Undergraduate Student Experience with Research Facilitated by Project Management and Self-regulated Learning Processes

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Abstract

Background: There is a growing popularity of undergraduate research programs (URPs) as they benefit students, faculty mentors, and the university. However, maintaining URPs is often difficult. Therefore, it is critical to find ways to reduce the workload of faculty mentors and develop self-regulation in undergraduate research students. To address this need, we implemented Scrum methodology as a framework to manage three teams of undergraduate students pursuing undergraduate research projects during a semester and promote self-regulated learning skills.

Purpose: The study was designed to gather insights into the students' experience with the research course and understand what self-regulated learning skills they developed as part of this learning experience. Specifically, the study examines "*What are students' perceptions of the role of self-regulated learning and project management skills in the context of their research project?*"

Methods: The study was conducted in a senior-level undergraduate course offered at a large mid-western 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 stages of self-regulated learning, i.e., planning, performance, and self-reflection.

Results: Results indicate that students had prior knowledge of project management but lacked familiarity with the research process. Students encountered project management challenges, but effective communication and clear goal setting were key strategies in meeting deadlines and completing coursework. Students valued collaboration and continuous mentoring, and the course had a positive impact on students' understanding and interest in research, as well as their development of transferable skills for future practice. Overall, this study highlights the importance of project management skills and mentorship in promoting self-regulated learning and research skills in undergraduate students.

Implications: Implications of this study relate to (1) the need to provide students with professional skills, such as project management and teamwork, in addition to research skills to help them cultivate self-regulated abilities and (2) methods for facilitating undergraduate research.

Keywords: undergraduate research, self-regulated learning, project management, scrum, mentoring

1. Introduction

Undergraduate research is often described as the exploration of a specific research topic by an undergraduate student - on their own or in collaboration with faculty members or other students - to make an original contribution to the discipline. It is a recent concept in the academic community, with roots in the nineteenth and twentieth centuries. The creation of MIT's Undergraduate Research Opportunities Program in 1969 encouraged an explosion in popularity such that Undergraduate Research Programs (URPs) became fairly common globally by the 1990s.

Developing and maintaining URPs benefit students, faculty mentors, and the university equally. Incorporating a research component along with a sound academic foundation enables students to gain research and professional experience, work on real-world applications, develop oral and written communication skills as well as better relationships with faculty and peers [1]. According to Thiry et al. [2], "Through coursework and out-of-class experiences, students described learning to work and think independently, to take responsibility for their learning, and to take the initiative to solve problems on their own rather than relying on experts for the answers." In addition, institutions find value in promoting undergraduate research to recruit and retain students and prepare them for graduate studies [3]. However, maintaining URPs is often difficult. Students have busy academic and social schedules. This often causes challenges in scheduling research activities around students' classes and other commitments. It is also difficult for students to realistically determine the scope of their work commitments or assignments in a semester, and therefore they frequently run into time management issues. Since there is no standard method for managing URPs, the responsibility of managing these logistics falls on the faculty mentors. As a result, faculty mentors devote considerable time to managing research logistics along with their teaching and research responsibilities [4]. Therefore, it is critical to find ways to reduce the workload of faculty mentors and develop self-regulation in undergraduate research students.

Even though results from the previous research have provided few methods of how processes in URPs can be streamlined, there does not exist a comprehensive framework or model to guide practices, responsibilities, processes, and events to effectively implement URPs. Therefore, the critical need to develop a model - comprehensive, scalable, and transferrable across disciplines and universities - for effective URP management remains. To address this need, we implemented a Scrum methodology as a framework to manage undergraduate research projects. Scrum is a framework for project management that emphasizes teamwork, accountability, and iterative progress toward a well-defined goal. It is a widely accepted and followed methodology in the IT industry. For this study, the Scrum framework was adapted to manage projects and promote self-regulated learning skills in the context of research projects. We implemented this framework to manage three teams of undergraduate students pursuing undergraduate research projects during the course of a semester. To gather insights into the students' experience, we asked them to submit a guided final reflection at the end of the semester prompting them to describe what self-regulated learning skills they developed as part of this learning experience. The questions were categorized based on three phases of self-regulated learning – forethought, performance, and self-reflection. A qualitative analysis was used to identify patterns in students' responses.

