators and students to track and improve based on the feedback" (VIP7) so that "[feedback becomes] more meaningful for students" (VIP10).

Managing emotions This code examined how students perceive PolyFeed's support in managing emotional responses to feedback and how analytics motivate and guide their reflection and actions. Specifically, the peer comparison presented in the dashboards (Figure 2, Step 2, and Figure 1, Step 4) could aid students in benchmarking themselves against their peers, helping them regulate their emotions: "[the comparisons] show me that I need to work a bit harder and I'm not doing as well as I thought. Or I might think I'm doing really bad, but in reality, I'm doing better compared to the rest of the class." This recognition can inform reflections on their own work, transforming negative emotions into motivations and strategic actions. For example, VIP9 said, "If you feel you're constantly failing on something, but it's something that comes across the whole cohort, I guess it makes you feel less alone and it's motivating." Similarly, VIP3 admitted that while the comparison data can bring stress, "it's very useful, because it's really good to know if you are struggling in the same ways as everyone else." This could "help me to take initiative of my learning; I can recognise where I can improve" (VIP9).

5. Discussion

5.1 RQ1: Students' Experiences with Feedback and Their Feedback Literacy

This study explored the multifaceted dynamics of student feedback literacy by understanding the experiences, perceptions, and interactions of students with feedback. The primary goal was not only to understand their feedback literacy but also to leverage this understanding and engage students in the design process of a feedback analytics tool, with the aim to scaffold student feedback literacy. In response to RQ1, our findings revealed a noticeable discrepancy in the feedback literacy skills demonstrated by students. Students exhibited a significant degree of feedback literacy skills when discussing their current feedback practices in making use of feedback. However, their articulation of the challenges within the feedback process was predominantly attributed to challenges created by external factors. For instance, challenges include the lack of opportunities for students to use feedback in subsequent work (*learning design*); the absence of actionable, clear, and detailed feedback to act upon (*feedback characteristics*); and educators who are unapproachable and unresponsive (*agent characteristics*).

The study also found that students generally exhibited limited ability to *manage their emotions* effectively, particularly in relation to stress and disappointment encountered when receiving negative feedback. This lack of emotional management skills in the feedback process emerged as a significant barrier to students in using feedback effectively. This is in alignment with a previous study (Pitt & Norton, 2017), emphasizing that students' feedback cognition processes—including their ability to process, interpret, and use feedback effectively—are notably influenced by their negative emotional states, such as anger and frustration. On the other hand, a study by Olafson and Ferraro (2001) illustrated that emotional resilience to negative feedback can result in an enhanced motivation to respond to feedback, suggesting that positive emotional states (e.g., pride, gratitude) can enhance motivation to approach learning tasks. This highlights the importance of scaffolding students to *manage emotions*, since the emotional facet of feedback can directly influence the acceptance of feedback, behaviours related to eliciting feedback, motivation to learn, and the effectiveness of feedback (Carless & Boud, 2018; Price et al., 2010; Robinson et al., 2013; Yang & Carless, 2013).

5.2 RQ2: A Feedback Analytics Tool for Scaffolding Feedback Literacy

Based on the requirements identified in Phase 1, we designed a feedback analytics tool named PolyFeed. The tool contains three key functions: *annotate feedback*, *create work plan*, and *view summary*, validated in four scenarios. Specifically, PolyFeed collects data about students' sense-making of feedback (*annotate feedback*) and their formulation of actions (*create work plan*). Subsequently, the tool generates analytics regarding common strengths and weaknesses and actions across courses, assignments, and peers, along with insights into individual learning behaviours (feedback analytics). In response to RQ2, the students highlighted the potential of PolyFeed to scaffold their feedback literacy in accordance with the intentions behind the designed functions. Specifically, the *annotation* function enabled them to consolidate relevant feedback from various sources into a unified view by highlighting, labelling, and note-taking, thus eliminating the need to navigate between multiple locations. This feature made the feedback more accessible and easier to analyze and process. In this way, the participants found it possible to engage with feedback more deeply and derive actions based on it using the *create work plan* function. They also found the *view summary* function useful to help them monitor their learning progress and make sure that they are on the right track to their learning goals. The potential of PolyFeed to facilitate deeper engagement with feedback (actively making sense of feedback and deriving action plans) and reflection on learning as well as further dialogue with educators can instill a sense of *agency* in students, thus addressing one of the key findings in Phase 1, where there is a general lack of awareness among the students in terms of the active role they need to play in a feedback process.

