A Research Pathway Model for evaluating the implementation of practice-based research – the case of self-management health innovations

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Abstract

This study explores the evaluation of research pathways of self-management health innovations from discovery to implementation in the context of practice-based research. The aim is to understand how a new process model for evaluating practice-based research provides insights into the implementation success of innovations. Data were collected from nine research projects in the Netherlands. Through document analysis and semi-structured interviews we analysed how the projects start, evolve, and contribute to the healthcare practice. Building on previous research evaluation approaches to monitor knowledge utilisation, we developed a Research Pathway Model. The model's process character enables us to include and evaluate the incremental work required throughout the lifespan of an innovation project and it helps foregrounding that innovation continues during implementation in real-life settings. We found that in each research project pathways are followed that include activities to explore a new solution, deliver a prototype, and contribute to theory. Only three projects explored the solution in real life and included activities to create the necessary changes for the solutions to be adopted. These three projects were associated with successful implementation. The exploration of the solution in a real-life environment in which users test a prototype in their own context seems to be a necessary research activity for successful implementation of self-management health innovations.

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1. Introduction

For dealing with complex societal problems, such as the ageing population and rising healthcare costs, much is expected from self-management health innovations (Lorig and Holman 2003). Self-management concerns a series of activities performed by patients to manage their symptoms, support treatment, and to alleviate physical and psychosocial consequences (Barlow et al. 2002) outside the clinical setting and integral to their daily lives (Cruz-Martínez et al. 2019). Innovations to support self-management range from digital tools for e.g. monitoring body indicators to health education programs, and potentially improve health outcomes and reduce costs (Jonkman et al. 2016). However, there are barriers to self-management health innovations which are associated with their highly-various character (Kennedy et al. 2014). The highly-contextualized setting makes the generation of evidence on efficacy and safety difficult, which is needed for healthcare professionals to prescribe and insurance companies to reimburse these products (Sivertsen and Meijer 2020). Moreover, such setting requires these products to be constantly adapted during implementation (Rosenberg 1994; Candy and Edmonds 2010; Bornmann 2013), calling for studying the entire innovation process.

Many self-management health innovations are studied and developed in so-called practice-based research (PBR) projects at Universities of Applies Sciences (UASs). We define PBR as a co-creation process in which the implementation of results into practice is realised by integrating research results throughout the entire process in the form of activities, interventions and interactions with stakeholders (McColl-Kennedy et al. 2012). The practice-based way of doing research and the research pathways involved with PBR are understudied phenomena though (Coombs and Meijer 2021).

Both developing and implementing self-management health innovations and the nature of PBR projects underline that the steps in the innovation are heavily interconnected. Thus, we evaluate research pathways using previous conceptual approaches to knowledge utilisation by employing a process-based approach (Langley and Tsoekas 2012; De Jong et al. 2014). Employing a process perspective enables us to include and evaluate the incremental work of researchers and stakeholders required throughout the lifespan of an innovation project and it helps foregrounding that innovation continues during implementation in real-life settings (e.g. Janssen 2016), emphasising the ‘daily’ practical organisational level of interaction (Sivertsen and Meijer 2020). To address the gap in the literature of ways to evaluate research pathways involved with PBR, our study focuses on the following question: *What are the requirements for a process model to evaluate the implementation success of self-management health innovations developed in practice-based research projects?*

2. Theoretical framework

This study focuses on the pathway to successful implementation of self-management health innovation in the context of practice-based research (PBR) projects. The aim of such PBR projects is to develop a prototype of a self-management device, training protocol, etc. and related knowledge on safety, usability and so on. As discussed above, we apply a process perspective to evaluate successful implementation. Section 2.1 elaborates on this. Section 2.2 discusses examples of existing research impact models that use a process-based perspective. As implementation is an integral part of PBR, this requires an approach to evaluate the impact step by step throughout the entire research process. Therefore Section 2.3 proposes a dedicated process model to describe research pathways of self-management health innovation in PBR projects.

2.1 Successful implementation of self-management health innovations

Several studies about the implementation of self-management health innovations have led to the identification of success factors for innovation, such as the 'involvement of end-users, partners or stakeholders' (Van Beest et al. 2020). The evaluation of self-management health innovations should be extended and tailored to those originating from PBR. PBR projects have specific characteristics, such as the involvement of and high degree of interaction between many different stakeholders in the project and the frequent touching base with practice, i.e. the specific context in which the project is intended for.

Self-management health innovations aim to equip individual's ability into their daily lives to manage the symptoms, treatment, and physical and psychosocial consequences, as well as the lifestyle changes inherent in living with a chronic condition (Barlow et al. 2002; Cruz-Martínez et al. 2019). As such, these innovations focus on achieving "normal impact", i.e. influencing daily activities and how well they are organised, not about individual cases of particularly interesting or impressive impact (Sivertsen and Meijer 2020).

Moreover, what is regarded as successful implementation varies from one context to another (Janssen et al. 2015). The value assigned to an innovation is the result of interactive processes in which actors are involved and which are context-dependent. Not only does this mean that valuation of PBR projects varies across contexts, but also that innovation activities do not stop at diffusion and continue throughout implementation (Janssen 2016).

So, PBR projects should be valued by taking into account particular contexts as well as using a process perspective describing the activities that lead to implementation success. Studying the implementation of innovations as a result of research projects is not a new issue. Over the last decades scholars have analysed the social, cultural, environmental and economic returns on research investment (Bornmann 2013). The following section presents an overview of existing research impact models that follow a process approach.

