

AGILE METHODOLOGIES TO FOSTER TRANSVERSAL COMPETENCIES IN AGRICULTURAL MECHANIZATION EDUCATION: A PILOT EXPERIENCE

Angela Melado-Herreros, Adolfo Moya, & Belen Diezma

Department of Agroforestry Engineering, Universidad Politécnica de Madrid (Spain)

Abstract

This pilot study examines the integration of the SCRUM framework into the practical component of the *Sustainable Agricultural Mechanization* course at the Universidad Politécnica de Madrid (UPM), with the aim of enhancing both technical learning and transversal competencies. Students were organized into four teams to design and deliver field-based sessions on key mechanization topics, using SCRUM roles, sprints, and AGILE tools. Quantitative results show consistently high scores in organizational and management competencies (7.65–10.00), demonstrating that students effectively defined objectives, managed tasks, and coordinated activities within the AGILE structure. Technical learning outcomes were positive in three of the four practices (mean scores >7), although the Seeding session revealed reduced technical performance (4.81) due to limited preparation time caused by scheduling constraints. Qualitative feedback further highlighted challenges in peer management, communication, and leadership when coordinating large groups in field settings. These findings suggest that SCRUM can be successfully adapted to field-based engineering education, promoting student autonomy, engagement, and the development of transversal competencies. However, as the results derive from a single implementation, they should be interpreted as preliminary. Future iterations across consecutive academic years—integrating the improvement actions identified in this pilot—will be necessary to confirm the robustness of the approach, refine its application, and determine its long-term impact on both technical learning and professional skill development in agricultural engineering.

Keywords: *Educational innovation, active learning, student-led, teamwork, transversal skills.*

1. Introduction

Higher education is increasingly challenged to prepare graduates who can thrive in complex, uncertain, and rapidly evolving professional environments. Beyond disciplinary knowledge, employers now prioritise transversal competencies such as collaboration, communication, critical thinking, autonomy, and effective project management (Paraskeva, Choustoulakis, Karampa, Lepenitsa, & Nikoloudakis, 2024). Traditional lecture-based approaches have been shown to be insufficient for fostering these skills, prompting a shift toward active, student-centred methodologies. Recent research highlights that Agile framework, originally developed for industry, offer promising structures for enhancing teamwork, adaptability, and problem-solving within higher education contexts (Fernandes, Dinis-Carvalho, & Ferreira-Oliveira, 2021; Neumann & Baumann, 2021). Agile principles emphasise iterative learning, shared responsibility, visual management, and continuous improvement, all of which align with competence-based educational models.

Among agile approaches, SCRUM has been successfully applied to educational environments, especially in those of engineering and technology, due to it can enhance students' competencies such as teamwork, autonomy, and communication (Castro, Silveira, da Silva, Silva & Câmara, 2025). Integrating SCRUM in practice-based contexts has shown an increase on students' engagement and sense of ownership over their learning processes (Neumann & Baumann, 2021).

In this context, this study examines the implementation of SCRUM within the practical component of the course *Sustainable Agricultural Mechanization* within the Agro-Environmental Engineering degree at the Universidad Politécnica de Madrid.

2. Objectives

The pilot experience aimed to integrate the SCRUM framework into the practical component of the Sustainable Agricultural Mechanization course to strengthen transversal competencies, technical learning, and methodological innovation. Specifically, the project sought to develop key skills such as teamwork, organization, time management, communication, and shared decision-making; to promote student autonomy by assigning learners responsibility for planning, executing, and evaluating their own practical sessions; and to enhance engagement by positioning students as active facilitators. In parallel, the initiative aimed to reinforce understanding of core mechanization concepts through hands-on, student-led activities and to assess technical learning through standardized individual tests. Methodologically, the experience explored the feasibility and pedagogical value of applying AGILE structures to an engineering context, while also developing a rubric-based evaluation tool and gathering evidence from observations and student feedback to identify strengths, challenges, and opportunities for improvement.

3. Design and methodology

3.1. Context and participants

The experience was carried out during the 2025–2026 academic year in the course ‘Sustainable Agricultural Mechanization’, part of the third year of the Agro-Environmental Engineering degree at the ‘Escuela Técnica Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas’, from UPM. The course typically has an enrolment of 30–35 students; in the current academic year, 36 students were enrolled. The course is structured into two types of lessons: (i) theoretical lectures delivered in the classroom, and (ii) practical sessions conducted in an experimental field using real agricultural machinery.

