User-Driven Information Systems Development in Living Lab Contexts: Evidence from the SynAir-G Case

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Abstract

Information Systems Development (ISD) increasingly occurs in socio-technical environments, where systems are developed and evaluated in real-life contexts involving diverse stakeholders. Living Labs provide a setting in which stakeholder engagement and experimentation can shape the evolution of systems during development. This research examines the SynAir-G project digital sentinel system as a case of user-driven ISD in a Living Lab context. Using an interpretive case research approach, the study analyses how iterative testing, field experimentation, and stakeholder interaction influenced the development of interconnected system components, including a mobile application, monitoring dashboard, and supporting services. The findings show that engagement cycles and real-life experimentation function as mechanisms through which system requirements, design decisions, and governance arrangements evolve. The paper discusses implications for organising ISD processes in multi-stakeholder real-world environments.

Keywords: Information Systems Development, Living Labs, stakeholder engagement, participatory design, SynAir-G

1. Introduction

Information Systems Development (ISD) is widely recognised as a socio-technical process in which technologies, organisational arrangements, and everyday practices evolve together over time [7, 13]. When digital systems are developed for real-world environments rather than organisational settings, the complexity of this process increases significantly. Stakeholders often participate voluntarily, system requirements evolve through experimentation, and development must accommodate diverse user groups and contexts [9, 16]. These characteristics make participation, iteration, and contextual development central challenges for ISD research and practice.

Participatory Design (PD) provides an important foundation for addressing such challenges [1, 6]. PD emphasises democratic involvement, mutual learning, and the right of affected stakeholders to influence the design of technologies that shape their lives [4, 5]. Over the past two decades, Living Labs have emerged as a prominent approach for operationalising this perspective in innovation processes that take place in real-life contexts [3, 10, 12, 14]. Living Labs organise experimentation and co-creation activities in which researchers, users, and other stakeholders collaboratively develop and evaluate innovations under realistic conditions.

Within Living Lab research, several guiding principles have been proposed to characterise such processes. These include (1) early and continuous stakeholder engagement, (2) value co-creation, (3) openness and transparency, (4) iterative processes, (5) real-life experimentation and evaluation, (6) distributed decision-making, and (7) social inclusivity [8, 11, 15]. Although these principles are widely referenced, ISD scholarship still benefits from empirically grounded studies showing how they are enacted in complex development settings, particularly when innovations consist of multiple interconnected digital systems.

Some research highlights how engagement and experimentation can shape the evolution of digital systems when development takes place outside organisational boundaries [11, 13]. SynAir-G is a European research project investigating indoor air pollution and child health through combined sensor measurement and behavioural data collection in school environments. The project implemented a digital sentinel system to operationalise large-scale, real-life experimentation: the sentinel is composed of a mobile app (with gamified engagement elements used in classroom field tests), an identity and role management service, an operations dashboard for site coordinators, and a data ingestion pipeline for structured questionnaires and sensor metadata. These distinct yet integrated components jointly perform enrolment, authentication, event logging, data capture and engagement management; functions that meet common definitions of information systems as socio-technical systems. Because the project's development strategy relied on repeated field experiments and stakeholder feedback loops, treating these components as the unit of ISD analysis permits a focused investigation of how engagement practices materially shaped design decisions and governance arrangements.

This research aims to examine how stakeholder engagement and real-life experimentation shape the ISD process of the SynAir-G sentinel system in a Living Lab context. In particular, it seeks to understand how user-driven interactions influence system evolution, design decisions, and coordination mechanisms during ISD. By analysing the SynAir-G case through this lens, the study contributes to a more process-oriented understanding of ISD in real-world, multi-stakeholder innovation environments.

2. Research Approach

This study adopts an interpretive case research strategy suitable for examining socio-technical development processes in context [2]. The empirical setting is the SynAir-G project, a European research and innovation initiative that investigates the combined effects of indoor air pollutants on children's health and wellbeing in school environments. The project integrates environmental monitoring, health data collection, and digital technologies to better understand and mitigate the impact of indoor air pollution in classrooms.

Within this broader context, the project developed a digital sentinel system designed to support health monitoring and engagement of participating school cohorts. The system consists of several interconnected information system components, including a gamified mobile application, identity and access management services, a monitoring dashboard supporting administrative coordination, and a data ingestion infrastructure for structured questionnaire-based reporting. These components collectively enable participation management, health data capture, and coordination across participating research centres and schools.