2.2 Impact of research

Within the scientific and policy community there is a growing concern about assessing the impact of research. This has resulted in emphasizing methods to evaluate the process and impact of research. An emerging stream of literature has focused on interaction between researchers and stakeholders, taking slightly different perspectives. Examples are multidimensional models focused on the social impact of research, like the Payback model (Donovan and Hanney 2011) and Public Value Mapping (Bozeman and Sarewitz 2011). Other models aim to uncover the contribution of interactions, such as the Social Impact Assessment Methods through Productive Interactions (SIAMPI, Saapen and Van Drooge 2011) and Contribution Mapping (Kok and Schuit 2012). A third group is the actor- and process-oriented frameworks focused on diverse outcomes and interactions, such as Participatory Impact Pathway Analysis (PIPA, Douthwaite et al. 2007) and Socio-Economic Analysis of the Impacts of Public Agricultural Research (ASIRPA, Joly et al. 2015). This section discusses these models and their relevance for assessing practice-based research (PBR).

The Payback Framework was created by Buxton and Hanney (1996) to assess the outcomes of health research structures. It consists of a logic model of the research processes, and various categories of research paybacks and anticipated impacts. The Payback Framework recognises and explicitly makes room for a plurality of types of impact, and has been applied in a range of different contexts both within and beyond healthcare (Donovan and Hanney 2011). The framework is relevant for PBR because PBR involves different contexts, types of impacts, and ways of doing research. At the same time, it is not possible to tie the categories of benefits to specific stages of the model, as the Payback Framework is mainly focused on the outcomes of research. A focus on the entire process is important, though, because implementation of PBR into follow-up research and daily organisational practice is realised during the whole research process. Bozeman and Sarewitz (2011) propose Public Value Mapping (PVM) as an approach to assess what they call public values of science. PBM is, just like PBR, based on the idea that science outcomes should serve and advance public values. Public values include outcomes like environmental quality, environmental sustainability, health care and meeting basic needs, e.g. housing and food. PVM does not a priori define the different dimensions of effects (the set of public values), ensuring that PVM can take a context-specific approach. At the same time, PVM makes it difficult to compare projects.

Two approaches which are more focused on the contribution of interactions during the process are SIAMPI (Saapen and Van Drooge, 2011) and Contribution Mapping (Kok and Schuit, 2012). Both approaches focus on interactions during the process which are better traceable and provide more insightful information regarding implementation. Central to the SIAMPI framework is the concept of productive interactions: the mechanisms through which research activities lead to a socially-relevant application. The SIAMPI framework introduces the notion of impact pathways in which interactions occur during or after a research project, or even before it has started. Using process indicators does help anticipating societal impacts that may not yet have materialised at the moment of evaluating (De Jong et al. 2014). SIAMPI is an inspiration for capturing impact throughout the entire PBR process. Contribution Mapping is a three-phase process. Each phase is associated with its own research activities, goals and interactions between different stakeholders. Contribution Mapping emphasises that different activities and different types of interactions may be important during different stages of a research project. Both frameworks (SIAMPI and Contribution Mapping) are focused on efforts instead of results. For PBR it is relevant to use a framework that emphasises that each phase requires different interactions through activities, without reducing the complexity of interactions. The types of impact described in these two frameworks are primarily about knowledge transactions in interactions whereby knowledge could be implicitly contained in products or services. In PBR, impact is just as often explicitly achieved through the development of products, through the personal development of the involved people and through interventions during the research with the aim of initialise change in practice. Recognising the different ways in which PBR generates impact is essential to evaluate the impact of this type of research (Greven and Andriessen 2019).

PIPA (Douthwaite et al. 2007) is an actor- and process-oriented framework focused on diverse outcomes and interactions. For PBR this integration is helpful because PBR is a co-creation process between actors with the aim to directly contribute to practice. However, PIPA does not make explicit the different contexts, types of impacts, and ways of doing research. Essential for PBR is the way in which practical real-life problems are analysed and how research contributes to practice by means of generating actionable knowledge and developing practical solutions, methods and instruments. ASIRPA (Joly et al. 2015) pays attention to the process of transformation of knowledge actionable by incorporating it into new products, processes or governing things. ASIRPA is multidimensional; based on the involvement of networks of actors, at different stages and playing a variety of roles, and over a nonlinear impact pathway. The method is useful for PBR where it offers assessment of the societal impact from design and scaling up to the level of the organisation. The ASIRPA framework contains all factors in the research process to achieve impact and is therefore comprehensive. At the same time, the way in which impact is incrementally realised during the whole process is not part of the model. In PBR, impact is achieved through steps from the early start through the implementation. Mapping the entire pathway provides insights into the different ways in which PBR generates impact which is essential to evaluate the impact of this type of research. It is therefore important for PBR to obtain an overview of the entire research path, whereby during the project it is made explicit which output can be attributed to a certain impact area such as further research or practice. Table 1 gives an overview of the above-mentioned models and shows which elements for a model to analyse the pathway of the implementation of PBR resulting in self-management health innovations can be used.

Table 1: Overview of models to evaluate research projects.

Model	Description	Helpful elements for PBR	Missing elements for PBR
ASIRPA (Joly et al. 2015)	Comprehensive approach for assessing the socio-economic impact of public-sector research organisations through theory-based case studies, selected to characterize the diversity of the	- Actor- and process oriented framework focused on diverse outcomes and interactions. - Pays attention to the process of transformation of knowledge actionable by incorporating it into	The way how impact step by step is realised during the whole process is not part of the model.