2. Research Question

The overall research question is: *What were students' perceptions of the role of self-regulated learning and project management skills in the context of their research project?*

Sub-Question 1 (Forethought): What was the level of familiarity that undergraduate students had with project management and research prior to taking a formal research course?

Sub-Question 2 (Performance): What project management challenges did undergraduate students face during a research course, and how did they overcome these challenges to successfully complete their project?

Sub-Question 3 (Self-Reflection): What impact did the research course have on undergraduate students' skills and knowledge and interest in research?

3. Background

Various efforts have been made to effectively organize and manage undergraduate research programs (URPs). One of the efforts, as suggested by Weldon and Reyna [5] and Thornton et al. [6], is to design a lab manual that outlines clear expectations for undergraduate researchers in the lab to help with a smooth transition for new students so that faculty mentors do not have to reinvent the wheel each time a new student joins the laboratory. The lab manual would include components like grading policy, teamwork expectations, communication methods, and policy, emphasis on initiative, professionalism, quality work, and positive attitude, domain knowledge requirements, technology needs and tutorials, the relationship between graduate and undergraduate researchers, and expectations around progress check-ins. Furthermore, Weldon and Reyna [5] recommended assigning concrete laboratory tasks to students – the more specific, the better. Examples of concrete educational tasks include running specific data analyses (e.g., run a correlation between sensation-seeking score and proportion of risky choices) or finding a certain number of recent articles on a certain topic (e.g., create a spreadsheet that includes 10–15 articles on fMRI studies of adolescent risky decision making). It is also important for mentors to develop well-defined projects with student interest and ability in mind since many undergraduate students may or may not have previous experience in research [7].

Another way of facilitating undergraduate research is to schedule regular weekly and monthly meetings to check in on progress, roadblocks, and accomplishments [8]. A mentor should host regular research update meetings and provide direction as needed. Additionally, a mentor should provide meaningful feedback on students' scholarly products during these meetings or on a regular basis. Students should be encouraged to revise work or ask new questions. ([7], [9], [10], [11], [12]). Wenderholm [13] highlighted the importance of giving students the freedom and lots of creative licenses since that led to them not only coming up with great ideas but also implementing them, much to the delight of the research ecologists.

Knox, DePasquale, and Pulimood [14] developed a model for undergraduate research experience for furthering faculty scholarship while introducing students to emerging technologies and

building a strong research community at undergraduate institutions. According to the model, there should be weekly/biweekly faculty guidance with a 2:1 student: faculty ratio, team meetings, program meetings with team reports, topical discussions, and peer mentoring to foster independent research skills as a contributing group member. There should also be regular project progress report presentations, student-led presentations on techniques, tools, or background information, poster presentations, or wiki to strengthen student communication and presentation skills. It is important to note, in the post-COVID era, that arrangements must be made to work through unforeseen situations. As such, faculty mentors and participating students should have fallback plans in case classes are moved to hybrid or fully online schedules. Appropriate communication channels and research methods should be identified and deployed in such scenarios [15].

4. Theoretical Framework

The constructivist perspective of self-regulated learning was the theoretical framework guiding the design of this study. Constructivist perspectives emphasize that to be able to acquire knowledge, it is necessary to experience that knowledge personally. In constructivist learning, the "process of learning" has more importance than "the products of learning" [16]. Constructivist teaching is based on recent research about the human brain and what is known about how learning occurs. According to Caine and Caine [17], the brain processes information all the time. It digests experience to some extent in the same way that we digest food. It is always responding to the complex global context in which it is immersed. Brain-based education, therefore, involves: (1) designing and orchestrating lifelike, enriching, and appropriate experiences for learners and (2) ensuring that students process experience in such a way as to increase the extraction of meaning. Constructivist teaching is, therefore, rooted in principles of brain-based education.

Self-regulated learning is a constructivist approach that refers to one's ability to understand and control one's learning environment. Constructive or self-regulated learning environments are most effective where initial misconceptions and biases can be discovered and negotiated. Since we are dealing with undergraduate students, prior misconceptions and biases regarding research foundations and project management skills are usually difficult to exist, and even if they do, the initial reflection or self-evaluation will help the instructor identify them and employ ways to fix them as well. Constructivist strategies include using real-world contexts, and in the learning design of the study, students would be working on a real-world research project with real data.

