Investigating Requirements Management Practices in a Proprietary Educational Software Ecosystem

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Abstract. *Software ecosystems (SECO) are dynamic environments where multiple actors develop products over a common technological platform. Requirements management (RM) in SECO is challenging due to multiple stakeholders, evolving relationships, and governance boundaries. This exploratory study investigates RM practices in a proprietary educational SECO, namely the SOLAR SECO, through semi-structured interviews with key stakeholders. The findings indicate the absence of a formal RM process and a reliance on informal practices, such as urgency-driven prioritization and communication-based traceability. These findings reinforce the need to balance coordination mechanisms and adaptability when structuring RM practices in proprietary SECO.*

1. Introduction

Software ecosystems (SECO) are complex and dynamic environments in which interdependent actors collaborate around a common technological platform [Santos et al. 2024]. In such settings, a platform provider (i.e., keystone) coordinates value creation with other organizations, adding functionality beyond the core product while also sharing risks associated with inaccurate or evolving requirements [Damian et al. 2021].

SECO introduces complexity in requirements management (RM) due to multiple actors, different communication channels, and the need for coordination across boundaries [Jansen 2020, Damian et al. 2021]. According to [Damian et al. 2021], managing requirements in SECO challenges partnerships between the keystone and external developers. In line with this discussion, [Malcher et al. 2023] found that empirical investigations addressing RM in proprietary SECO (PSECO) remain limited. Moreover, empirical

evidence on how RM is enacted in SECO remains limited, particularly in proprietary contexts [Malcher et al. 2023, Malcher et al. 2025]. Understanding how RM is enacted in PSECO may therefore help reveal practical gaps and support improvements in coordination, documentation, and communication practices in SECO.

Educational PSECO introduce additional challenges because requirements emerge from heterogeneous actors with different priorities and communication expectations. In addition, centralized governance and restricted visibility of internal processes may intensify informal coordination and communication-based RM practices. This exploratory study investigates RM practices in a proprietary educational SECO, namely the SOLAR SECO, through semi-structured interviews with key stakeholders. The findings indicate the absence of a formal RM process and a reliance on informal and experience-based practices, such as urgency-driven prioritization and communication-based traceability. These findings reinforce challenges related to coordination, documentation, transparency, and stakeholder interaction previously discussed in the SECO literature.

2. The SOLAR SECO Context

The SOLAR SECO is centered on a virtual learning environment (VLE) that integrates multiple software components, tools, and services to support teaching and learning activities [Coutinho et al. 2017]. PSECO are centered in closed environments where multiple platforms relate and are typically protected by intellectual property management, and are therefore less reported in the literature because internal processes and data are often restricted [Manikas 2016, Costa et al. 2022, Outão et al. 2025].

The SOLAR SECO is a VLE integrating user management, content authoring, communication, and evaluation tools. Different actors, such as developers, instructors, students, and institutional managers, interact through these modules to create and maintain learning services. These actors have different priorities and levels of technical expertise, requiring coordination and communication across the ecosystem. Over time, multiple integrations have been developed around the platform through an application programming interface that enables the extension of its functionalities [Coutinho et al. 2017].

3. Research Method

We conducted a field study based on semi-structured interviews [Singer et al. 2008] to investigate how RM practices are enacted in the SOLAR SECO. A research protocol was defined, including the research question, participant selection, interview procedures, and data analysis[1]. The guiding research question is stated as in the following: *How are RM practices conducted in the SOLAR SECO?*

Two key stakeholders occupying complementary roles in the SOLAR SECO participated in the study: (i) the development team coordinator, responsible for managing product and service demands, with over six years of experience in the ecosystem; and (ii) an experienced platform user with more than ten years of interaction with the system. Although limited in number, these participants provided coordination and usage perspectives on RM practices.

To explore RM practices, the interview guide was structured around core RM activities, including requirements identification, communication, prioritization, negotiation,

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change control, traceability, and challenges. Interviews were conducted online, recorded with consent, and transcribed for analysis. Participants were informed about the study objectives, voluntary participation, anonymity, and data usage before the interviews. Subsequently, we applied the Card Sorting method [Spencer 2009] to organize and interpret the collected data. Interview excerpts were grouped through an open card sorting procedure to identify recurring RM themes and coordination patterns. The resulting thematic groups were discussed among the researchers to reduce interpretation bias.

4. Results

Results are organized according to the RM activities defined in the interview guide, namely: specific aspects of RM, requirements identification, communication, prioritization, negotiation, change control, traceability, and overall challenges.

Specific aspects of RM. From the coordinator's perspective, the SOLAR SECO does not adopt a specific approach (technique, method, or tool) for RM. Instead, RM activities are conducted based on professional experience, with a specific actor responsible for filtering and managing requirements. As highlighted by the coordinator: *"No specific technique is used for RM. However, a specific person with experience in RM is responsible for filtering and managing the requirements, and this part has the participation of the university management"*.