Model	Description	Helpful elements for PBR	Missing elements for PBR
	broader impacts, and standardized to allow the scaling-up of the analysis of impact to the level of the organisation.	new products, processes or governing things. - Multidimensional; based on the involvement of networks, at different stages, playing a variety of roles, over a nonlinear impact pathway.	
Contribution Mapping (Kok and Schuit 2012)	A three-phase process. Each phase is associated with its own research activities, goals and interactions between different stakeholders. The phases are separated by soft, blurry borders as activities of one phase may continue into the next.	Focus on interactions during the process which are traceable and provide insightful information regarding the process of implementation.	Primarily about knowledge transactions in interactions.
Payback Framework (Donovan and Hanney 2011)	Facilitate data collection and cross-case analysis by providing a common structure and consists of two elements: 1. A logical structure which describes the various stages of outputs, outcomes and dissemination. 2. An element describing the outputs, outcomes and impact.	- Recognizes a plurality types of impact, explicitly makes room for these and has been applied in a range of different contexts both within and beyond the health service. - It is possible to do a cross-case analysis by providing a common structure.	- It is not possible to tie the categories of benefits to specific stages of the model. - It is focused on the outcomes (goals) of research.
PIPA (Douthwaite et al. 2007)	Evolving tool that offers a deeper understanding of the results that projects might attain with specific partners to help set priorities and support funding proposals.	- Actor- and process-oriented framework focused on diverse outcomes and interactions. - Possible to use before, during and after the project.	The model does not make explicit the different contexts, types of impacts, and ways of doing research.
Public Value Mapping (Bozeman and Sarewitz, 2011)	Conceptual tool for developing systematic understanding of the multiple determinants of social outcomes and the role of science as part of institutional arrangements and networks. The focus is on social impacts rather than scientific and economic impacts.	- Case-based approach. - Focusing on assessing the impacts of a given research endeavour on public values. - Based on the idea that science outcomes should serve and advance public values.	Difficult to compare cases.
Social Impact Assessment SIAMPI model (Saapen and Van Drooge 2011)	Central to the framework is the concept of productive interactions. Involves two central tasks: 1. to enlighten the mechanisms by which social impact occurs; 2. to develop methods to assess social impact.	- Focus on interactions during the process which are traceable and provide insightful information regarding the process of implementation. - Can occur during or after a research project, or even before it has started.	Primarily about knowledge transactions in interactions. In PBR, impact is just as often achieved through the development of products, the personal development of the involved people and through interventions during the research with the aim of initialize change in practice.

The existing models share a process-based approach, but the models are not sufficient for PBR because of the missing elements as mentioned in Table 1. Coombs and Meijer (2021) emphasize that there is a need for a new process-based evaluation approach for PBR which makes the inclusion for stakeholders in the process explicit In Section 2.3 we describe the contours of such a process model building on the elements as mentioned in Table 1.

2.3 A process model to study innovation processes in practice-based research

There is a need for a process model which makes explicit what type of impact can be attributed to what research step to achieve a better understanding of the pathway to a successful implementation through Practice Based Research (PBR). We propose a Research Pathway Model as a step in this direction.

A Dutch version of the *Research Pathway Model (RPM),* PRO-model, was developed in an earlier research project (Van Beest et al., 2017) for research in different domains to discuss the readiness of research projects for real-life practice before, during and after the project. The early version of the RPM uses the Technology Readiness Levels (TRL) as a structuring device (Mankins 2009). TRL is meant to assess the readiness of a particular technology from the discovery phase to the implementation in the market. TRL indicates the degree of a technology in nine levels, whereby TRL 1 stands for technology at the start of development and TRL 9 captures a technology that is technically and commercially ready for upscaling (Mankins 2009). However, TRL could not be used one-on-one because the linearity of the model does not fit into the implementation process and TRL is only focused on technological innovations, whereas the self-management health innovations could also be non-technological. The main difference between TRL and the RPM is that TRL is a linear model with nine consecutive levels, while the RPM is a process model placed in a matrix (Figure 1) without imposing a predefined order of activities. The model was discussed, updated and translated into English in two co-design sessions together with a group of Dutch researchers from the research groups Co-design, Physiotherapy, Education and Research impact at an UAS who have been working with the Dutch version of the RPM and in a third session with a group of experts on practice-based research. The model consists of two axes (research contexts and research activities) and nine research goals (Figure 1).

We discern three research contexts: *theoretical context*, *conceptual context* and *real-life practice context*. The contexts are based on Dalsgaard and Dinder (2014) who distinguish 'theory', 'bridging concepts' as one form of intermediary knowledge bridging between theory and practice and 'real-life practice', and Hevner (2007) who demarcated the 'knowledge base' (theoretical context), the design cycle which iterates between research processes and the core activities of building and evaluating the design artefacts (conceptual context), and environment (real-life practice context).The RPM extends these concepts from design studies and makes them applicable to PBR. In the theoretical context the research is focused on creating, exploring and delivering a better understanding of problems and related propositions for solutions, which are advanced and not verified in practice yet. The conceptual context makes the translation from presupposed solutions to a more specific prototype that is created, explored and made. In this context researchers, project partners and other stakeholders bring in experiential knowledge to translate theory to prototype, by themselves, together with the consortium and with or without the end-users, but always in a protected niche as a brainstorm room, a pilot environment or in the context of a pilot organisation. The real-life practice context concerns the context in which the prototype is tested in the world of professional practice and/or the living environment of end-users.

Figure 1: Research Pathway Model.

Research contexts Research activities	Theoretical context	Conceptual context	Real-life practice context
Create	A.1 Create theoretical understanding	B.1 Create a concept	C.1 Create understanding of real-life practice
Explore	A.2 Explore theory or a concept in a controlled situation	B.2 Explore a concept	C.2 Explore a solution in real-life practice
Deliver	A.3 Deliver theory or knowledge	B.3 Deliver a concept	C.3 Deliver change in real-life practice

In addition to the focus areas the model discerned three overarching research activities: *Create, Explore* and *Deliver,* which has been explored and validated during previous application in PBR innovation processes (see also above for how this validation has been done). *Create* refers to research goals with the aim to create more understanding of the problem and to create an idea to solve the problem. These goals can be realised by research activities throughout the whole research pathway, whereby it is possible that a research goal returns during the iterative process. Examples are: performing a literature review (create theoretical understanding), co-designing a prototype (create a concept), observing end-users in their own context (create understanding of real-life practice).