Zimmerman and Moylan [18] provide a cyclical phase model of self-regulation that maps these constructivist strategies to different phases in self-regulation, as shown in Figure 1. It presents a cyclic feedback loop between the forethought phase, performance, and self-reflection phase.

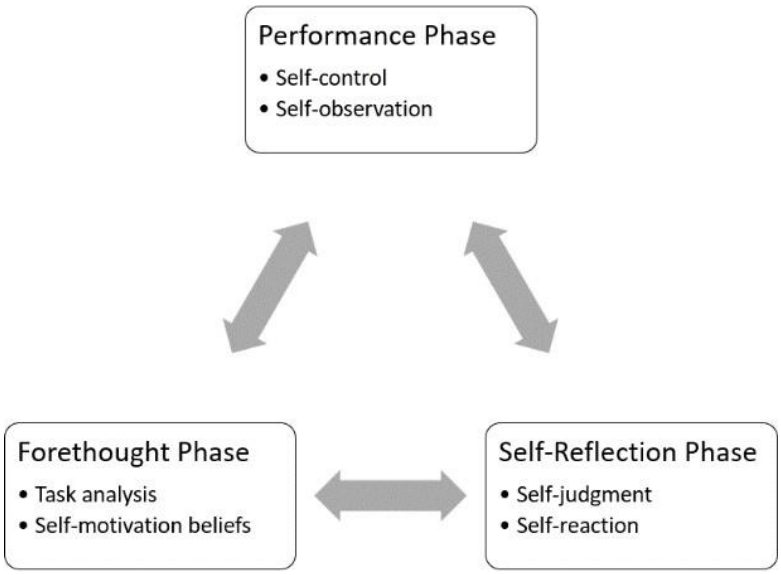

Figure 1. Cyclic Phase Model of Self-Regulation

The first phase, *forethought* is a preparation step for self-regulated learning. It involves task analysis through goal setting and strategic planning and Self-motivation through self-efficacy, outcome expectations, task interest, and goal orientation. The second phase is *performance*, where the learner manages their learning through self-control. Self-control involves task strategies, self-instruction, time management, help-seeking, self-consequences, and so on. The *performance* phase also involves self-observation, which refers to metacognitive monitoring and self-recording. The last phase is *self-reflection*, consisting of two aspects: cognitive (self-judgment) and affective (self-reaction). During this phase, the self-regulated learner can diagnose whether they achieved their learning goal or not and, importantly, measure their self-satisfaction level. Since this model provides a structured way to implement constructivist strategies, this model is used directly to guide the study.

5. Conceptual Framework

The conceptual approach to facilitating the learning experience, and promoting self-regulated learning skills, was Scrum. Scrum is a framework for project management that emphasizes teamwork, accountability, and iterative progress toward a well-defined goal [19]. Scrum is a widely accepted and followed methodology in the technology industry where the software is delivered in increments called *sprints* (usually 2–4 weeks iterations). Each sprint starts with *sprint planning*, a time-boxed meeting to develop a detailed plan for the *sprint*, which typically lasts 2-4 hours. During the sprint, the *development team* holds a 15-30 min *stand-up* meeting daily wherein each team member addresses three questions: what did they do yesterday, what will they do today, and what impediments are in their way? At the end of the sprint, the development team presents a *demo* of their work to the stakeholders to showcase the progress and gain feedback. Finally, the team conducts an internal *retrospective* meeting to assess the teamwork and answers three questions: what went well during the sprint, what did not go well, and what can they do to address it during the next sprint?

Scrum produces four artifacts, namely: *product backlog* (list of all the tasks that need to be completed to develop the final product), *sprint backlogs* (list of all the tasks that the team volunteered to complete during that sprint), *increment* (the unfinished product developed at the end of each sprint), and *product* (the finished product at the end of the final sprint).