5.3 Implications for Research and Practice

Winstone (2019) argued that making feedback impacts and interactions tangible can facilitate an ongoing feedback process, which could encourage students' engagement with and uptake of feedback. As such, we designed a feedback analytics tool that goes beyond the conventional use of LA for delivering feedback. Instead, this tool provides analytics on students' sense-making of feedback, their learning progress based on the feedback, and the progression of their planned learning activities, thus addressing the challenge of tracking feedback impact. The design of the tool is grounded in feedback literacy theories (Carless & Boud, 2018; Molloy et al., 2020), aiming to support the development of feedback literacy among students and address the misalignment of LA tools with educational theories (Tsai, 2022). It is important to highlight that feedback analytics needs to incorporate mechanisms that can assist students in managing emotions that may occur in the feedback process. As the validation of PolyFeed shows, the *view summary* function allows students to not only track their own learning progress but also benchmark it with their peers. This can reduce unnecessary stress evoked by feedback highlighting students' weaknesses. However, it would also be useful to make peer comparison optional, allowing individuals to activate relevant visualizations that are deemed helpful for their own learning.

Carless and Boud (2018) highlighted the proactive nature of feedback-literate students in seeking suggestions. PolyFeed builds upon this capacity by enabling students to obtain further clarifications (*eliciting feedback*) not only from educators but

also through interactions with artificial intelligence (AI) (e.g., ChatGPT), specifically by employing LLMs. This approach supports students in making evaluative judgments about their work, helping them distinguish between constructive and unhelpful feedback (*processing feedback*). By engaging in dialogue with ChatGPT, students can receive further explanations about the feedback they have received, thus enhancing their understanding and fostering more effective application. However, reliance on AI-generated explanations, as opposed to original feedback from educators, raises concerns among students regarding privacy, accuracy, and the risk of receiving misleading information. Additionally, sharing educators' feedback with third-party service providers introduces ethical issues related to LA, including data ownership, transparency, validity, and reliability (Slade & Tait, 2019). While ChatGPT could potentially aid in scaffolding feedback literacy, it is crucial to address these ethical concerns in the development of feedback analytics. For example, although students can choose whether or not to use the *explain further* function supported by ChatGPT in PolyFeed, concerns about the use of LLMs in elaborating educators' feedback need to be addressed by offering a clear disclosure indicating that the explanations are LLM-generated. Moreover, developing an LLM based on discipline-specific feedback may increase the accuracy of the explanations on feedback provided to students. Finally, the formulation of policies on the use of LLMs in feedback contexts can address some concerns raised in this study through collective efforts of researchers, policy makers, educators, and students.

6. Conclusion

The study highlighted that cultivating students' awareness of their proactive roles and fostering emotional management within the two-way feedback process are crucial. We presented a feedback analytics tool, PolyFeed, to demonstrate the potential of feedback analytics in addressing these and in scaffolding students' overall feedback literacy. However, involving students in the design and development of feedback analytics tools is essential to ensure that these tools address their nuanced needs and the challenges they face with feedback, as well as supporting them in effectively using the feedback. Additionally, the study has limitations in terms of selection bias, with participants possibly having a higher inclination toward feedback. Our future work thus aims to pilot PolyFeed in a real classroom setting involving a larger student sample. In addition, based on the insights from this study, we plan to adopt a similar approach to develop an educator-facing tool, aiming to support educators to facilitate effective feedback processes. We are inspired by the work of Lin and colleagues (2023), which demonstrated how leveraging LLMs can significantly enhance the feedback process by providing real-time corrective feedback to educators. Building upon these findings, our educator-facing tool will aid educators in refining and tailoring their feedback strategies more effectively. It will offer guidance on improving the content and structure of the feedback they provide to students, thereby enhancing both the quality and the impact of feedback provided to students. The combination of student- and educator-facing tools is expected to build an interactive and integrated feedback process, thereby enriching the learning and teaching experience.

7. Declaration of Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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