Explore refers to research goals with the aim of exploring an idea, concept, construct or solution by research activities. Examples are: laboratory research and tests in a controlled environment (explore theory or a concept in a controlled situation), evaluate a prototype in a pilot (explore a concept), testing a prototype in the environment of the end-user (explore a solution in real-life practice).

Deliver refers to goals related to the delivery of the insights during the research pathway. Examples are: publishing research papers or grey literature (Deliver theory or knowledge), deliver a prototype to the market (deliver a concept), working on an implementation strategy in an organisation (deliver change in real-life practice).

Based on the characterization of pathways in e.g. SIAMPI and ASIRPA, we define a research pathway as the order or sequence in which a project goes through the nine research goals, where it is possible to have goals iterate several times. The matrix does not prescribe an ideal sequence of goals. The RPM can be used as a process model mapping activities, patterns and the linkage between them. By using the RPM impact analysts are able to visualise goals and the underlying activities. As such, the activities that need to be done to implement an innovation in practice become visible for the researchers themselves and communicable to other stakeholders. By using such a process model, researchers are able to ex ante design their research pathways to plan their actual research activities, to monitor them during the project, and to evaluate their pathway after concluding the research project. The matrix makes it possible to map the activities that contribute to the implementation of the innovation project whereby the contributions to the real-life practice, conceptual and theoretical context can be made explicit.

Inspired by and based on the impact models presented in Section 2.2 we offer RPM as a research evaluation framework suited for PBR. Following a process approach, we are able to analyse how the activities that contribute to the implementation of research in practice give meaning to a self-management health innovation and how this work is made manageable. Thus, we apply the RPM to nine illustrative self-management health research projects.

3. Method

To explore how a process model for innovation provides insights into the implementation success of self-management health innovations developed in research projects, we used a qualitative multiple case study approach (Stake 1995). Empirical data in this study came from nine research projects on the development of self-management health innovations, with consortia that consist of practice-based researchers, healthcare professionals and/or healthcare entrepreneurs. The research design is exploratory due to the newness of the *Research Pathway Model*.

3.1 Case selection

For this multiple case study, we selected nine illustrative self-management health research projects from the HU University of Applied Sciences Utrecht with consortia consisting of researchers, healthcare professionals and entrepreneurs (see Appendix 1). We focused on only one UAS because we are studying implementation success in a particular context. Cases were selected from the project databases of websites of the Taskeforce for Applied Research SIA and ZonMW, the Netherlands Organisation for Health Research and Development, and the website of the UAS. The criteria for including a case were based on criteria in the self-management definition by Jonkman et al. (2016, pp. 36): *"self-management innovations aim to equip patients with skills to actively participate and take responsibility in the management of their chronic condition in order to function optimally through at least two of the following aspects: (1) providing knowledge about the condition and/or treatment, (2) active stimulation of symptom monitoring, (3) enhancing problem solving skills (self-treatment, resource utilisation, stress/symptom management), (4) enhancing physical activity, (5) enhancing dietary intake, (6) enhancing smoking cessation, (7) enhancing medication adherence."* The project description was assessed by one researcher, and iteratively validated during a three-hour group discussion with the other authors. This resulted in the selection of nine projects. They were funded between 2010 and 2020, with a lead time of two to five years, and are briefly described in Appendix 1.

3.2 Implementation success

We define implementation success as the actual use or integration of an innovation within a specific setting in an organisation (Rabin et al. 2008). Implementation success in this study meets at least one of the following criteria: (1) the innovation is used in a specific programme of at least one organisation by the end-users themselves, (2) the innovation is integrated in daily organisational routines of end-users in a specific setting in or related to an organisation, (3) the innovation is sold to organisations through a (healthcare) entrepreneur or publisher, (4) the innovation is made available in an organisation whereby the actual use is monitored by the organisation as well.

Table 2 presents the nine projects and shows which projects reach a successful implementation at the moment of data collection (February- May 2019) related to the criteria of Rabin et al. (2008). Three projects (Projects 1, 2 and 3) achieved a successful implementation of a self-management health innovation. In Project 1 the intervention tool is made freely available and can be downloaded. The intervention is integrated with a different working method within a participating partner and a non-partner organisation. The intervention has also been implemented in an education programme of another university. The main researcher provides training to interested organisations on the use of the intervention. The researchers obtained a grant for a follow-up study with the aim of digitalising the tool. In Project 2 the mobile-phone app is implemented by a business partner. The researchers have applied for and received grants for an extension of the app so that it can help to self-manage other disorders. In Project 3 the tool is made available via a publisher. Participating speech therapists and speech therapists in their network will implement the tool in their treatments.

In five of the projects (4, 5, 7, 8, and 9) which have not reached a successful implementation yet, one or more project members are still active in the implementation process of the innovation. This means that they are still engaged in innovation activities (see Appendix 2), and that the implementation success of these projects is thus not guaranteed (yet). The development of the tool was discontinued in Project 6 with no further work being planned.

Table 2: Implementation success in the nine cases.

