Effectiveness of Scrum in Enhancing Feedback Accessibility among Undergraduate Research Students: Insights from Integrated Feedback Dynamics Framework

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Abstract

Background: Undergraduate research experiences hold great potential for students to develop critical thinking skills, engage in hands-on learning, and contribute to academic and professional growth. Central to the success of these research experiences is the accessibility of timely and constructive feedback, which aids in students' development and performance. Traditional approaches to research program management in such contexts often lack structured feedback mechanisms. However, the Scrum framework of project management offers a structured framework that could potentially enhance feedback accessibility.

Purpose: This study aims to evaluate the effectiveness of the Scrum framework in enhancing feedback accessibility and effectiveness in undergraduate research mentoring. The specific research question of the study is: *"How does the implementation of the Scrum framework influence the dimensions of feedback sources, timing, content, and use in undergraduate research programs?"* By focusing on this overarching question, the study seeks to offer valuable insights into the potential benefits and challenges of applying agile methodologies, aiming to enrich the mentoring experience and improve learning outcomes and student satisfaction.

Methods: The study was conducted in a senior-level undergraduate course offered at a large midwestern university. The course focused on project management, research skills, and mentorship in the context of a research project. Data were collected through guided student reflections at the end of the semester and analyzed thematically according to the " Integrated Feedback Dynamics Framework," comprising four dimensions: Feedback Sources, Feedback Timing, Feedback Content, and Feedback Use.

Results: Implementation of Scrum resulted in a diverse range of feedback sources, with students valuing the multiple perspectives received. Timely feedback emerged as a significant benefit, with weekly stand-up meetings and milestone retrospectives allowing for rapid, responsive feedback. The content of feedback was praised for its specificity and relevance, guiding students in refining their research effectively. Furthermore, students demonstrated a strong engagement with the feedback, applying it methodically to their work and expressing appreciation for the iterative improvement it enabled.

Implications: The findings highlight the transformative power of structured feedback in Scrum, enhancing teamwork, co-regulation, and metacognition in undergraduate research. The study suggests the potential of agile methodologies like Scrum in educational settings to improve feedback processes and student engagement. However, it acknowledges the need for a balance between structured feedback and self-directed learning in research education.

Keywords: Feedback accessibility, undergraduate research, Scrum, Project Management, cooperative learning, teamwork, research mentoring, feedback literacy, Integrated Feedback Dynamics Framework

1. Introduction

1.1 Undergraduate Research Mentoring

Undergraduate research mentoring is a critical component of undergraduate research programs which have increasingly become a focal point in higher education, offering students an opportunity to engage in meaningful, hands-on learning experiences [1], [2]. These programs are instrumental in developing critical thinking, creativity, and problem-solving skills, which are essential for academic and professional success [3], [4], [5]. They also provide a platform for students to immerse themselves in research methodologies, enhancing their understanding of their field of study [6]. Such experiences not only foster a deeper academic engagement but also prepare students for future research endeavors or professional careers [7]. Moreover, undergraduate research has been linked to increased student retention and satisfaction, highlighting its impact on the overall educational experience [8], [9].

Research mentoring plays a crucial role in these programs by providing guidance, support, and expertise to help students navigate their research projects effectively [2], [10]. Current mentoring processes often involve one-on-one interactions, group meetings, and continuous assessment, but they may vary significantly across disciplines and institutions. Despite the recognized importance of mentoring, there are gaps in its practice. One major challenge is the inconsistency in mentorship quality and approach, which can lead to varied student experiences and outcomes [11]. Studies have shown that inconsistency in mentorship quality and approach often stems from varying mentor experiences, expectations, and institutional resources, leading to disparate student outcomes across disciplines and universities [10]. This variability has been analyzed through surveys and longitudinal studies, revealing significant differences in student research experiences and highlighting the need for standardized mentorship practices [11].

1.2 Feedback Processes in Undergraduate Research Mentoring

Feedback plays a pivotal role in the mentoring process within undergraduate research programs. Effective feedback mechanisms are crucial for guiding students through complex research processes, ensuring they learn from their experiences and enhance their skills [12], [13]. Constructive feedback from mentors helps students to refine their research questions, develop robust methodologies, and critically analyze their findings [14]. Furthermore, feedback is not just limited to academic or technical aspects; it also encompasses guidance on professional development and career planning, significantly influencing students' future paths [15]. The quality and frequency of feedback are key factors in the success of undergraduate research experiences, impacting students' confidence, motivation, and overall learning outcomes [16].