Since Scrum principles were developed to address software development in the IT industry, a modified version of these principles was used to fit the context of the research projects for the course. The course professor assumed the role of *product owner* while the undergraduate research students became the *development team* in Scrum. The 16-week course was divided into four 4-week sprints with *weekly stand-ups* instead of *daily stand-ups*. The decision to transition from daily to weekly stand-up meetings was motivated by the recognition that the pace of research progress is typically not of a magnitude that warrants a daily evaluation. Additionally, due to variations in the schedules of team members, not all individuals may be engaged in project activities daily, with some preferring to work on weekends or at specific times. As such, daily meetings may not always represent an efficient allocation of resources. Incorporated into the *end-of-sprint demos* were student-led presentations highlighting their progress. Finally, the different Scrum artifacts such as the *product backlog* and *product* were repurposed to a comprehensive *research tasks list* to be finished during the semester, and the *final technical report* to be submitted at the end of the semester respectively.

Specifically, students were guided through the forethought phase by asking them to develop a list of tasks they needed to finish, setting priorities, and developing a realistic timeline. This phase was accomplished by asking students to complete a *product backlog*, which precisely lists the activities that need to be completed, ordered by the level of importance, and with an estimated time frame to complete them. Students were then guided through the performance phase by asking them to monitor work, remove blockers, checking progress. This phase was accomplished through the implementation of *sprints*, accompanied by *stand-up meetings*. Finally, in the self-reflection phase, students were guided on identifying what went right/wrong and thinking about improvements. This phase was accomplished by having students complete a *sprint retrospective*.

6. Methods

6.1 Context and Participants

The context of the study was an in-person independent study research experience in the computing department. This practice-based course aimed to provide students with the foundational knowledge and strategies that will enable them to conduct research. Five students divided across three teams of two, two, and one students respectively, worked on a semester-long research project by first identifying a research question, conducting a brief literature review on the topic, analyzing existing or to-be-collected 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.

This qualitative study approached the research question regarding students' perceptions of their self-regulated learning skills as applied to this undergraduate research experience. Table 1

provides a summary of the demographic data of the research participants.

Table 1. Study Participants' Demographic Details

Demographic Category	**Demographic Variable**	**Count**	**Percentage**
Gender	Male	1	20%
	Female	4	80%
Student Classification	Sophomore	2	40%
	Junior	1	20%
	Senior	2	40%
Major	Cybersecurity	2	40%
	Computer & Information Technology	3	60%

Additionally, pseudonyms were utilized for students to ensure confidentiality and protect their identities when reporting results in the *results* section.

6.2 Data Collection

This study took place during a 16-week semester wherein the students worked in teams and participated in a semester-long research project. At the end of the semester, students were asked to submit a written reflection on their learning experience describing how they applied the self-regulated processes of planning, performance, and reflection. Table 2 summarizes the questions students answered as part of their end-of-the-semester guided reflection. Students were instructed to answer each question in a minimum of 100 words.

Table 2. Reflection Prompts for Data Collection

SRL Phase	**#**	**Reflection Question**
Forethought	Q1	How much did you know about project management and the fundamentals of the research process before you started the course?
	Q2	What were your expectations before starting this project, and were they met?
Performance	Q3	What project management strategies did you implement throughout the course to successfully accomplish the deadlines and submissions?
	Q4	What project management challenges did you face, and how did you overcome them?
	Q5	What were the strengths you experienced working as a team? (Team in this context includes classmates, mentors, and consultants)
	Q6	What were the challenges you faced working as a team, and how did you overcome such challenges? (Team in this context includes classmates, mentors, and consultants)

	Q7	What specific methods or processes did you use to track your progress, manage time and seek assistance?
	Q8	How did your specific methods and processes help you achieve your final project goals? Discuss any wins or shortcomings.
Reflection	Q9	What do you feel went well throughout this research experience, and what would you do differently in a hypothetical next time?
	Q10	How do you think the research methods you learned as part of this experience can be applied in your future academic or professional career?
	Q11	How do you think the professional, coordination, and management skills you learned as part of this experience can be applied in your future academic or professional career?
	Q12	How has this research experience changed your perspective of your academic or professional goals?