Project	Type of innovation	Implementation stage during data collection	Implementation success
1	Intervention tool	The innovation is used in a specific programme of at least one organisation by the end-users themselves.	Yes
2	App	The innovation is made available in an organisation whereby the actual use is monitored by the organisation as well.	Yes
3	Talking tool	The innovation is sold to organisations through a (healthcare) entrepreneur or publisher.	Yes
4	Technology for stimulating self-management	Multiple prototypes are available for research in follow-up projects. There is market demand for one of the prototypes. The researchers are looking for an entrepreneur who wants to market the product.	No
5	App	There is a prototype and the researchers are working on a grant application. One of the healthcare entrepreneurs is collaborating with the healthcare entrepreneur of project 2 to implement the app in their system.	No
6	Talking Touchscreen	There is a prototype.	No
7	Tool to monitor conditions	There is a prototype.	No
8	Digital platform	A final prototype is delivered and the business partner is project leader of this project and will decide about the further development.	No
9	mHealth intervention	There is a prototype of the product. The researchers are looking for an entrepreneur who wants to market the product.	No

3.3 Data collection

To explore the contributions of self-management health innovation projects to the implementation success of the developed innovations, we used a qualitative multiple case study approach, including document analysis and semi-structured interviews (Stake 1995). For the document analysis, we manually analysed documents from the project website or the public website of the UAS to gain insights into the published activities of the projects. To acquire information about additional information of activities and researchers' motives, we participated in activities during the project and in interactions with stakeholders. We also conducted semi-structured interviews with an interview schedule (Appendix 4) with the most involved researchers (project leaders or PhD students) of the nine projects, i.e. healthcare entrepreneurs (n=3), healthcare professionals (n=4), and researchers with a different expertise (co-design and information systems) from the main researcher (n=2). In addition, we conducted evaluation interviews after the project with healthcare professionals of one of the projects (n=6). Interviewees were asked to describe how the research pathway had evolved. Interviewees were encouraged to be specific about the research processes and to provide examples. To increase the reliability of the data, the interviews were audio-recorded and transcribed verbatim. Respondents gave approval to record and use the data, and checked the manuscript for inaccuracies.

3.4 Data analysis

Data analysis was done in two steps: 1) a detailed qualitative within-case analysis to analyse each research pathway, and 2) a cross-case analysis to compare the different pathways and to discover patterns (Stake 1995). The documents and transcripts were used to iteratively analyse the research pathways of the projects.

The first step of the analysis consisted of coding the documents and interviews through a coding scheme (see Appendix 2) which we developed based on the RPM in Section 2.3. The documents and interview transcripts were read and the content was highlighted using Atlas-ti software version 8.4.15. Coding was done by one researcher. The second step of the analysis was clustering all relevant data in the form of quotes from both interviews and documents. For the within-case analysis, we analysed the presence of the selected process features, and structured them per project in separate tables (Appendix 3). The transcripts of the interviews with researchers were compared to the interviews with the other involved interviewees of the same case to complete the pathway. Process features could only be analysed if the project explicitly undertook a research activity, or named an event or interaction related to the predefined research goals. We then conducted a systematic cross-case analysis and clustered all relevant data in the form of quotes both from interviews and documents in a data matrix (Miles and Huberman 1994). This clustering was structured by the codes of the RPM. To be able to gain insights into the pathways of the projects we needed to combine the data of the codes. Our analysis was recursive, constantly moving from the specific cases, to the more general, with the aim of identifying commonalities and patterns across the variety of cases.

4. Results

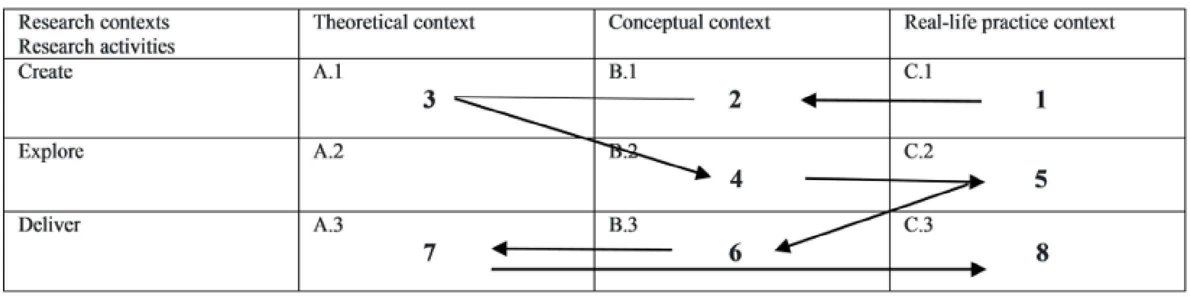
The aim of this paper is to understand what requirements are needed for a process model to evaluate the implementation success of self-management health innovations developed in practice-based research projects. We applied the Research Pathway Model on nine cases. Section 4.1 describes the nine cases using the RPM and explicates how the model can illustrate the steps taken. Section 4.2 then explores how the RPM can be used to demarcate activities and requirements that lead to implementation success. Section 4.3 then emphasises the sequencing of these activities and puts these activities into a process perspective.

4.1 Using the Research Pathway Model

The *Research Pathway Model* (Section 2.3) was used for evaluating research pathways in PBR projects which aimed at developing and implementing self-management health innovations. Figure 2 illustrates the research pathway of one of the nine cases (Project 1).

A number of rehabilitation centres in the Netherlands had questions about the long-term effectiveness of the existing self-management chronic pain programmes. These treatment programmes focus on patients with chronic musculoskeletal pain associated with personal and social dysfunction. The interventions are aimed at changing the behaviour of patients so that they can better deal with pain complaints in their daily lives. To address the articulated problem, the general aim of the project was to develop and bring together knowledge and skills in the field of self-management and chronic pain rehabilitation.

Figure 2: Steps taken in Project 1 following the Research Pathway Model. In Project 1 the following steps were taken in this sequence: *step 1* C.1 Create understanding of real-life practice, *step 2* B.1 Create a concept, *step 3* A.1 Create theoretical understanding, *step 4* B.2 Explore a concept, *step 5* C.2 Explore a solution in real-life practice, *step 6* B.3 Deliver a concept, *step 7* A.3 Deliver theory or knowledge and *step 8* C.3 Deliver change in real-life practice. A.2 'Explore theory or a concept in a controlled environment' is no part of this project.



