RESEARCH IN PROGRESS

TOWARDS AN ADAPTIVE IMPLEMENTATION TOOL FOR DEVICES IN COMPLEX HOSPITAL DEPARTMENTS

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Implementation of technological digital devices in existing complex hospital environments remains a challenge. We constructed a framework for the implementation of technological devices in operating rooms. In this research, we address users' needs for an adaptive (digital) implementation tool or app. We use a requirements engineering method to identify stakeholders and to identify steps to define requirements for this digital tool. We will construct personas to identify requirements and based on these findings a market search will follow to decide, either to buy and configure an existing tool or to develop a new tool that facilitates the implementation of devices in complex hospital departments.

Keywords: implementation framework, technological devices, digitization, hospitals, operating room

University of Maribor Press

DOI https://doi.org/10.18690/um.fov.6.2023.50
ISBN 978-961-286-804-8

1 Introduction

Digitization of healthcare occurs in many hospitals and affects many stakeholders in hospitals. Many technological devices are used in hospitals to facilitate health care processes and these devices are connected with various information systems. For example, when vital signs are recorded these can be transferred to a patient electronic health care record (EHR) automatically; many other devices used in operating rooms are connected to EHR's, and thus increase digitization in operating rooms in hospitals. Not only because of this dependence on and connectivity to information systems, but also due to many other situational and contextual variables, implementation of new devices into an existing and complex environment such as an operating room in hospitals, is a challenge. Success rates of implementations of information systems and other technological devices vary and numerous implementations fail (Damschroder et al., 2022; Jacobs et al., 2015; Rafferty et al., 2013). Less successful implementations of systems and devices in healthcare are reported less often, and many learnings for successful implementations can be derived from less successful implementation projects (Ebad, 2020). Successful implementations require well-prepared implementation activities in preparation to the introduction of the device and to influence adoption for use of the new device (Fennelly et al., 2020). To facilitate the implementation of new technological devices in OR's, we conducted several studies to construct a framework for implementation of new technological devices (Sewberath Misser, 2023). Based on the findings and the evaluation of this research, potential users of this framework identified a need for a (digitized) tool or app that enables users to be equipped with situational relevant implementation activities In this study, we adress this need and we composed the following research question:

How can requirements be identified for a user friendly and adaptive digital tool or app for implementation activities for new devices and software in complex hospital environments such as operating rooms?

In the next section, we in short describe the framework for implementation for technological (digital) devices in operating rooms (Sewberath Misser, 2023). In section three, we describe an approach to develop an adaptive tool for the implementation of activities.

2 Background

2.1 Introducing technological and digital devices

Implementation of new technological devices in hospitals appears to be a challenge, as many stakeholders and departments are involved when introducing these new tools. Edmondson et al. refer to a successful implementation of a new tool when the tool is used in day-to-day activities of users (Edmondson et al., 2001). This implementation remains a challenge and will need to be addressed carefully. To address this challenge, we used characteristics from design science research (Peffers et al., 2007). In previous research, we identified in three phases to develop and evaluate an implementation framework, starting with identifying a problem definition. Based on these findings, we developed an artifact in the second phase of research. In the third and last phase of our research we evaluated this artifact. We constructed a problem definition by providing an overview of the research context and by identifying the problem. Schoville et al. state that there is no overarching implementation theory but only a number of models and processes to facilitate implementation (Schoville & Titler, 2015). For the implementation of electronic health care records (EHR) various studies have been conducted to identify factors or barriers for the implementation and adoption of EHR (Fennelly et al., 2020). Based on existing literature an implementation framework or process model for the implementation of new technological devices in an existing operating room environment appeared not available (Damschroder et al., 2009; Moullin et al., 2015; Nilsen, 2015). Based on these findings, an artefact to implement new technological devices in OR's was needed. With that knowledge, we conducted several studies to develop the artifact: a framework for implementation. In this framework we distinguished determinants for implementation, and we identified activities and instructions for implementations. To construct this framework for implementation we conducted an explorative study with scrub nurses and circulating nurses in Operating Rooms to identify relevant factors for implementation (Sewberath Misser, Jaspers, et al., 2018). In a systematic literature review we focused on relevant factors and activities for implementations based on existing studies and theories (Sewberath Misser, Zaane, et al., 2018). Based on the findings of these two studies, we composed a baseline framework for implementation, consisting of implementation factors, implementation activities and implementation instructions (Sewberath Misser et al., 2020). We conducted two studies to validate this framework. In the first validation