Current feedback methods in URPs often involve informal discussions, written comments on work, and periodic evaluations. However, these methods can sometimes be inconsistent and lack timely responses, which are crucial for students' progress [15]. The gaps in current feedback processes include a lack of continuous and structured feedback, which can impact students' motivation and confidence [16]. Additionally, there is often a limited focus on feedback regarding professional development and career planning, which is essential for students' future success [7].

1.3 Purpose of the Study

The purpose of this study is to address these gaps by evaluating the effectiveness of Scrum, an agile project management framework, in enhancing feedback accessibility and effectiveness in undergraduate research mentoring. The study is motivated by the need for more structured, consistent, and holistic feedback processes in URPs. By adopting the "Integrated Feedback Dynamics Framework," (IFDF) this research aims to systematically assess how Scrum can transform feedback dynamics in terms of sources, timing, content, and use. This approach seeks to enrich the undergraduate research mentoring experience, thereby potentially improving learning outcomes and student satisfaction in URPs. It is important to note that structured feedback may occasionally limit creative freedom and self-learning, its benefits, particularly for undergraduates engaging in research for the first time, significantly outweigh such limitations, offering a guided and supportive environment critical for their development [17].

The specific research question is: *"How does the implementation of the Scrum framework influence the dimensions of feedback sources, timing, content, and use in undergraduate research programs?"* By focusing on this overarching question, the study seeks to offer valuable insights into the potential benefits and challenges of applying agile methodologies, specifically Scrum, in enhancing the feedback experience for undergraduate researchers.

2. Conceptual Framework

The IFDF model developed for this research paper is a carefully constructed synthesis of established theoretical frameworks and scholarly literature, specifically tailored to explore feedback dynamics within Scrum-facilitated undergraduate research environments. By bridging the gap between theoretical models and real-world applications, the framework provides a robust basis for understanding and enhancing the feedback dynamics in undergraduate research settings, ultimately contributing to the enhancement of learning outcomes and research productivity.

The framework is structured around four key dimensions - Feedback Sources, Feedback Timing, Feedback Content, and Feedback Use. These dimensions were selected for their recurrent emphasis in the educational and organizational literature, highlighting their critical role in effective feedback processes [18], [19], [20], [21]. Each dimension encapsulates a vital aspect of feedback that collectively addresses the holistic needs of learners in a Scrum-based environment, as depicted in Figure 1.

1. *Feedback Sources:* This dimension is informed by Boud and Molloy's [18] work on the importance of diverse feedback sources in developing feedback literacy. The framework also draws from Nicol and Macfarlane-Dick's [20] principles of good feedback practice, emphasizing the role of peer and self-assessment in feedback processes. In the context of Scrum, this dimension reflects the framework's collaborative nature, where feedback sources are not limited to the traditional instructor-student dynamic but include peers and self-reflection [22].

2. *Feedback Timing:* Timeliness in feedback is highlighted by Hattie and Timperley's [19] model of effective feedback, which emphasizes the importance of immediate feedback in learning processes. This aspect is mirrored in the Scrum methodology, where regular sprint reviews and retrospectives [23] provide structured yet flexible timelines for feedback, aligning well with the need for immediate and ongoing feedback highlighted in educational literature.