Requirements identification. According to the coordinator, requirements originate from multiple internal and external actors, including management, faculty, students, external partners, and developers themselves, and are primarily identified via email. From the experienced user's perspective, questionnaires and email are the primary mechanisms for submitting demands. As reported by the coordinator: *"The sources of requirements come from management... through external partnerships, by faculty, by other users (students) and by the developers themselves who suggest new requirements, so several actors are involved"*. The experienced user also highlighted it as in the following: *"Usually, the [platform] maintainers publish a questionnaire... In addition, I use email to communicate with the team and send demands"*.

Requirements communication, prioritization, and negotiation. Communication primarily occurs via email and direct interaction with the development team. Requirements are not stored in a centralized repository but distributed across spreadsheets and project management tools. No formal prioritization approach is applied, and prioritization decisions rely mainly on urgency and deadlines. Negotiation occurs through direct communication between stakeholders and the development team. As highlighted by the coordinator: *"The requirements are not stored in a central platform... The Pivotal Tracker tool and Trello tool are used to store new and old requirements"*. Regarding prioritization, the coordinator explained: *"The requirements prioritization considers the urgency of the demand... Another factor that is considered is deadlines... these requirements are prioritized automatically"*. Regarding negotiation practices, the coordinator added: *"The requirements negotiation occurs early in the requirements identification. We talk with users or other actors... We document all definitions"*.

Change control and traceability. Change requests may originate from users or the development team and are analyzed for impact and implementation. However, no formal traceability is adopted, and tracking relies on identifying the communication channel

and requester. As reported by the coordinator: *"The changes in requirements are identified during the project... When we receive a change request, we analyze the impact with the team and come up with a strategy to implement the change"*. Regarding traceability practices, the coordinator stated: *"The team does not use a technique for requirements traceability. The closest to requirements traceability is to follow which communication channel requirements came from and who was the actor who requested the demand"*. From the experienced user's perspective, there is no formal way to track the status of submitted demands.

Challenges in RM. Challenges include prioritization complexity, communication difficulties, clarification of functionalities, impact analysis of changes, and a lack of user feedback. According to the coordinator: *"The requirements management difficulties are related to requirements prioritization and impact analysis of requirements changes... Requirements communication with the end-users is one of the challenges..."*. The experienced user reinforced the importance of feedback mechanisms: *"a communication channel to receive feedback on the requested demands would be a way to improve and have more effective communication between the SOLAR SECO team and the user"*.

Overall, RM practices in the SOLAR SECO are characterized by informal coordination, experience-based decision-making, urgency-driven prioritization, distributed documentation, and communication-based traceability without formal tracking.

5. Discussion

The findings indicate that RM in the SOLAR SECO is not supported by a formalized process but relies on experience-based coordination led by a specific actor. This reflects patterns observed in SECO contexts, where RM practices emerge informally rather than through predefined governance mechanisms [Scacchi 2009, Knauss et al. 2018]. While such informality may provide flexibility, it may also limit documentation, traceability, and long-term sustainability in PSECO [Malcher et al. 2023].

Communication and prioritization are central to RM practices. Requirements are identified and negotiated primarily through email interaction, while prioritization relies on urgency and deadlines rather than explicit criteria. Although these mechanisms may support responsiveness, they reduce visibility into decision-making and limit transparency across ecosystem actors. Previous studies also identify communication and coordination as recurring challenges in SECO environments [Soltani and Knauss 2015, Damian et al. 2021]. The findings suggest a trade-off between lightweight and formal RM practices. While informal coordination may increase responsiveness, the absence of structured traceability and feedback mechanisms may reduce transparency and increase dependence on tacit knowledge.

The decentralized storage of requirements across spreadsheets and project management tools further reflects the fragmented nature of RM practices in this ecosystem. Similar patterns have been reported in SECO contexts characterized by heterogeneous actors and distributed repositories [Vegendla et al. 2018]. In the SOLAR SECO, these challenges are exacerbated by heterogeneous stakeholders and centralized governance structures, which affect communication and coordination dynamics. Overall, the absence of structured RM mechanisms suggests tensions between SECO evolution and formal process adoption in proprietary contexts. These findings contribute to discussions on RM

structuring challenges in PSECO and open opportunities to investigate governance and coordination strategies that balance adaptability and formalization in SECO.