study we organized three focus group sessions with implementation experts from varying backgrounds and hospital departments. These experts were surgeons, anesthesiologists, logistics employees, scrub nurses, OR-management, and a methodologist. Based on these findings suggestions for revisions were proposed and analyzed (Sewberath Misser, Jaspers, Van Zaane, et al., 2021). In the second validation study, our base line implementation framework was used to introduce an exoskeleton in the OR (Sewberath Misser, Jaspers, van Zaane, et al., 2021). An exoskeleton is a wearable, mechanical external structure that enhances or supports the power of someone when performing specific activities (De Looze et al., 2016). Based on the data of this case study and the outcomes of the validation study with experts, revisions for the baseline protocol were identified and processed. The final and revised framework for implementation consists of four implementation factors, with related activities and instructions. In the next subsections these factors are explained.

- *Set up a project plan.*

The first factor for implementation focuses on the composition of a project plan. Activities involve identifying topics, goals, performance indicators, risks and relevant implementation activities based on the complexity of the device.

- *Organizational preparation*

The second implementation factor involves preparation of the organization. Implementation activities include activities to assemble a multi-disciplinary implementation team and to prepare the existing stakeholders of the organization. Processes and activities that need adjustment due to the introduction of a new technological device are redesigned and shared with relevant users and departments. Simulations using the new device are prepared and executed and communication plans are identified and deployed.

- *Technical preparation*

The third factor for implementation involves the technological preparation of the environment and the configurational preparations of the device. These configurational preparations include positioning of the device as well as assembly

and disassembly procedures. Technical preparation also entails composing and deploying data management plans, maintenance plans, and updating (safety) regulations.

- *Training and evaluation*

Training and evaluation activities include composing and deploying a training and evaluation plan. Training involves technical and non-technical skills and technical skills also include troubleshoots and interpretation of necessary data and alarms. This training and evaluation plan also covers assessment of skills, as well as evaluation of the device and evaluation of the implementation project. Our implementation framework is included in appendix 1.

3 Towards an adaptive tool for implementation activities

In the previous chapter, the implementation framework and its activities are described. The purpose of this research is to identify requirements to develop an adaptive tool or app for implementation activities, depending on the user requirements and the device. There are different ways to develop or to configure a tool, such as the waterfall method or more agile methods to develop software. A waterfall method of software development generally consists of sequential phases: requirement analysis, system design, implementation, system testing, system deployment and system maintenance (Zayat & Senvar, 2020). The advantages of this method are that this method is described as structured, simple to understand and to implement. However, this method is described as less flexible and difficult when changes in requirements need to be considered and processed (Kramer, 2018). Similarly, the Software Development Life Cycle (SDLC) consists of the following phases: surveying and assessing the feasibility of a software development project, analyze existing information systems, determine requirements for the system, selecting the best solution, determine hardware and software, designing the system, building the system, implementing the system, and maintain the new system (Adi Guna Permana, 2015; Zayat & Senvar, 2020). A more flexible method for developing a software tool is for example the agile development method SCRUM. In agile development methods a development team is selected with a common goal to develop a holistic product. Different team roles are identified. One team member (product owner) defines business goals and requirements for the tool and this team

member initiates the development process by prioritizing activities. These activities are scheduled and executed in development cycles (sprints) (Adi Guna Permana, 2015; Zayat & Senvar, 2020).

To develop a tool for our framework for implementation, we need to consider these development frameworks. As the requirements for a tool are not clear yet, one of the steps in the development process is to identify requirements for the tool. Panday et al. introduced a requirements engineering process model, in which they consider four steps to identify and select requirements for a software tool (Pandey et al., 2010). In the first step, requirements elicitation and development, stakeholders are identified to provide requirements. In the second step, requirements are documented and in the third step requirements are verified and validated. In the last step, they describe how the agreed requirements can be tracked and controlled during the development process of a software tool (Pandey et al., 2010). When focusing on the identification of requirements, Mayas et al. introduces the use of personas to identify requirements for users (Mayas et al., 2016). They describe personas as archetypes: distinguishable characters based on behavior and dispositions of real people.

