IIAI Open Conference Publication Series
IIAI Letters on Informatics and Interdisciplinary Research
Vol.005, LIIR280
DOI: https://doi.org/10.52731/liir.v005.280

Investigating the Influence of Competencies and Attitudes Nurtured through K-12 Education on Student Performance in Scrum-based System Development of Project Based Learning

Shun Sato [*], Hiroto Yamakawa [*]

Abstract

In software engineering curriculums at universities, project-based learning often incorporates agile methodologies, such as Scrum, to teach students how to continuously develop high-value software. However, the students' implementation of Scrum is frequently met with challenges. This study investigates the relationship between the development processes of Scrum and the competencies and attitudes of the students, arguing that the problem may be due to the competencies and attitudes nurtured through K-12 education.

Keywords: Competencies and Attitudes of Student, Project-based Learning, Scrum, Software Engineering Education

1 Introduction

The agile methodology, grounded in the "Manifesto for Agile Software Development," equips developers with the flexibility to quickly adapt to customer needs and their changes. Within the context of university-level software engineering curriculums, project-based learning (PBL) attempts to offer hands-on experience with these methodologies, particularly Scrum. Nonetheless, students who are new to system development may struggle to grasp and adhere to the prescribed methodologies and their associated processes. Therefore, a growing dialogue exist around enhancing students' adherence to Scrum development processes through objective project evaluation methods [1][2]. In prior research that focused on what skills as IT engineers are nurtured through PBL and evaluated students who experienced PBL and their problem-solving skills, students who were active as core members showed high scores in problem-solving skills [3].

Focusing on such a relationship between PBL or specific activities in it and the students' competencies, this study aims to explore how student competencies and attitudes, potentially shaped their K-12 education, affect their engagement with Scrum-based system development projects in PBL. It posits that the difficulties encountered in implementing Scrum methodologies may stem from the competencies and attitudes developed during earlier educational experiences. To this end, this study examines the relationship between these pre-existing competencies/attitudes and Scrum processes based on students' self-assessments.

[*] Chitose Institute of Science and Technology, Chitose, Japan

Section 2 outlines three key areas of investigation: 1. PBL projects that implement the Scrum processes; 2. the introduction of a self-assessment method for assessing "Seven Competencies and Attitudes" nurtured through K-12 education in Japan; and 3. the development of a self-assessment method for applying Scrum processes in PBL. Section 3 compares the results of self-assessment for the competencies/attitudes and Scrum processes. Section 4 considers the relationship between competencies/attitudes and Scrum processes.

Building on the insights of a previous study, this study expands the investigation with a larger number of teams and a longer period to increase data reliability [4].

2 Investigation Methods

2.1 PBL Projects as an Investigation Field

The authors conducted a study on four teams (referred to as Teams A–D) that participated in PBL projects at our university, attempting to use Scrum methodologies. Table 1 outlines the objectives of each team and the number of students involved. Typically, team members independently worked, although occasionally they received guidance from senior students with previous PBL project experience. The study observed students engaging in six one-week Sprints according to Scrum for each team. Prior to the commencement of these projects, the authors provided the teams with a foundational understanding of Scrum by introducing them to the "Scrum Guide" [5]. Detailed instructions were provided on how to effectively engage with Scrum processes. These PBL projects were conducted during the spring vacation as part of extracurricular activities, targeting students keen on deepening their software engineering knowledge. The authors expected the students to apply the Scrum processes while devoting themselves to daily team activities.

Table 1: PBL projects as an investigation field

Team	Objective of the team	Customers	Number of students
A	Improvement of the feature of part-time worker attendance management system	Office workers in our university	5
B	Improvement of the feature of taxicabs reservation system for transporting employees	Cooperating company of PBL	4
C	Prototyping of wayfinding bot using beacons with messaging apps	Office workers in our university	3
D	Prototyping of software license management system	Office workers in out university	4

2.2 Self-assessment Method for "Seven Competencies and Attitudes"

The authors administered a questionnaire to 16 students across Teams A–D before the start of the PBL. The purpose of this questionnaire was to facilitate a self-assessment among the "Seven Competencies and Attitudes" nurtured through K-12 education in Japan. These competencies and attitudes are deemed addressing challenges and fostering a sustainable society [6]. Questions were formulated to gauge the students' proficiency in the Seven Competencies and Attitudes. This was achieved by drawing sentences from the National

Institute for Educational Policy Research's "Specific examples of competencies and attitudes" [7]. Students were asked to rate each question on a 5-point scale, with 1 being "not applicable at all" and 5 being "very applicable."

2.3 Self-assessment Method for Scrum Processes in PBL

The authors administered a questionnaire to 16 students across Teams A–D after their third Sprint. This questionnaire was designed to enable students to self-assess their ability to consistently perform the developers' processes within Scrum. Questions were formulated to inquire about the students' proficiency with the Scrum processes, drawing sentences from the "Scrum Events" section of the "Scrum Guide." As with the previous questionnaire, students were asked to rate each question on the same 5-point scale.