For the implementation of the pilot experience, students were first invited to select the practical topic they wished to organize among the following four: tillage, fertilization, seeding, and pesticide application and then grouped accordingly into the four working teams of up to nine members. Each group was responsible for designing, planning, and leading the selected practical session. All students participated both as designers and facilitators, as well as attendees in the practical sessions conducted by their peers.

3.2. Integration of the SCRUM methodology

To integrate Agile project management into the course dynamics, the SCRUM framework was selected. The process was supervised by an Assistant Professor with professional experience in corporate settings and project management based on AGILE methodologies. During an initial session with the whole class, the methodology was introduced and the roles were collectively defined as follows:

- **SCRUM Master:** responsible for facilitating the workflow and ensuring adherence to the methodological framework. Given her prior experience with AGILE approaches, the Assistant Professor assumed this role.
- **Product Owner:** tasked with coordinating the definition of the objectives for each practical session, prioritizing tasks, and validating deliverables. It was agreed that the course instructors would jointly take on this role.
- **Development Team:** composed of the students in each group, responsible for carrying out all tasks related to the design, preparation, and execution of their assigned practical session.

Project work was organized into one- or two-week sprints, aligned with the academic calendar. For each sprint, groups defined specific tasks and completion criteria. A digital Kanban board developed in Trello (Figure 1) was used to support planning and monitor progress, promoting transparency and enabling students to visualize the evolving status of their project.

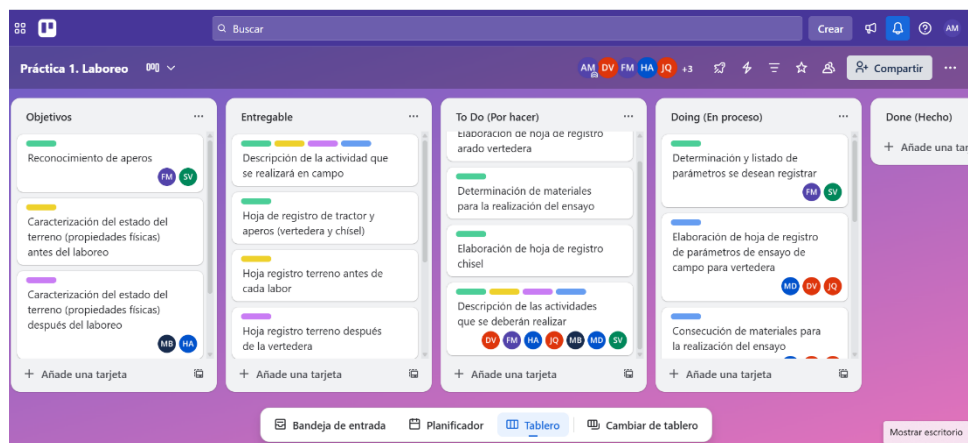
3.3. Activities carried out by the students

The main tasks that each group had to complete included:

- Technical review of the content associated with the assigned practice.
- Design of the practical session, given the objectives. They designed the methodology, and planned activities.
- Preparation of a detailed guide, to be delivered to classmates and teaching staff.
- Logistical planning, considering materials, machinery, and time allocation.
- Execution and coordination of the practical session, acting as facilitators.
- Final review of the process through a retrospective aimed at identifying areas for improvement.

Throughout the process, the teaching staff acted as observers and facilitators, ensuring the technical accuracy of the content and guiding the adaptation of SCRUM to the academic context.

Figure 1. Example of a Trello board used in the experience.



3.4. Evaluation instruments

The evaluation of the pilot experience was structured around two complementary dimensions: (i) the assessment of students' organizational and management competencies, and (ii) the assessment of their acquisition of technical concepts. For the evaluation of **organizational and management skills**, a consensus was reached with the students that, given the self-management principles inherent to the SCRUM framework, each team's performance would be reflected in a single group grade. Thus, all members of the same group would receive the same mark unless the group explicitly requested otherwise. A specific rubric was designed for this purpose (Table 1), incorporating the following weighted criteria: definition of short- and medium-term objectives and their relevance (40%); monitoring and management of tasks using AGILE methodologies and ICT tools (Trello) (30%); and joint review of planning to ensure the achievement of team objectives (30%).