To identify requirements for an adaptive tool or app for implementation activities we will use personas, as we expect the tool to be used by different stakeholders in OR's. When executing the first step of the requirements engineering process we will identify personas based on potential users with stakeholders (Mayas et al., 2016; Pandey et al., 2010). We will then use these constructed and validated personas to define requirements for an adaptive tool or app for implementation activities. These requirements will be documented and after documentation these requirements will be verified and validated with stakeholders. Following the SDLC method, the best solution needs to be selected based on validated requirements. In this phase, it should become clear whether a new tool needs to be developed or whether an existing tool used for other purposes needs to be considered. If a suitable tool is not available on the market, tool development can be prepared. Agile methods of tool development are preferred, as with our current knowledge we consider the tool to be an incremental tool which would enable rapid development cycles. To develop this adaptive tool, we would like to include users and developers to increase development success and adoption (Abrahamsson et al., 2017).

4 Conclusion, limitations and further research

Implementation of technological digital devices in complex environments such as operating rooms remain a challenge. To address this challenge, we developed and evaluated a framework for implementation consisting of implementation factors, related implementation activities and implementation instructions. These factors are: setting up a project plan, organizational preparation, technical preparation and training and evaluation. This research adresses the need of potential users of this framework. These users identified a need for an adaptive tool or app enabling users to select and prioritize implementation activities. To respond to the research question we will use process steps of requirements engineering to identify requirements for this tool. Based on the findings up to now and our current knowledge, we need to select stakeholders and develop personas. Based on these personas we will identify requirements. A market search on available tools needs to be executed to decide whether to buy and adjust an existing vendor tool or to develop a new tool. In case of a development of a new tool, we prefer an agile method for development.

Limitations and further research

In this research in progress we initiate the process to follow up on users needs to develop or acquire a tool or app that facilitates implementation of new technological equipment. Up to now did a provisonal and limited search, on development methodologies for software to develop this tool. We use the body of knowledge of requirements engineering to identify requirements with use of personas. After these requirements have been specified, further research needs to be conducted on the preferred agile development method.

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Appendix 1: implementation framework for technological devices in operating rooms

A revised framework for implementation for technological devices was constructed and is presented in the next table (Sewberath Misser, 2023). We intend to use the contents of this framework as first data set for an adaptive digital tool or app to help users to implement new digital and technological devices.

Table 1: Revised implementation framework (Sewberath Misser, 2023)

Id	Implementation Activities	Instructions for implementation
1	**Set up a project plan**	
1.1	Identify strategic and tactical topics	Operationalize overall strategic and tactical goals for the implementation stage.
1.2	Identify performance	Identify performance indicators to define the performance of the implementation stage and define how these variables are measured and analyzed. Performance metrics for success could be efficiency, finance, and ergonomics.
1.3	Identify stakeholders	Identify (groups of) stakeholders, which are responsible, accountable, consulted and informed such as sponsors, key-representatives, staff, teams. Identify a project manager for implementation
1.4	Identify risks related to implementation	Perform a risk assessment to identify risks and identify unintended outcomes as new technology may have unforeseen consequences.
1.5	Identify activities for implementation	Identify relevant activities for implementation, based on listed activities. Generate a planning or timeline for execution of these activities.
2	**Organizational preparation**	
2.1	Assemble a multidisciplinary implementation team	Assemble a team which includes various members of involved departments and stakeholders such as scrub nurses, circulating nurses, anesthesiologists, perioperative technicians, surgeons, administrators, IT specialists, and schedulers. Consider assigning an extra team member during implementation to