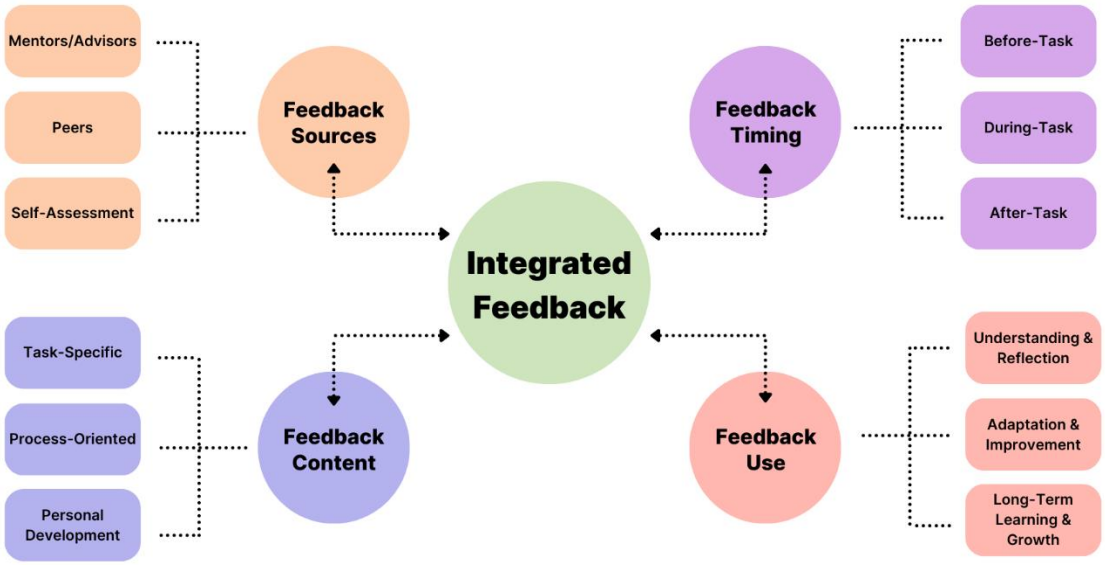

Fig 1. Integrated Feedback Dynamics Framework

3. *Feedback Content:* Drawing from Hattie and Timperley's [19] work, this dimension stresses the need for feedback to be clear, purposeful, and task-oriented. Additionally, Sadler's [21] theory of formative assessment and feedback reinforces the need for quality feedback that enables learners to close the gap between current and desired performance. In Scrum, this translates to feedback that is specific, goal-oriented, and directly related to the tasks at hand. This alignment with Scrum's focus on specific deliverables and outcomes ensures that feedback is not only constructive but also directly applicable to the students' ongoing projects.

4. *Feedback Use:* Informed by Carless and Boud's [24] research on students' engagement with feedback, this dimension focuses on the application and implementation of feedback. This dimension is reflected in Scrum's iterative process, which is consistent with Kolb's [25] experiential learning theory, where feedback is continually applied and leads to continuous improvement and learning.

3. Learning Design

3.1 Learners and Context

The study context is an in-person, 3-credit, 16-week, 'Independent Study' research experience for junior and senior undergraduate students in the Computer and Information Technology

department of a large midwestern university in the USA. This practice-based course provides students with the foundational knowledge and strategies that will enable them to conduct research. Students are divided into teams, with each team advised by a consultant, who is a subject matter expert (typically junior professors or postdocs). They work on a semester-long research project by first identifying a research question, conducting a brief literature review on the topic, analyzing data, applying qualitative, quantitative, or computational analytical methods to derive insights from the data, and presenting their findings in the form of a technical report and oral presentation. Additionally, there are 1-2 teaching assistants (TAs) or mentors, typically graduate students, who provide day to day mentoring as well as course management support. These TAs are trained in project management processes as well as Scrum methodology implementation. Finally, there is a course professor who serves as a guide for both the students and the mentors. The course professor oversees the overall progress of the research projects ensuring that the course objectives are met and facilitating the integration of theoretical knowledge with practical research skills.

3.2 Learning Objectives

The research experience has the following learning objectives:

- Students will be able to demonstrate research project management skills.
- Students will be able to demonstrate knowledge of research foundations skills.
- Students will be able to demonstrate a positive attitude towards project management and research skills.

3.3 Pedagogy – Scrum Framework

The pedagogical approach used in this study is Scrum. Scrum is a framework for project management that emphasizes teamwork, accountability, and iterative progress toward a well-defined goal [23]. Originating from the premise of beginning with the known or visible and adapting as progress is made, Scrum embodies three critical roles. The *Scrum Master* focuses on ensuring the team's efficiency and adherence to Scrum values, which includes facilitating meetings and addressing obstacles. The *Product Owner* aligns the team with the overarching goals of the product, integrating customer expectations and market trends. The *Development Team*, consisting of professionals like engineers, designers, and analysts, executes the tasks in a Scrum sprint, sometimes consulting Subject Matter Experts (SMEs) for specialized guidance.