Furthermore, the authors prepared activity log sheets for documenting the Scrum processes, as shown in Figure 1. These sheets were distributed to the 16 students across Teams A–D, who were instructed to record their activities during their sixth Sprint. The purpose of collecting these logs was to corroborate the self-assessment results by comparing them with actual recorded activities.

3 Results of Self-assessment Investigation

For the questionnaires discussed in Sections 2-2 and 2-3, the authors determined the mean of the students' 5-point scale for each question and the median of those means. Table 2 presents the questions that scored below this median, indicating areas where students may have demonstrated weak competencies/attitudes or where their performance during the third Sprint was lacking. This table shows 13 valid responses from 16 students across Teams A–D.

Moreover, regarding the activity log sheets in the sixth Sprint, the authors identified key items that needed to be completed and calculated the completion rates for these items. Table 3 shows the average completion rates across all students. An additional survey was conducted to further understand why some sections of the activity log sheets were left blank. The findings from this survey are also included in Table 3.

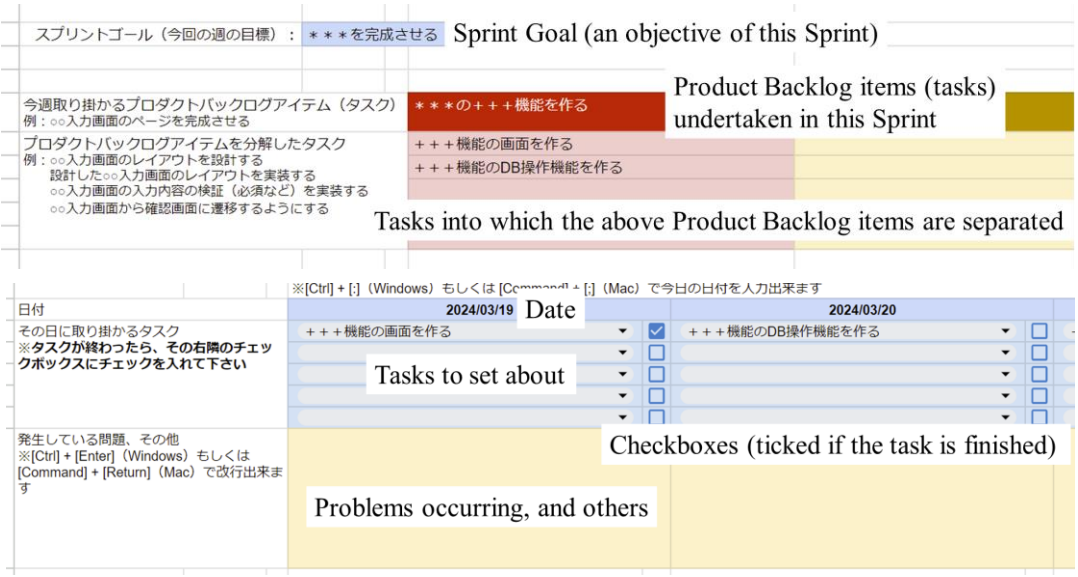

Figure 1: Examples of activity log sheets for Scrum processes

Table 2: Questions with low mean values

Question	Mean (n=13)
Self-assessment for "Seven Competencies and Attitudes" (Median: 3.846)	
QA-3: I can think better solutions in a proactive and developmental manner.	3.615
QA-5: I can plan with a sense of prospects and purpose.	3.462
QA-9: I can relate various things to each other.	3.769
QA-11: I can summarize and concisely share my thoughts.	2.538
QA-19: I am interested in my connection to various things.	3.769
QA-25: I can act willingly for others.	3.692
Self-assessment for Scrum processes in PBL (Median: 3.077)	
QB-3: By QB-2, I could improve the accuracy of my Sprint forecasts. (cf. QB-2: In Sprint Planning, I could develop a better understanding of my past performance, my upcoming capacity, and my Definition of Done.)	2.692
QB-4: In Sprint Planning, for each selected Product Backlog item, I could plan the work necessary to create an Increment that meets the Definition of Done.	2.615
QB-5: In Daily Scrum, I could focus on progress toward the Sprint goal and produce an actionable plan for the day of work.	2.538
QB-6: By Q5, I could create focus and improve self-management.	2.692
QB-7: In Daily Scrum, I could often meet throughout the day for more detailed discussions about adapting or replanning the rest of the Sprint's work.	2.231