Id	Implementation Activities	Instructions for implementation
		increase familiarity with procedures, e.g. setup procedures.
2.2	Foster team familiarity	Team familiarity and stability impacts teamwork, communication, and satisfaction during implementation. Assign a dedicated implementation team. Involve and inform this team well.
2.3	Identify affected activities and/or processes	Introducing new (medical) equipment influences existing activities and work processes. Identify these and analyze how these processes are affected and which identified stakeholders are involved.
2.4	Update checklists and/or protocols	Checklists improve safety and reliability prior to, and during surgical procedures. Update operating procedures or protocols. If necessary, update existing check lists.
2.5	Perform simulations	Simulate with stakeholders (and departments) how processes and work activities are executed prior to introducing (medical) equipment. Practice with a new tool or new (prototype) equipment on trial basis.
2.6	Identify and deploy activities to increase employees' engagement	Participation of employees when introducing new (medical) equipment increases employees' engagement in the OR. Deploy activities to engage employees in the OR, e.g., involvement of work councils, create a communications council.
2.7	Identify and deploy activities to increase employees' adoption	Embedding information systems or new (medical) equipment in day-to-day activities as an accepted routine is a challenge. Identify and deploy activities to increase adoption with stakeholders such as demonstrating relative advantages, possibilities to observe and experiment, demonstrate benefits, use training and assign key users or champions.
2.8	Communicate with stakeholders	Communication with stakeholders increases engagement and involvement of stakeholders. Set up a communications plan, consisting of

Id	Implementation Activities	Instructions for implementation
		communication activities over time. Involved stakeholders should be aware what their role is relating to the new (medical) equipment. For example, nursing personnel should be familiar with the instrumentation needs and they should be proficient in properly connecting, calibrating, set up and use (medical) equipment. Communication activities can be: (pre-operative) group briefings, interviewing stakeholders, using videos and newsletters, developing patient centered information.
3	**Technological preparation**	
3.1	Prepare equipment	Prepare technical facilities related to the use of the information system or device in the OR e.g., power and plugs (if needed)
3.2	Consider ergonomic aspects	Introducing a new tool or system may affect ergonomic aspects of staff in the OR. Consider these aspects in an early stage of the project, prior to implementations. Simulations may lead to ergonomic changes and positioning of tools in the OR.
3.3	Prepare interfaces with other information systems	Introducing new equipment requires integration in and with other devices in the OR. Consider the connectivity to the clinical networks to ensure safety and reliability.
3.4	Integrate device within existing environment	The introduction of new equipment affects current workflows and processes. These workflows need to updated, and existing standard operating procedures need to be updated accordingly.
3.5	Manage generated data	When introducing equipment data can be generated and/or stored, e.g. when introducing a new information system. Consider data processing and security aspects and develop or update procedures.
3.6	Set up maintenance plan	New equipment in use should be maintained periodically and in case of problems, support

Id	Implementation Activities	Instructions for implementation
		should be available. To address and facilitate this, a maintenance plan should be set up. Provide instructions how to maintain (clean) tools/equipment such as screens in the OR and confirm who is responsible for this activity.
3.7	Update safety (regulations)	The introduction of new equipment may affect work activities of personnel. Assess the safety procedures and if needed, update these procedures accordingly.
4	**Training and evaluation**	
4.1	Train involved staff	(Recurrent) training is crucial for correct and safe use of the system or tool and affects adoption and success of an implementation. Training focuses on technical skills and non-technical skills. Technical skills may include cognitive, integrative, and automatic skills such as congress visits, demonstrations, research results, online courses, knowledge training, expert opinions, and simulation trainings. Specific trainings on changing ICT and updated workflows and activities should be included as well. Non-technical skills may include decision making, communication and leadership skills.
4.2	Interpret screens and troubleshooting	In case of electronic equipment, notifications may occur visibly on screens, lights, or audible (alarms). Involved personnel should be able to interpret these notifications and should be able to troubleshoot in case of occurring problems.
4.3	Assess Skills	To assess the readiness for use, a skills assessment plan needs be developed and executed, tailored to the stakeholders. This plan may include supervision by co-workers. An assessment plan can be determined and executed by a manufacturer, the hospital or a department. (If applicable) assess whether skills need to be recorded and tracked.
4.4	Evaluate experiences	Evaluate experiences and gather feedback regarding the use of the new device, provide

Id	Implementation Activities	Instructions for implementation
		input to optimize the device, the use of the device or the workflow.
4.5	Evaluate implementation process	Evaluate the implementation process and relate results to the performance indicators mentioned in the implementation plan.