The unit of analysis is the ISD process of the sentinel system, treated as an interdependent set of information systems rather than a single application. The analysis focuses on how stakeholder engagement and real-life experimentation influenced the ISD process. The empirical base includes technical artefacts (architecture descriptions, API docs and dashboard feature specifications), operational artefacts (test plans, field-test logs, and post-test questionnaires) and scholarly outputs describing the gamified app and field evaluations. The analytic approach combined process tracing of development events (mapping releases and test cycles to subsequent design changes) with qualitative document analysis: iterative coding targeted engagement mechanisms (recruitment, incentives, feedback channels), experimentation instances (field test descriptions, measurement protocols), and governance actions (account management, data deletion procedures). Cross-source triangulation (operational logs vs test reports vs publications) was used to corroborate claims about how stakeholder input translated into ISD actions.

The analysed material covered the development and evaluation period of the sentinel system from initial prototype development through field testing and refinement cycles. The author participated in the project as a Living Lab and user engagement researcher, contributing primarily to stakeholder engagement and field-testing activities.

3. Findings

The development of the SynAir-G sentinel system illustrates how engagement and experimentation shape ISD processes in Living Lab contexts. Rather than progressing through a strictly predefined sequence of development stages, the system evolved through interaction with its intended users and stakeholders during deployment and testing activities. The sentinel system itself consists of several interconnected information systems that together support participation and monitoring activities. These include a mobile application through which participants interact with the system, identity and access management mechanisms that regulate participation, a monitoring dashboard supporting administrative coordination, and a data ingestion infrastructure enabling structured health data reporting. This configuration highlights how user participation is not mediated solely through the application interface but through a broader socio-technical infrastructure that enables recruitment, monitoring, and coordination across multiple actors. For instance, observations from classroom field experiments prompted a redesign of the app notification schedule and the addition of contextual prompts to improve completion rates during in-school sessions, illustrating how experimentation directly informed development choices.

During development, the system underwent several cycles of testing and refinement in which early versions of the application were evaluated with participating users. Field testing with children and other stakeholders provided feedback on usability, engagement mechanisms, and contextual constraints. Insights generated during these activities informed adjustments to system functionality and interaction design. In this way, experimentation with real users provided design knowledge that guided subsequent development iterations.

Stakeholder participation also played an important role in shaping the evolution of the system. Children primarily influenced usability and engagement-related features through field testing and feedback activities, while teachers and research coordinators contributed operational requirements related to participation monitoring, user management, and system administration. Engagement activities involved children as primary users together with parents, teachers, developers, and healthcare professionals. These actors contributed perspectives on usability, motivation, and contextual conditions of use. Their participation helped reveal practical considerations that informed design decisions, system features, and subsequent development iterations.

Overall, the case demonstrates how engagement activities and real-life experimentation can function as mechanisms through which ISD processes evolve. The sentinel system developed through continuous interaction between technical development and stakeholder feedback, illustrating how Living Lab contexts support iterative inclusive processes and adaptation during system development.

4. Discussion and Conclusion

The SynAir-G case provides insight into how engagement and experimentation can influence ISD processes when systems are developed in real-world contexts. Rather than treating stakeholder participation as a separate phase of development, the project illustrates how engagement can function as a continuous mechanism for generating knowledge about system use and contextual constraints. Through testing activities and interaction with stakeholders, insights about usability, motivation, and operational conditions emerged during development and informed subsequent design decisions. In this sense, engagement acted as a driver of system innovation [9] rather than merely a validation activity.

The case also highlights how ISD in Living Lab environments depends on a broader socio-technical infrastructure that supports participation. Components such as authentication services, monitoring dashboards, and data ingestion mechanisms enable recruitment, coordination, and participation management across multiple actors and locations. These infrastructural elements shape how stakeholders interact with the system and how engagement can be sustained during development. Consequently, user-driven ISD extends beyond participatory activities and becomes embedded in the technical architecture that supports collaboration and experimentation [10].

From an ISD perspective, these observations suggest that real-life experimentation can provide a valuable mechanism for learning about system use in complex environments where requirements and user expectations evolve over time. Iterative experimentation with stakeholders allows development teams to refine system features and interaction design while gaining a deeper understanding of contextual conditions in which the system operates. Such processes may complement more traditional ISD practices by introducing structured opportunities for learning through use.

Overall, the SynAir-G case demonstrates how engagement and experimentation can shape the development of interconnected information systems in Living Lab contexts. By illustrating how iterative interaction with stakeholders informs system evolution, this research contributes to understanding how ISD processes can be organised in multi-stakeholder innovation environments where digital systems emerge through continuous interaction with users and their contexts of use.

Acknowledgements

This work was funded by the European Commission in the context of the Horizon Europe project SYNAIR-G (Grant Agreement No. 101057271).

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