Scrum is a widely accepted and followed methodology in the technology sector, particularly in software development, where products are delivered in increments or *Sprints* typically spanning 2–4 weeks [23]. Each sprint begins with a planning meeting and includes *daily stand-up* meetings where team members discuss their recent work, plans for the day, and any impediments. The sprint concludes with a *demonstration* to stakeholders and a *team retrospective*, aimed at evaluating performance and planning improvements for subsequent sprints. Scrum produces four primary artifacts: the *product backlog* (a comprehensive task list for the final product), the *sprint backlog* (tasks chosen for the current sprint), *the increment* (the unfinished product at the end of a sprint), and the *final product*.

Since Scrum principles were developed to address software development in the IT industry, a

modified version of these principles [4] was used to fit the context of the research projects for the course.

- Roles: In the research project context, the course professor takes on the role of the *product owner*, guiding the overall direction of the research. Undergraduate research students form the *development team*, executing research tasks. Course teaching assistants serve as the *scrum master*, facilitating the process and addressing issues. Individual project consultants are analogous to *SMEs*.
- Events: Traditional 2–3-week *sprints* are adapted into 1-month *milestones*. *Sprint planning* becomes *milestone planning*. The *daily stand-ups* are transformed into *weekly stand-ups*. The *sprint demo* and *sprint retrospective* are paralleled by *milestone presentations* and *milestone retrospectives*.
- Artifacts: The *product backlog* is mirrored by the *research tasks list* and the *sprint backlog* by the *milestone tasks list*. *Increments* correspond to *milestone presentations*, and the *final product* translates to the *technical report*.

This adaptation of Scrum to a research setting enables a structured yet flexible approach to managing research projects, aligning with contemporary pedagogical practices that emphasize active learning and collaboration [26].

3.4 Operationalizing Integrated Feedback Dynamics Framework

In this study, the IFDF was operationalized within the Scrum-based undergraduate research course to enhance the feedback process. To diversify *feedback sources*, several measures were implemented. Firstly, peer and mentor feedback was integrated into weekly stand-up meetings and milestone retrospectives. This approach encouraged collaborative learning and promoted a culture of mutual support and constructive criticism. Additionally, consultants and the course professor offered expert feedback during milestone presentations, ensuring that students received professional insights into their research progress. The integration of multiple feedback sources provided students with a well-rounded feedback experience.

Timely feedback was a critical focus of the course design. The weekly stand-up meetings allowed for immediate feedback on students' weekly progress, challenges, and next steps, allowing students to receive prompt responses to their queries and concerns and adjust their work swiftly. The milestone retrospectives, held at the end of each month, provided a structured opportunity for more comprehensive feedback on the research projects, enabling students to reflect on their progress and plan for future milestones.

The *feedback content* was carefully structured to be specific, constructive, and relevant to the tasks at hand. During milestone presentations, feedback focused on the quality of research methods, the validity of findings, and the clarity of presentations. This specificity ensured that students could directly apply the feedback to improve their research projects. Additionally, feedback during weekly stand-ups was targeted at immediate tasks, helping students stay on track and address any issues in a timely manner.

To facilitate effective *feedback use*, the course incorporated reflective practices. After receiving

feedback, students were encouraged to reflect on it during their weekly stand-up meetings and incorporate it into their subsequent work. This reflection process was supported by the mentors (TAs) and consultants, who guided students in understanding the feedback and developing action plans. Moreover, the guided reflection at the end of each milestone and semester allowed students to retrospectively evaluate how the feedback received throughout the course had influenced their learning and research.

Through the operationalization of the IFDF framework within the Scrum framework, the course aimed to create a dynamic, supportive, and effective learning environment. This approach was designed to enhance students' feedback accessibility and literacy, improve their research skills, and foster a deeper engagement with their projects.

4. Methods

4.1 Context & Participants

The study was conducted at a large research-based Midwestern university involving five students who participated in the 16-weeks, in person, 3 credit undergraduate research experience (as described in the previous section). These students were divided into three teams: two teams consisting of two students each and one team with a single student. The participant demographics included one male and four females. In terms of academic classification, two students were sophomores, one was a junior, and two were seniors. The students' majors were divided between Cybersecurity (2 students) and Computer & Information Technology (3 students). This diverse group provided a range of perspectives on the research experience and the feedback processes involved.