In *step 1* (C.1, Figure 2) of the project the researchers conducted a retrospective survey of the effects of pain rehabilitation, the degree of self-management and the percentage of relapse within six months. The survey took place at the rehabilitation centre involved, amongst patients who had completed a chronic pain rehabilitation programme indicating that this research step takes place in the real-life practice context. According to the research protocol, these patients completed a short questionnaire three, six and twelve months after the start of rehabilitation. After these research activities the investigators had an understanding of the effects of the existing programme. In *step 2* (B.1, Figure 2) professionals and patients with chronic pain were asked about the underlying reasons that could possibly cause the relapse and about methods that could be useful to prevent such a relapse. Through co-design, in the conceptual context, a prototype for an intervention was developed to help people with chronic pain to retain the results of their rehabilitation. This is an intervention tool in which values and goals can be formulated and important moments or experiences can be saved during rehabilitation and afterwards, as a reminder and support in the event of a relapse. In a parallel process (Numbered as *step 3*; A.1, Figure 2), a systematic literature study, in a theoretical context, was conducted covering the effects of a self-management intervention on self-efficacy, daily activities and limitations in patients with chronic pain complaints. In *step 4* prototypes developed by students were presented at the rehabilitation centre. The exploration was not just about the prototype but, by hidden design and in line with step 2, about the principle of the presented interventions in a conceptual context. In *step 5*, the prototype was tested by eight patients in a feasibility study (C.2, Figure 2) in a real-life context. They rated the usability of the tool on average with a 7.8 and motivated them to actually carry out their goals in the treatment programme. The practitioners of the rehabilitation centres have also been asked about their experiences. They were positive about the possibilities of the tool. Based on the experiences of users, the tool was then adapted and made available for all rehabilitation centres. The pathway was followed by *step 6* (B.3, Figure 2) in which a game was developed and delivered (in a conceptual context) that could support people with chronic pain to make their lives with chronic pain clear to their relatives. The research project was followed up by a PhD project to capture all studies in academic publications. The results were shared during a symposium and in a few newsletters (*step 7*, A.3, Figure 2) in the theoretical context. The pathway ended with *step 8* in which the intervention is made freely available for downloading (C.3, Figure 2). The intervention is integrated in the real-life practice context within a participating partner and a non-participating organisation. The principal investigator provides training to new interested organisations on the use of the intervention. The intervention has also been implemented in a teaching program of another university.

A description of the research path of all cases can be found in Appendix 3. To illustrate the use of the RPM, Figure 3 shows activities with examples from each case to cover all nine research goals.

Figure 3: Examples out of the nine projects for each step in the RPM.

	Theoretical context	Conceptual context	Real-life practice context
Create	**Create theoretical understanding** Literature review or a Delphi study: *"We started with a literature review on self-management behaviour, followed by a Delphi study with international experts on the topic."* (Project 9)	**Create a concept** Co-design session or interviews with the aim to find a solution: *"We evaluated the co-design sessions with the [target group]. (...) It became clear that it had to be a touchscreen."* (Project 6)	**Create understanding of real-life practice** Observations or interviews in a real-life setting with the aim to understand the context: *"Because the system needs to be integrated into the homes and lives of elderly, we visited them at home and asked them about hobbies, daytime activities and time schedules."* (Project 8)
Explore	**Explore theory or a concept in a controlled situation** Laboratory research or taking measurements in a controlled area such as a hospital or physiotherapy practice: *"Exercise therapists and physical therapists test with 50 participants (tested twice, with seven days between the two measurements) in an exercise laboratory"* (Project 7)	**Explore a concept** Testing a low fidelity prototype in a pilot or test environment with different stakeholders: *"We tested the prototype in an iterative process with speech therapists and parents and incorporated the recommendations in each round into a new prototype."* (Project 3)	**Explore a solution in real-life practice** Testing a high fidelity prototype in real life: *"People have downloaded the app that can advise them to go to a physiotherapist. But of course you don't want to do that too early, nor too late. We will discuss what the indicators are based on the use of the app and what is possible to integrate into the app."* (Project 2)
Deliver	**Deliver theory** Sharing information via a scientific or professional journal, information folders or congresses: *"We have organised a number of conferences for the professional field and others interested to share knowledge and have prototypes experienced. It makes people think about the possibilities of technology."* (Project 5)	**Deliver a concept** Transferring the prototype to the next project, a developer or a company: *"The goal was to make a prototype. But I see that it is in demand through guest lectures, presentations and workshops that I have given and now I have a follow-up grant to develop it further."* (Project 4)	**Deliver change in real-life practice** Implementing and/or evaluating the solution in real life: *"It is currently used in three pain rehabilitation centres, in the current version. People see it as an added value for current practice. If people are interested, I come by, give a training and then they get that workbook."* (Project 1)

By structuring activities into the RPM, a research pathway can be drawn made for each case. Up to this point, examples from the cases were used to provide insights into the working of the model. The next section discusses the activities and requirements to reach implementation success by using the RPM.

4.2 Explaining implementation success by using the Research Pathway Model

We discuss the model by focusing on the three research activities (Create, Explore, Deliver) to explore which insights about project success can be derived from using the process model.