Table 1. Assessment rubric for evaluating Organization and Management competencies using AGILE methods.

Indicators	Beginning (0-4.9)	Developing (5-6.9)	Proficient (7-8.9)	Exemplary (9-10)	ITEM
40% - Define short or medium term objectives and their importance	Objectives required for the field test have not been identified.	A basic or unclear outline is provided; improvements are needed for functionality; limited understanding of required tasks.	A clear outline is provided, showing understanding of the tasks and planning for execution.	A clear and detailed outline is provided; tasks are well understood, execution is well planned, and possible actions to improve task completion are identified and explained.	Preliminary Work (Deliverables)
30% - Monitor and manage tasks and projects using AGILE methodologies and ICT tools (Trello)	No task monitoring is performed before or during field work.	Task monitoring is performed before field work but is limited during field work.	Monitoring of tasks before and during field work is conducted, implementing solutions to optimize execution and validating results.	Thorough monitoring before and during field work is conducted, implementing optimized solutions, validating results, and generating evidence using the established procedure.	Preliminary Work (deliverables and evidence) + task monitoring and execution using AGILE methodology
30% - Review planning with team members to meet the team's objectives	Planning and test results are not reviewed.	A review of planning and test results is performed but shows limited understanding.	A review of planning and test results is carried out, identifying aspects to be improved or adjusted by team members.	A comprehensive review of planning and results is performed, identifying key aspects to improve or adjust by the entire team following the established method.	Planning report using AGILE methodology

In parallel, the acquisition of **technical knowledge** was assessed through an individual test completed by the entire class, including both the group responsible for organizing the practical session and the students attending it. This test evaluated understanding of the theoretical concepts and calculations applied throughout the practical activity.

4. Results and discussion

The results are presented in two parts: quantitative findings, which include students' performance in technical knowledge acquisition and the development of organizational and management competencies, and qualitative findings, derived from the feedback gathered during the final retrospective session.

4.1. Technical knowledge acquisition and interpretation

Figure 2.a) shows the comparison between the test scores obtained by the organizing groups and the rest of the class for each practical topic. In general, results indicate that acting as organizers may have contributed to slightly better performance.

For the Tillage, Fertilization, and Pesticide application sessions, the organizing teams performed slightly better than the rest of the class: 7.17, 7.15 and 7.63 respectively for the organizing groups and 6.53, 6.68 and 7.23 respectively for the rest of the class. These results suggest that the process of preparing and delivering the practical sessions may have reinforced conceptual understanding for many of the organizers, likely due to the need to anticipate peers' questions, structure explanatory content, and engage more deeply with the material. Similar findings have been reported in studies where students engaged in SCRUM-based or challenge-based learning environments (Coelho et al., 2024) and on eduScrum implementations, which shows that acting as facilitators in authentic, practice-based contexts increases student engagement and promotes a more thorough internalization of the material (Neumann & Baumann, 2021).