6.3 Data Analysis

The thematic analysis involved applying open coding, axial coding, and selective coding. Open coding was performed on each student's response to identify, label, and categorize important concepts or themes in the data set. It involved reading through each student's response carefully, breaking down raw data into meaningful segments, and assigning codes or labels to these segments to generate a preliminary code book to organize the data and generate new insights. Axial coding was then conducted to examine the relationships between these codes to make connections between the codes and develop a more nuanced and comprehensive interpretation of the data. It involved looking for patterns and connections among the codes identified in the open coding stage of analysis and developing a code set for each question. Therefore, by the end of this stage, there were 12 sets of axial codes – one for each reflection question – each derived from open codes of 5 student responses for the question. Finally, selective coding was performed to synthesize the codes identified in the axial coding stage into a coherent or integrated theme. It involved looking for the core concept or category that ties all the other categories together. These core categories form the basis of the study results, as discussed in the next section.

6.4 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 assigning pseudonyms to the participants and storing their data securely.

Trustworthiness considerations were addressed by conducting an interrater reliability test. To enhance the dependability and consistency of the analysis, the researcher enlisted a second coder to code a portion of the data independently. The interrater reliability score of 87% was obtained to ensure consistency in the coding process.

7. Results

The results discuss the research question: *What were students' perceptions of the role of self-regulated learning and project management skills in the context of their research project?* This section is organized into themes corresponding to each of the stages of self-regulated learning.

7.1 Forethought

This section answers sub-question 1: What was the level of familiarity that undergraduate students had with project management and research prior to taking a formal research course?

Students had familiarity with project management. All five student reflections showed that they had some level of familiarity with project management, with some having taken multiple classes on the topic and others having had experience working on team projects in their majors. Talking about their prior experience, “Sarah” stated, "I had used various project management tools and techniques in my previous endeavors" (Sarah, Participant 5, December 2022). According to “Jennifer”, "I had opportunities to work as a group more than 10 times before, so project management was a familiar topic. Most of the time, I took the role of project manager. I usually plan, schedule, and share the work and check the assignment before submission." (Jennifer, Participant 4, December 2022).

Students lacked research knowledge. All students expressed a lack of familiarity with the research process before taking the class, with this class being the first time they received formal training in the research process. Some mention having no prior experience with research, while others mention having done some scientific research in grade school. Discussing their research experience, “David” mentioned, "did not have any formal training in the research process prior to starting the course." (David, Participant 3, December 2022). “John” shared a similar experience and said, "I had zero bases on research, and I did not know anything about its structure, fundamentals, and process." (John, Participant 2, December 2022).

Students changed their expectations through the course. Many of the students had some preconceived notions about what the course would entail, and in some cases, these expectations were exceeded, while in others, they were met or slightly adjusted. All the students seemed to appreciate the learning process and structure of the course, which included incremental assignments, guidance, feedback, and mentorship. The students were interested in developing their research skills and knowledge, particularly regarding the research process, structure, and methods. Several students mentioned that the course helped them prepare for graduate school, both in terms of the research skills they learned and the experience of working on a research project. For example, “John” stated, "This class went above and beyond my expectations." (John, Participant 2, December 2022). Similarly, “Jennifer” mentioned, "I thought this class was going to be more about theoretical learning of how to do research and the proper method of writing a paper, which would then lead to me doing actual research outside. What I did not know but soon understood was that this class performed fully-fledged research and composed a paper as well, which was excellent." (Jennifer, Participant 4, December 2022).

7.2 Performance

This section relates to sub-question 2: What project management challenges did undergraduate students face during a research course, and how did they overcome these challenges to successfully complete their project?

Students experienced project management challenges. The reflections provide insight into the project management challenges students faced during the course. Common themes include scope creep, communication challenges, language barriers, and confusion about deadlines. Some students also mentioned that they struggled with motivation and technical issues, such as difficulty understanding research papers or trouble with a computational method. Despite these challenges, the students were able to find solutions, such as setting personal deadlines, working in teams, and seeking help from mentors. Overall, the reflections suggest that the students were able to learn from their challenges and improve their project management skills throughout the course. According to “Samantha”, "Some of the project management challenges I encountered were related to scope creep. In a lot of the sections that were being written, I constantly found interesting new additions that would bolster the credibility of the paper and thus would deviate from the task to research that portion in an effort to add it to the project." (Samantha, Participant 1, December 2022).