4.2.1 Create

'Create' refers to research goals with the aim of deepening the understanding of the problem (in theory or in real-life practice) and to develop ideas to solve the problem. The research goal of creating a concept and/or understanding the problem was the start in all nine cases. Surprisingly, only two projects included a study with the goal to understand the real-life situation of the end-users before they started creating the idea. More often the projects involved end-users creating a prototype or product in co-design sessions at a later stage. But in the projects doing research activities to understand the real-life situation of end-users, researchers themselves have developed the idea for a prototype or product without the use of input from the end-users: *"The idea of finding the solution in a tool, was our own. The speech therapists have made the problems clearer. And they were very recognizable to me, because I had actually experienced the same problems as a speech therapist"* (project 3). Although the idea in this quote did not arrive from practice, the researcher had experience in practice. All projects created a concept with researchers from different disciplines and/or together with end-users and/or stakeholders. The involvement of stakeholders is seen in the research goals 'create a concept' (n=8) and 'create understanding of real-life practice' (n=7) and not in the goal 'create theoretical understanding', which confirms that practical relevance in research done in the 'theoretical context' is limited. Creating an idea or understanding a problem is not just a goal in the beginning of the process. Throughout the whole process activities with the goal to create a concept or understand the problem occur: *"the researchers collaborated with business partners to keep the tool online after the project had finished, but this partner ended the cooperation. Then we found each other (...) and started a collaboration and have integrated the online tool as a module in our own tool"* (Project 2). This fragment shows that understanding the problem and creating ideas could be an activity in the implementation phase. With this the quote also shows that there are different levels of creating an idea or understanding a problem. Sometimes it can be about understanding a fundamental question and sometimes about adapting an existing idea or practical solution.

4.2.2 Explore

'Explore' refers to research goals that cover research activities in which concepts, constructs or solutions are explored. All projects included research activities to test or develop their prototype together with the target group (explore a concept). In this step researchers mostly test a low fidelity prototype. One of the interviewees from a healthcare organisation was critical about testing with the target group in early stages of the project and suggested more testing in a controlled environment without end-users: *"sometimes a product must be more developed before you introduce it. If you have consulted or tried out the concept with someone and the basic idea could work well, then you should continue with a product that is actually good and not try it again with some adjustments. Overall it is disappointing for clients that a product is still not available for them"* (Project 4). The quote shows that exploring the concept could lead to frustrations among the end-users involved, because the prototype did not work well and/or because the prototype is only available for a short period. Four of the projects included a research activity with the goal to explore theory or a concept in a controlled environment. In three projects researchers explored the solution in a real-life environment in which the users tried the last version of a prototype in their own context. The projects that succeeded in implementing their project benefited from the exploration with the target group and the enthusiasm for the a final prototype.

4.2.3 Deliver

'Deliver' refers to goals related to the articulation and diffusion of the insights during the research pathway. All cases delivered theory and a prototype. Three out of nine cases delivered real-life changes by implementing a product. In these three cases the product is also scaled up or it is possible for healthcare organisations or individuals to buy or download the intervention. Four projects did involve a business partner, aiming for the business partner to play a role in developing the innovation or putting the innovation into production or onto the market. Some of these business partners dropped out during the project because the further development of a prototype is more expensive than the expected reward. One of the business partners who decided not to develop the tool yet stated (Project 5): *"the target group is too small if you want to start selling an app. (...) It would be better if we could add it to the existing service and make those functionalities not only available for the target group, but also for others."* Some projects did not aim to deliver a market-ready product: *"the goal was to make a prototype"* (Project 4). In this case a plan or idea for developing the prototype to a product was missing. Other researchers integrated the implementation process in their study, for example, by participating in a competition in order to collect money and help for further development and implementation: *"We estimate that the app will be successfully implemented. Yet there are many challenges, such as the growth of similar applications on the market. Some of them already have agreements with hospitals. On the other hand, we have noticed as a result of the challenge we have won, there is a lot of attention for our project and there are parties who contact us"* (researcher project 9). Two projects (both having succeeded in implementation) changed their first idea of making a digital product to creating a non-technical product to increase the chance of success. Time and a limited budget are the main reasons to change plans. The other project that succeeded in implementation was a follow-up project. All researchers interviewed indicated that they could use more help with the delivery of their prototype or product to real-life contexts.

The described activities = that contribute to implementation success of self-management health innovations developed in PBR should be perceived through a process lens, which is done in the next section.

4.3 Patterns in research pathways

Table 3 presents the pathways the projects followed using the RPM. A research pathway contains all research goals (and underlying activities) in all conceivable sequences. Table 3 shows the nine projects on the vertical axis and the sequences of research goals (in numbers) on the horizontal axis. The table does not provide insights in the underlying activities, but reports at the level of the research goals.

Table 3: research pathways of the nine cases following the Research Pathway Model (Figure 1).

Pathway Projects	1	2	3	4	5	6	7	8	9	10	11	Implementation success
Project 1	C.1	B.1	A.1	B.2	C.2	B.3	A.3	C.3				Yes
Project 2	B.1	A.1	B.2	C.2	C.2	A.2	B.2	C.2	B.3	A.3	C.3	Yes
Project 3	B.1	B.1	C.1	B.1	B.2	B.2	B.2	C.2	A.3	B.3	C.3	Yes
Project 4	B.1	C.1	A.1	A.3	B.1	B.2	A.3	B.3				No
Project 5	B.1	B.2	B.2	C.1	A.1	B.2	A.1	B.1	A.3	B.3		No
Project 6	C.1	C.1	A.1	B.2	B.3	A.3						No
Project 7	B.1	A.1	A.2	B.1	B.2	B.2	A.3	B.3				No
Project 8	C.1	B.1	A.2	B.1	B.2	B.1	B.3	A.3				No
Project 9	A.1	B.1	B.1	A.1	C.1	A.2	B.2	A.3	B.3			No

'A' stands for the *theoretical context*, 'B' for the *conceptual context* and 'C' for the *real life practice context*. '1' stands for activities with the goal to Create, '2' stands for Explore and '3' stands for Deliver (see Table 1).