6. Threats and Limitations

We recognize that semi-structured interviews may introduce biases or incomplete interpretations despite the precautions taken. As in most qualitative and exploratory studies [Kitchenham et al. 2015], the small number of participants and the focus on a single educational SECO limit the generalization of the findings. However, consistent with the exploratory nature of this short paper, the study prioritizes in-depth insights from two structurally central actors rather than statistical representativeness. The interviewees occupy complementary roles in the SECO and have extensive experience, providing credible and context-rich evidence about RM practices.

Regarding external validity, the results are limited to this context but may offer useful insights for similar PSECO. Possible threats to internal validity, such as interpretation bias and question formulation, were mitigated through review of the interview guide and clarification during the interviews. For construct validity, the guide was reviewed by independent researchers to ensure alignment with established RM concepts. Finally, conclusion validity was supported through recording, faithful transcription, and the use of the Card Sorting method to ensure analytical consistency.

7. Final Remarks

This study investigated RM practices in a proprietary educational SECO (SOLAR SECO). The results revealed the absence of a formal RM process and a reliance on informal and experience-based practices, such as urgency-driven prioritization and communication-based traceability. These findings provide a preliminary indication, within the investigated ecosystem, consistent with challenges previously identified in the literature regarding the informality and fragmentation of RM practices in SECO. The lack of structured documentation and defined processes may hinder communication and coordination among ecosystem actors. In addition, dependence on informal communication and centralized decision-making may reduce transparency in RM activities.

Improving documentation, prioritization criteria, and communication mechanisms could enhance traceability and collaboration in RM activities. As an exploratory study, this work contributes to discussions on the challenges of RM structuring in PSECO. As future work, we intend to expand this investigation to other ecosystems and explore strategies to support more structured and transparent RM practices in SECO.

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References

Costa, L. A., Fontão, A. and Santos, R. (2022). Toward proprietary software ecosystem governance strategies based on health metrics. *IEEE Transactions on Engineering Management*, 69(6):3589–3603.

Coutinho, E. F., Viana, D. and Santos, R. (2017). An exploratory study on the need for modeling software ecosystems: The case of solar seco. In *2017 IEEE/ACM 9th International Workshop on Modelling in Software Engineering (MiSE)*, pages 47–53, Buenos Aires, Argentina.

Damian, D., Linåker, J., Johnson, D., Clear, T. and Blincoe, K. (2021). Challenges and strategies for managing requirements selection in software ecosystems. *IEEE Software*, 38(6):76–87.

Jansen, S. (2020). A focus area maturity model for software ecosystem governance. *Information and Software Technology*, 118:106219.

Kitchenham, B. A., Budgen, D. and Brereton, P. (2015). *Evidence-based software engineering and systematic reviews*, volume 4. CRC Press, London.

Knauss, E., Yussuf, A., Blincoe, K., Damian, D. and Knauss, A. (2018). Continuous clarification and emergent requirements flows in open-commercial software ecosystems. *Requirements Engineering*, 23(1):97–117.

Malcher, P., Silva, E., Viana, D. and Santos, R. (2023). What do we know about requirements management in software ecosystems? *Requirements Engineering*, 28:567–593.

Malcher, P., Viana, D., Antonino, P. O. and Santos, R. (2025). Towards an understanding of requirements management in software ecosystems. *Information and Software Technology*, 180:107672.

Manikas, K. (2016). Revisiting software ecosystems research: A longitudinal literature study. *Journal of Systems and Software*, 117:84–103.

Outão, J., Costa, L., Zacarias, R., Fontão, A., Constantinou, E., Santos, R. and Serebrenik, A. (2025). Proprietary software ecosystems: What we already know and future perspectives. In *2025 IEEE/ACM 13th International Workshop on Software Engineering for Systems-of-Systems and Software Ecosystems (SESoS)*, pages 17–24.

Santos, R., Constantinou, E., Antonino, P. and Bosch, J. (2024). Software engineering for systems-of-systems and software ecosystems. *Information and Software Technology*, 165:107335.

Scacchi, W. (2009). Understanding requirements for open source software. In *Design Requirements Engineering: A Ten-Year Perspective*, pages 467–494, Berlin, Heidelberg. Springer Berlin Heidelberg.

Singer, J., Sim, S. E. and Lethbridge, T. C. (2008). *Software Engineering Data Collection for Field Studies*, pages 9–34. Springer, London.

Soltani, M. and Knauss, E. (2015). Cross-organizational challenges of requirements engineering in the AUTOSAR ecosystem: An exploratory case study. In *2015 IEEE Fifth International Workshop on Empirical Requirements Engineering*, pages 41–48, Ottawa, ON, Canada.

Spencer, D. (2009). *Card Sorting: Designing Usable Categories*. Rosenfeld Media, New York.

Vegendla, A., Duc, A. N., Gao, S. and Sindre, G. (2018). A systematic mapping study on requirements engineering in software ecosystems. *Journal of Information Technology Research*, 11(1):49–69.