Students noticed the importance of effective communication and clear goal setting. The five student responses all indicated that effective communication and clear goal setting were key strategies used to successfully meet deadlines and complete coursework. Some students emphasized the importance of creating lists of deadlines and deliverables, setting personal due dates, and clearly dividing tasks between partners. Others mentioned the usefulness of weekly check-in meetings and the Scrum approach to project management. Additionally, some students emphasized the importance of understanding the goals and priorities of the coursework to effectively allocate time and resources. Overall, the responses suggest that effective planning, clear communication, and a clear understanding of the project goals were essential in successfully completing the coursework. Speaking about the importance of clear setting, “John” mentioned, "Everytime I worked on the paper, there was a clear goal as to what I had to achieve. This made it easier to focus and finish my work on time to meet the deadlines of submissions." (John, Participant 2, December 2022). “Jennifer” shared their strategies as well and stated, "I prioritized open and honest communication between me and my partner to ensure that all conflicts are known between us and that it will not impact the final project goals." (Jennifer, Participant 4, December 2022).

Students valued collaboration and continuous mentoring. The student reflections indicate that working in a team and having access to mentors were major strengths of the course. The students mentioned that working in pairs or teams helped to provide feedback, divide tasks, and make up for individual shortcomings. Additionally, the availability of mentors was seen as very helpful in guiding the research process and providing support and feedback. The students also mentioned the importance of clear communication, regular check-ins, and accountability in working effectively as a team. Overall, the reflections suggest that the students valued the collaborative aspect of the course and found it beneficial for their learning and research process. According to “David”, "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." (David, Participant 3, December 2022).

7.3 Self-Reflection

This section corresponds to sub-question 3: What impact did the research course have on undergraduate students' skills and knowledge and interest in research?

Students increased their interest in research and graduate school. Overall, the student reflections suggest that the course had a positive impact on students' understanding and interest in research. Many of the students expressed that the course helped them gain a better understanding of what research entails and gave them the confidence and skills to pursue research in the future.
Students also mentioned that the course clarified their career goals and made them more interested in pursuing graduate studies. “Sarah” shared her experience, "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." (Sarah, Participant 5, December 2022).

Students developed transferrable skills for future practice. The reflections indicate that the course has been beneficial for the students in terms of developing skills that can be applied in their future academic and professional careers. They learned valuable research skills that have helped them with other classes and will be useful if they pursue further education or a career in academia. Additionally, they have gained experience in report preparation, which they saw as beneficial in their current or future jobs. They also developed an interest in graduate school and have learned how to effectively read and analyze research papers. Overall, the students gained valuable skills in research methods, problem-solving, data analysis, and presentation that they believe will be useful in various aspects of their lives. According to “David”, "I believe that the professional, coordination and management skills I learned as part of this experience can be applied to all aspects of life." (David, Participant 3, December 2022).

Students experienced a sense of personal development. Apart from technical learning, students reflected on personal development throughout the course. For example, students reflected on learning valuable skills like persuasion and teamwork, understanding the importance of planning, communication, and collaboration, and developing an appreciation for feedback and guidance. “Samantha” discussed her thoughts, "These skills will help me to be a participatory and organized team member. I will be able to interact efficiently with future teams in the work environment." (Samantha, Participant 1, December 2022). “John” also mentioned, "I've learned that having the right support system and continuously working on a paper throughout the semester results in great content." (John, Participant 2, December 2022).

8. Discussion and Implications

8.1 Overview and Interpretation of Findings

The study aimed to explore students' perceptions of their self-regulated learning skills applied to their undergraduate research experience. The thematic analysis of the data revealed themes that were further interpreted following the three stages of self-regulated learning, namely

forethought, performance, and reflection.

Regarding the forethought phase, the study found that students had familiarity with project management, but they lacked research knowledge. This finding suggests that students in computing fields have some exposure to project management, which may have prepared them to manage the research project's requirements. However, the lack of knowledge about the research process indicates that students need formal training to acquire the research skills necessary to conduct research effectively. Moreover, the study found that students' expectations were exceeded or met in some cases, while in others, they were slightly adjusted. This finding implies that students have some preconceived notions about what they expect to learn from the research experience, and it is important to align their expectations with the course's learning outcomes.