Although each research pathway to reach innovation success differs, Table 3 shows some similarities in these nine pathways: each of them achieved the research goals to create a concept (B.1), explore a concept (B.2), to deliver a concept (B.3) and to Deliver theory or knowledge (A.3). The research goal of creating a research idea and understanding the problem (A.1, B.1, C.1) was the start in all nine cases.

The fact that all projects created a concept (B.1) means that in these nine cases a prototype or product is created by researchers from different disciplines and/or together with end-users and/or stakeholders. All nine projects included the exploration of their prototype in a pilot or test environment with potential users associated with one of the consortium partners (B.2). All projects have delivered theory (A.3), which means that they shared their knowledge and results via e.g. publications in national and international papers, newsletters, project websites and/or congress presentations. All cases completed activities with the goal to deliver a concept (B.3). In Projects 1, 2 and 3 the prototype was adopted by either a publisher, a business partner or directly by the healthcare organisation. The other projects produced either a prototype which could be adopted by developers and business partners, or a product which is ready for the market, but not yet implemented. Some researchers indicated that delivering the prototype was the goal of the project. Another pattern is that most research activities do have an explorative character and/or are part of the *conceptual context* where researchers involved end-users.

What stands out in Table 3 is that three of the nine cases delivered changes in practice by implementing a product (C.3). Interestingly, in these three projects researchers explored the solution in a real-life environment in which the users tried the last version of a prototype in their own context through a feasibility study. In these three cases the product is also scaled up or it is possible for other healthcare organisations or individuals to buy or download the intervention. The activities underlying *deliver change in real-life practice* are related to working on an implementation strategy in an organisation with the goal to use or integrate the innovation in the setting or to introduce a product to the market.

Throughout their research pathways, the three projects that actually successfully implemented the innovation were working on activities with the aim to *explore the solution in real-life practice* and to *deliver change in real-life practice*.

By studying the different research goals and their underlying activities from early discovery all the way to implementation, the focus was not only on knowledge transfer (*deliver a theory*) but also on the activities to realise actual use in practice (*deliver change in real-life practice*).

5. Conclusions and discussion

The insights provided in this paper form a first attempt to understand how a process model provides insights into the evaluation of implementation success of health self-management innovations developed in practice-based research (PBR) projects and what the requirements are for such a process model. The process perspective enables us to include and evaluate the incremental work required during the whole innovation project. To evaluate research pathways which focus on PBR and "normal impact" a process-based approach is missing (Sivertsen and Meijer 2020). By performing a multiple case-study approach we were able to answer the following question: *What are the requirements for a process model to evaluate the implementation success of self-management health innovations developed in practice-based research projects?*

Through a process-based approach we were able to recognise three requirements for a process model to evaluate the implementation success of self-management health innovations developed in PBR projects. The first requirement is the specification of research goals. By mapping a process consisting of specific steps in the pathway which influence successful implementation of a self-management health innovation, we were able to recognise the incremental work of researchers and stakeholders.

The second requirement is the specification of the research contexts and research activities to structure the research goals. By making the research contexts explicit we were able to visualise the focus on theoretical contributions, contributions to further development (concept) or contributions to one or more specific organisations (real-life practice). The focus on specific contributions is helpful to evaluate impact, especially in the case of PBR projects as they have the ambition to go beyond theoretical contributions and have practical use. The research activities *create*, *explore* and *deliver* provide insights into the pathway to implementation success of self-management health innovations developed in PBR projects. Further research could possibly lead to refinements of these three research activities.

A third requirement is the possibility of the creation of sequences of research activities and the comparison of these pathways vis-à-vis the reported implementation success. We found that each project used a different sequence of research activities, resulting in different pathways. What these pathways have in common is that they include activities to explore a new solution, deliver a prototype construct and contribute to theory. Another insight is that most research activities did have the goal to explore whether an innovation could possibly work and/or is part of the 'conceptual context'. In these activities researchers involved end-users. However, only three projects that include the exploration of the solution in a real-life environment in which the users tried a prototype in their own situation, succeeded in implementing their product. Also activities with the goal to deliver real-life change, such as preparing health practitioners and organisations for using the solution through training and integration in the existing workflow, are prerequisites for success.

Several limitations of our analysis could be mentioned. First, process features could only be analysed if the available documents or interviewee explicitly described a research activity or factor. Second, as we evaluated the process in a retrospective way for each project, future research should focus on the perspective of the different stakeholders before or during the process. Third, for all projects we interviewed the main researcher and another stakeholder, but we are aware that we missed the perspectives of other involved stakeholders. This might result in a biased picture of the projects. However, we do think that this bias may be limited because we always included multiple perspectives, interviewing at least two stakeholders per project. In all cases both perspectives did not reveal real differences about the research pathway. In addition, some researchers, business partners and healthcare professionals were also involved in other cases and were able to compare cases and add information about other cases.

Subsidy providers and researchers may benefit from the success stories and challenges of these nine cases and use the RPM as a toolbox to prepare, monitor and evaluate their research projects together with involved stakeholders and to discuss their research pathways to successful implement innovations. The role of the researcher in the implementation of innovations is limited and ended at a certain moment. Other stakeholders are part of an ongoing process of developing the innovation further in their own or other specific contexts. An implemented innovation, therefore, is the starting point of a process in which practice continuously develops the innovation (Landry et al 2002). The Research Pathway Model aims to understand such continuous implementation process of practice-based research.

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Authors' contributions

WvB, EM, WB and DA conceptualized the study. WvB interviewed the respondents and analysed the data. All authors (WvB, EM, DA, WB, GvdV, HP) contributed to the final version and read and approved the final manuscript.

Competing interests

The author(s) declare that they have no competing interests.

Consent for publication

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The interviewees all agreed with their participation.