Table 3: Means of the completion rate for the activity log sheets

Scrum event in Sprint	Mean of completion rate (n = 16)	Why the sheets were left blank (multiple answers allowed)
Sprint Planning	56%	Had no time (2) Thought about doing it later but forgot (5) Felt the logging tedious (2) Accidentally used the previous week's one (1)
Daily Scrum	44%	Had no time (3) Thought about doing it later but forgot (5) Felt the logging tedious (1) Accidentally used the previous week's one (1)
Sprint Review	20%	Had no time (3) Thought about doing it later but forgot (7) Felt the logging tedious (3) Was muddled about how to use the sheet (1) Accidentally used the previous week's one (1) Had no idea about one of the required items (1)
Sprint Retrospective	25%	Had no time (4) Thought about doing it later but forgot (7) Felt the logging tedious (2) Was muddled about how to use the sheet (1) Accidentally used the previous week's one (1)
Overall	34%	---

4 Consideration

In Table 2, QA-5 is a question pertaining to students' "Ability to plan with anticipation of a future scenario" from the "Seven Competencies and Attitudes." This question was ranked second lowest in terms of students' self-assessed competencies and attitudes. Similarly, QB-4, QB-5, and QB-7, which focus on "Sprint Planning" and "Daily Scrum," were among the lowest-ranked questions in the students' self-assessment of their Scrum process skills. These questions pertained to Planning, indicating that students rated their planning abilities lower than the other competencies/attitudes and Scrum activities. Therefore, these results suggest that the Scrum activity may reflect the students' lack of mastery of competencies/attitudes regarding planning.

The findings are further supported by Table 3, indicating that the average completion rates for Sprint Planning and Daily Scrum were only 56% and 44%, respectively. This suggests that students struggle with planning tasks. Similarly, the primary reasons provided for incomplete activity log sheets were "Thought about doing it later but forgot" and "Had no time." These results imply that students may struggle with defining and executing detailed plans for Sprint Planning and Daily Scrum, potentially resorting to ad hoc activities to meet deadlines. However, our investigation was limited to 16 students from one university. Further data accumulation through the empirical studies is necessary to generalize the findings. Furthermore, we should deepen our consideration of the relationship between the competencies/attitudes and students' performance.

To support these students, it is important to provide learning processes for enhancing their competencies/attitudes. For instance, we explore experiential training methods based on instructional models such as First Principles of Instruction to enhance their competencies/attitudes through step-by-step activities; considering the development of a specific feature, discussing the necessary modules to realize this feature, and planning the detailed steps for developing these modules from start to finish.

5 Conclusion

Herein, the authors attempted to investigate the relationship between students' competencies/attitudes nurtured through K-12 education and their ability to implement Scrum methodologies. The findings indicate that the students struggle with planning aspects of system development, which in turn affects their capacity to effectively plan and implement Sprints in PBL. In future research, the authors intend to investigate training methods that could enhance students' understanding of the critical role of planning in system development and improve their planning skills for such projects.

References

[1] H. Igaki, N. Fukuyasu, S. Saiki, S. Matsumoto, and S. Kusumoto, "Quantitative Assessment with Using Ticket Driven Development for Teaching Scrum Framework," ICSE Companion 2014: Companion Proceedings of the 36th International Conference on Software Engineering, 2014, pp. 372-381; https://doi.org/10.1145/2591062.2591162

[2] N. Hinoto, K. Ito, and M. Oba, "Effects of Formative Assessment in Agile Software Development PBL" (in Japanese), Proceedings of the 36th JSSST Annual Conference, 2019, pp. 35-44

[3] Akira Inoue, Shigeo Kaneda, "A PBL Approach using Real World Application Development between University and Local Government" (in Japanese), Transactions of Information Processing Society of Japan, 2008, pp. 930-943; https://jglobal.jst.go.jp/en/detail?JGLOBAL_ID=200902204973592463

[4] S. Sato and H. Yamakawa, "Probe of Influence of Ability Nurtured in ESD to Students' Scrum Events at System Development PBL" (in Japanese), Japanese Society for Information and Systems in Education – FY2023 Students Research Presentation Conference, 2024; https://www.jsise.org/wp-content/uploads/2023/12/2023_hokkaido_a02.pdf

[5] "The Scrum Guide – The Definitive Guide to Scrum: The Rules of the Game," Scrum-Guides.org, 2020; https://scrumguides.org/docs/scrumguide/v2020/2020-Scrum-Guide-US.pdf (accessed Apr. 7, 2024)

[6] MEXT, "ESD (Education for Sustainable Development)," Ministry of Education, Culture, Sports, Science and Technology of Japan; https://www.mext.go.jp/en/unesco/title04/detail04/sdetail04/1375695.htm (accessed Apr. 7, 2024)

[7] NIER, "ESD Leaflet – A Framework for Conceptualizing and Developing Learning and Instructional Process for ESD" (in Japanese), National Institute for Educational Policy Research of Japan; https://www.nier.go.jp/kaihatsu/pdf/esd_leaflet.pdf (accessed Apr. 7, 2024)