The teams worked on three semester long research projects, that were later published in peer reviewed journals or conference proceedings, including, 1) Transformative Pedagogy as a Reflective Approach for Promoting Intercultural Self-Awareness in the Context of Teamwork [27], 2) Information Technology Undergraduate Students’ Intercultural Value Orientations and Their Beliefs about the Influence of Such Orientations on Teamwork Interactions [28] and 3) Supporting Teamwork Development Through Cooperative Learning and Real-Time Collaboration Platforms: Teamwork Attitudes and Perceptions in a Large-Size Course (Under Review).

4.2 Data Collection

Data was collected through guided written reflection submitted by the students at the end of the semester, focusing on their experiences within the research program. The reflections encouraged students to share aspects of the program they appreciated, elements they would like to change, any challenges they faced, and any strategies they employed to overcome the challenges encountered. This approach allowed for the collection of rich, qualitative data on students' experiences and perceptions.

4.3 Data Analysis

The data analysis was carried out using thematic analysis to provide an in-depth understanding of the students' experiences and perceptions of the research program and its feedback mechanisms. Initially, the students' written reflections were collated and prepared for analysis. They were then read multiple times to gain a deep familiarity with the content. The analysis began with a line-by-line coding of the data. During this phase, the researchers identified meaningful segments of text and assigned codes to them. The IFDF framework was integral to this step. Data were analyzed in the context of this framework, assessing how it related to the framework's four dimensions: Feedback Sources, Timing, Content, and Use. This approach provided a structured lens through which to view and interpret the data, ensuring that the analysis remained focused on the research objectives. This process was also iterative, with initial codes being refined, combined, or split as more data were reviewed. A coding scheme was developed, which served as a reference for ensuring consistency throughout the coding process. Following coding, the codes were examined to identify patterns and themes. This was a recursive process, where the researchers moved back and forth between the dataset and the developing set of themes, refining and defining them. Themes were identified based on the recurrence, relevance, and significance of the codes in relation to the research question. These refined themes formed the basis for the results section.

4.4 Ethical and Trustworthiness Considerations

Ethical considerations were addressed by obtaining informed consent from the participants and ensuring that they were aware of the purpose of the study, their rights as participants, and the potential risks and benefits involved. Confidentiality and anonymity were maintained by removing any person identifiers from the data, assigning pseudonyms to the participants, and storing their data securely. The trustworthiness of the data analysis was enhanced by involving a second coder who independently coded a portion of the data, achieving an inter-rater reliability (IRR) of 96%. This high level of IRR indicated a strong agreement between coders, adding to the reliability of the thematic findings. Furthermore, peer debriefing sessions were conducted throughout the analysis process, offering opportunities for discussion, challenging assumptions, and ensuring unbiased data interpretation. These measures collectively helped uphold the ethical standards of the study and reinforce the credibility and reliability of its findings.

5. **Results**

The thematic analysis of students' reflections revealed insights into the effectiveness of the Scrum framework in enhancing feedback accessibility in the undergraduate research course. The following themes emerged:

The adoption of Scrum in the research course facilitated a diverse range of feedback sources, which students found invaluable. One student noted, “Also, I was lucky to do research with my partner, so we could easily share information and ask questions to each other.” This highlights the benefit of peer collaboration in feedback processes. Another student mentioned the variety of feedback sources available, stating, “Having multiple different resources to be able to reach out to, from mentors and consultants to the professor made it incredibly useful to get distinct opinions helpful to the project.” This diversity in feedback sources was highly

appreciated by the students, as one reflected, “Not only my classmates but also mentors and consultants were willing to help me with many things. Difficulties could not arise. I enjoyed this class.”