Regarding the performance phase, the study found that students implemented various project management strategies to accomplish deadlines and submissions. Students tracked their progress, managed their time, and sought assistance using specific methods and processes. This finding suggests that students applied self-regulated learning strategies during the performance phase to achieve their project goals. However, the study also found that students faced project management challenges, such as communication issues and a lack of collaboration skills, which affected their performance. This finding highlights the importance of developing teamwork skills as part of the research experience to overcome project management challenges effectively.

Regarding the reflection phase, the study found that students reflected on their learning experience and identified what went well and what they would do differently in a hypothetical next time. Additionally, the study found that students recognized the applicability of research methods and project management skills in their future academic and professional careers. This finding suggests that the research experience enhanced students' awareness of the relevance of research methods and project management skills to their academic and professional goals.

The implications of our study relate to the need for providing students with professional skills, such as project management and teamwork, in addition to providing them with research skills. While in this independent study, the mentors implemented Scrum as a way to manage the projects and promote collaboration among team members, the findings of the study suggest that students developed some evidence of self-regulated skills as a result of the research project orchestration.

8.2 Implications for Facilitating Undergraduate Research

The Scrum methodology was implemented as a framework to manage the three teams of undergraduate students pursuing undergraduate research projects during a semester and promote self-regulated learning skills. The Scrum process included weekly stand-up meetings, end-of-sprint demos, sprint retrospectives, and the use of Scrum artifacts such as the product backlog and the product. The end-of-sprint demos included student presentations about their progress, and the Scrum artifacts were used to create a comprehensive research tasks list to be finished during the semester and the final technical report to be submitted at the end of the semester by respective teams. The Scrum methodology facilitated effective communication and clear goal setting, which were key strategies in meeting deadlines and completing coursework. Students

valued collaboration and continuous mentoring, which were also facilitated by the Scrum process.
The findings of the study suggest that the Scrum process was effective in promoting self-regulated learning and research skills in undergraduate students. The Scrum process facilitated effective communication and collaboration among team members, which helped students manage their time, track their progress, and overcome project management challenges. The use of Scrum artifacts such as the product backlog and the product also helped students create a comprehensive research tasks list and a final technical report, which were important deliverables of the research experience. In the future, it is recommended to provide more training and support to faculty mentors to effectively implement the Scrum process and promote self-regulated learning and research skills in undergraduate students.

The findings of the study suggest that the Scrum process can be applied to individual undergraduate research projects as well. The Scrum process facilitates effective communication, clear goal setting, and self-regulated learning skills, which can be beneficial for individual undergraduate research projects as well. However, it should be noted that the Scrum process may need to be adapted to fit the specific needs of individual projects and may require different levels of mentorship and support.

Overall, the Scrum methodology can be a valuable tool for promoting self-regulated learning and research skills in undergraduate students, and it is worth considering for implementation in other academic settings as well.

9. Conclusion, Limitations, and Future Work

The study's main limitation is the small sample size, which limits the generalizability of the findings. The study only involved five undergraduate students in computing fields, and therefore, the findings may not be representative of the larger population. Moreover, the study relied on self-reported data collected through written reflections, which may have been subject to social desirability bias. Future studies could involve larger sample sizes and use multiple methods, such as interviews and observations, to triangulate the data and enhance the validity and reliability of the findings.

The study provides insights into students' perceptions of their self-regulated learning skills as applied to their undergraduate research experience. The findings suggest that in addition to formal training to acquire the research skills necessary to conduct research effectively, students also need to develop self-regulated learning skills. Moreover, students need to develop teamwork skills to overcome project management challenges effectively. Finally, the findings of the study suggest that the research experience enhanced students' awareness of the joint relevance of research methods and project management skills to their academic and professional goals. These findings have implications for designing and implementing undergraduate research experiences that foster self-regulated learning skills and enhance students' research and teamwork skills.

Moreover, the Scrum methodology was found to be an effective framework for managing undergraduate research projects and promoting self-regulated learning skills. The study's

findings suggest that the Scrum process is worth considering for implementation in other academic settings as well. However, more training and support to faculty mentors may be necessary to effectively implement the Scrum process and promote self-regulated learning and research skills in undergraduate students. In summary, Scrum methodology is a valuable tool for promoting self-regulated learning and research skills in undergraduate students, and it can contribute to enhancing their academic and professional goals.

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