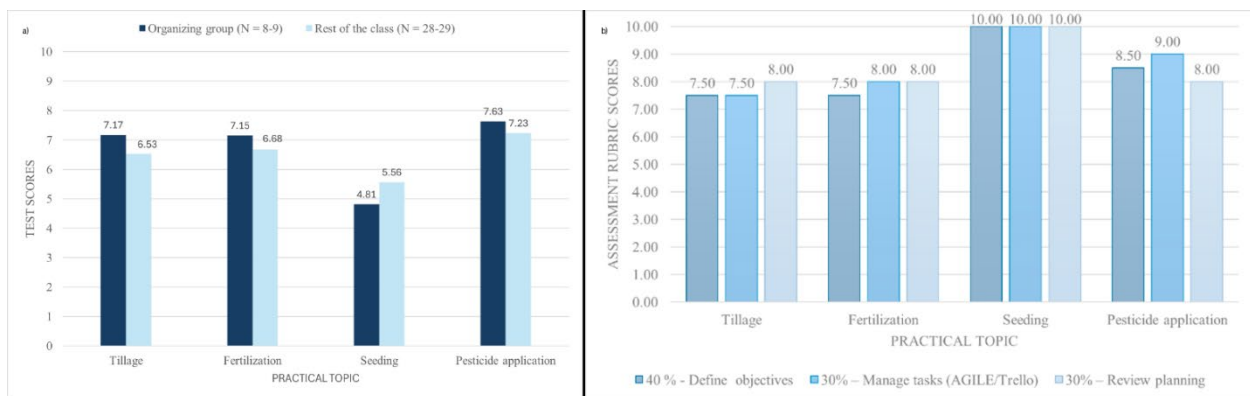
In contrast, the Seeding practice shows a deviation from this pattern. The organizing group scored 4.81, which is below both the value obtained by their peers (5.56) and the average performance observed in the other practices. As discussed in the qualitative feedback, this group faced significant time constraints caused by an unexpected change in field-resource availability, which drastically reduced their preparation window. Student reflections confirm that, under these circumstances, they prioritized the organizational and managerial components of the activity but had limited opportunity to consolidate the technical content. Importantly, this same group obtained the highest organizational score (10.00), indicating that the low-test result was not due to lack of engagement but rather to contextual limitations. This situation also influenced the performance of the rest of the class, whose test average for the Seeding session (5.56) was lower than in all other practices, suggesting that the shortened preparation and instruction time impacted the entire cohort. The organizing group appears to have been more affected, because the additional responsibility of coordinating the session required them to prioritize planning and facilitation over conceptual study.

4.2. Organizational and management competencies

The results on the rubric scores for organizational and management competencies (Figure 2.b)) reveal a consistently strong performance across all groups, with overall values ranging from 7.5 to 10.0.

Figure 2.a). Comparison of test scores between organizing groups and the rest of the class.

Figure 2.b). Rubric scores for organizational and management competencies across the four student-led practical sessions. The three indicators assessed were: definition of objectives (40%), task management using AGILE/Trello (30%), and planning review (30%). All groups achieved high performance, with the Seeding group obtaining perfect scores (10-10-10).



The Seeding group stands out in the figure, having obtained perfect scores (10-10-10) across all three indicators. This exceptional performance aligns with students' feedback, confirming that the group excelled in adhering to the SCRUM process and coordinating tasks efficiently. As discussed before, the contrast between their outstanding organizational performance and reduced technical learning highlights a pedagogical insight: while SCRUM supports project management and collaboration skills, adequate preparation time remains essential for technical content assimilation, particularly in field-based contexts. Across the remaining groups, rubric scores demonstrate engagement with AGILE methodologies. The Pesticide application group achieved particularly high results (8.5–9.0–8.0), reflecting effective coordination and shared task management during their session. Similarly, the Tillage and Fertilization groups displayed balanced performance across all indicators, reinforcing the suitability of SCRUM for structuring practical activities in agricultural mechanization.

4.3. Qualitative feedback

The theme that emerged across all groups was the difficulty of managing peers during the practical session. Although all organizing teams divided the class into two subgroups of 12–14 students to optimize

workflow and safety, students reported challenges in maintaining attention, ensuring engagement, and coordinating simultaneous tasks. These difficulties are consistent with findings in engineering education research, where leadership roles in self-organized student teams demand advanced coordination and decision-making skills that many undergraduates are not accustomed to (Routhe, Holgaard, & Kolmos, 2024). Likewise, studies on peer leadership highlight that guiding classmates requires communication and interpersonal abilities that can be unexpectedly demanding for students with limited prior experience (Keup, 2016).

5. Conclusions

The results of this pilot experience demonstrate that integrating the SCRUM framework into field-based agricultural engineering teaching is both feasible and pedagogically valuable. Students achieved high levels of organizational and management performance, while technical learning was satisfactory in most practices, highlighting SCRUM's potential to strengthen transversal competencies and foster active, student-centred learning. At the same time, the Seeding session showed that technical achievement is sensitive to preparation time and contextual constraints, and qualitative feedback revealed challenges related to peer management and leading large groups in practical environments. As these findings derive from a single iteration of the course, further applications across consecutive academic years—incorporating the improvement actions identified in this experience—will be essential to confirm the robustness of the approach and refine its implementation.

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