Timely feedback was a key strength of the Scrum framework, as evidenced by student reflections. One student commented on the effectiveness of the weekly stand-up meetings: “The weekly standup meetings and the SCRUM approach to completing the project were useful in allowing us to provide details on the stage of the project we currently were on and how to deviate from there if needed.” The consistent and fast feedback was also appreciated, as another student stated, “Mentors and consultants checked the progress constantly and gave feedback fast.” This was even more critical since most students were participating in research for the first time - “I thought that the consistent feedback loop was really well done throughout and I really appreciated it. Especially this being my first research paper, it was really nice to understand how our paper should be written, and what specific parts should be improved. I really appreciate the guidance provided by everyone involved”. The regular check-ins helped in early error detection, as one student noted, “I checked in regularly to see whether my partner needs any help and is on track with the goals. This resulted in many mistakes being caught early on which was good.”

The content of the feedback received was noted for its helpfulness and specificity. One student expressed satisfaction with the guidance provided, saying, “The check-in meeting time was helpful for me to keep working on my tracks.” while another student remarked, “Before starting this project my main worry was that we would be totally left to our own devices with minimal guidance. I really like that there were incremental assignments due and that there was guidance and feedback for everything. I think I learned a lot more this way”. The structured feedback approach contrasted positively with previous experiences, as another student remarked, “I know a lot of teachers would just take points off, and generally mark down the paper as being ‘wrong’ without actually guiding us to what specific points or how we can improve our paper. However, this was not the case in this class, which I believe enhanced our learning experience.”

Students demonstrated a high level of engagement with the feedback received, applying it effectively in their work. One student reflected on the impact of this feedback on improving work efficiency: “We knew that we would receive feedback on our presentation, which became the basis/outline of our paper, we could also incorporate the feedback received on our presentation straight to the paper without having to rewrite the whole paper”. Another student highlighted the iterative nature of feedback, stating, “everytime we got it back for feedback, it ensured that our paper only got better and better after each iteration.” The feedback also had a positive influence on students’ future aspirations, as multiple students shared, “guidance and the feedback provided was really useful. I definitely see myself going to grad school now and I am no longer as intimidated to have to read manuscripts or write a research paper.” “After taking this course, I really understood the research process and appreciated all the guidance my mentors, consultants, and Dr. <professor name> provided for us… helps me better prepare myself for the future and I now know what to expect from grad school.”

Students attributed their highly positive experience in the course to the effective mentorship

and feedback processes. One student expressed, “I think my biggest strength while working as a team was my mentors. Since I didn’t know anything about this process they really helped me. I never felt panicked or that I was alone and therefore I felt like I was really learning.” The supportive environment fostered by mentors and consultants was also appreciated, as another student remarked, “I really appreciated the help my mentors and consultants provided for me. They made it clear that they were there to help us and are willing to help us with anything. They encouraged us to ask questions and I have never felt scared to ask a question to the team.” The ability to overcome challenges through collaborative efforts was also emphasized, with a student noting, “Even if we can face unexpected difficulties in the middle, we will be able to overcome them because we have partners and mentors.”

6. **Discussion and Implications**

The study's findings offer several implications for the practice of undergraduate research mentoring and the broader field of educational pedagogy, especially concerning feedback processes and the use of agile methodologies like Scrum in educational settings.

6.1 Transformative Power of Feedback Processes

The guided reflection did not specifically prompt students to discuss their experiences with feedback loops and mentoring processes. Their voluntary and spontaneous emphasis on feedback processes highlights the profound impact that structured feedback, as facilitated by Scrum, had on the students' learning experience. This observation is supported by Boud and Molloy [18] who emphasize the transformative power of feedback in shaping student learning. They argue that effective feedback not only informs students about their performance but also engages them actively in the learning process, a notion evidently reflected in the students' reflections. Additionally, it suggests that when students perceive feedback as meaningful and constructive, it can significantly enhance their learning experience and satisfaction [19]. This aligns with the broader educational literature that positions feedback as a critical component of effective teaching and learning [20], [29].

6.2 Value of Teamwork in Undergraduate Research

The students’ reflections emphasize the positive impact of collaborative feedback loops and mentoring processes enabled by the Scrum framework. It is important to note that the collaborative dynamics fostered by Scrum extend beyond immediate project outcomes. These interactions cultivate a sense of community and mutual responsibility among students, which is crucial for their holistic development [30]. Active engagement in team-based activities not only enhances academic skills but also nurtures essential soft skills like communication, leadership, and empathy, which are vital in today’s interconnected and collaborative professional world [27], [31]. Additionally, the diversity of perspectives within a team enriches the research process, fostering a more inclusive and comprehensive approach to problem-solving and learning [28]. This aligns with Vygotsky's [32] social development theory, which states that social interaction plays a fundamental role in the development of cognition, emphasizing the value of collaborative learning environments in facilitating deeper understanding and skill development in undergraduate research.

6.3 Enhancement in Co-Regulation, Reflective Practices and Metacognition

The structured approach to feedback provided by Scrum in this study facilitated co-regulation among students. According to Hadwin and Oshige [33], co-regulation involves shared regulation of learning and performance, where individuals support each other's metacognitive, motivational, and behavioral processes. The regular feedback cycles in Scrum encourage students to reflect on their learning processes, thereby fostering their metacognitive skills [34], [35]. Students' ability to reflect on and utilize feedback effectively highlights an essential aspect of metacognition in learning [36]. Furthermore, the study echoes Nicol and Macfarlane-Dick's [20] principles of good feedback practice, which emphasize self-regulation as a key outcome of effective feedback processes. The results from this study indicate that Scrum can be an effective tool for enhancing students' feedback literacy, co-regulatory abilities, reflective practices and metacognition.

6.4 Balancing Benefits and Constraints of Structured Feedback

While structured feedback provides clarity and direction, it may also pose limitations by potentially restricting spontaneous exploration, independent problem-solving, and organic self-reflective growth - elements that are crucial int research education. However, for undergraduate students, particularly those new to research, a structured feedback process can be significantly beneficial since they require more guidance to navigate the complexities of research methodologies and academic expectations. Scrum offers a structured approach without being overly rigid, thus allowing room for self-directed learning and creativity. This structured yet flexible approach positively impacted student motivation and engagement, as revealed by study findings. This observation is in line with Ryan and Deci's [37] Self-Determination Theory, which emphasizes the importance of autonomy, competence, and relatedness in fostering intrinsic motivation. The Scrum framework, with its emphasis on self-organizing teams and iterative feedback, appears to promote these elements, thereby enhancing student motivation and engagement. This finding suggests that incorporating agile methodologies like Scrum in educational settings can create an environment conducive to active learning and student empowerment.

6.5 Recommendations for Educators and Curriculum Designers

Based on these findings, educators and curriculum designers are encouraged to explore the integration of agile methodologies like Scrum in their teaching practices. This could involve professional development workshops to train educators in Scrum and other agile frameworks, as well as the redesign of course structures to incorporate these methodologies. Moreover, the study suggests the need for educational institutions to rethink traditional feedback mechanisms and embrace more collaborative and iterative approaches to improve students' engagement, learning, and metacognitive skills.

7. Conclusion, Limitations, and Future Work

This study explored the effectiveness of the Scrum framework in enhancing feedback

accessibility among undergraduate research students. The integration of Scrum into the undergraduate research course was found to significantly improve the feedback process, aligning with key dimensions of the Integrated Feedback Dynamics Framework. The study's findings indicate that Scrum facilitated diverse and timely feedback sources, enhanced the relevance and specificity of feedback content, and promoted effective utilization of feedback by students.

While the study provides insightful findings, it is important to acknowledge its limitations. First, the study was conducted in a specific context - a single university and within a particular department, which may limit the generalizability of the findings. Second, the small sample size of five students offers a limited perspective and may not fully capture the range of experiences in such programs. Third, the study relied on self-reported data, which may be subject to bias and may not fully reflect the actual impact of the Scrum framework on students' research skills and feedback literacy.

To build on this research, future studies should consider expanding the sample size and including a more diverse range of academic disciplines to enhance the generalizability of the findings. Longitudinal studies could provide deeper insights into the long-term effects of using Scrum in educational settings. Additionally, incorporating quantitative measures, such as performance metrics or grades, could offer a more objective evaluation of the impact of Scrum on student learning and feedback processes. Exploring the adaptation of other agile methodologies in education could also provide valuable comparative insights.

Overall, the study contributes to the growing body of literature on the application of agile methodologies in education and highlights the potential of Scrum in enhancing feedback accessibility and improving learning outcomes in undergraduate research settings. The findings of this study provide a foundation for further exploration into innovative pedagogical strategies that harness the strengths of agile frameworks to enrich the educational experience of students.

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