On the validation of an evaluation framework: the case of Nursemapp

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Introduction

Högler et al. (2015) describe a framework that delivers insight into the tangible and intangible effects of a mobile (IT) system, before it is being implemented. The framework has been developed because of a lack of such insight (other frameworks merely focusing on monetary effects, neither taking into account singularities of mobile technologies). The framework consists of 3 pillars with 7 included activities. Figure 1 shows the framework, also identifying interdependencies between the activities and their inputs and outputs.
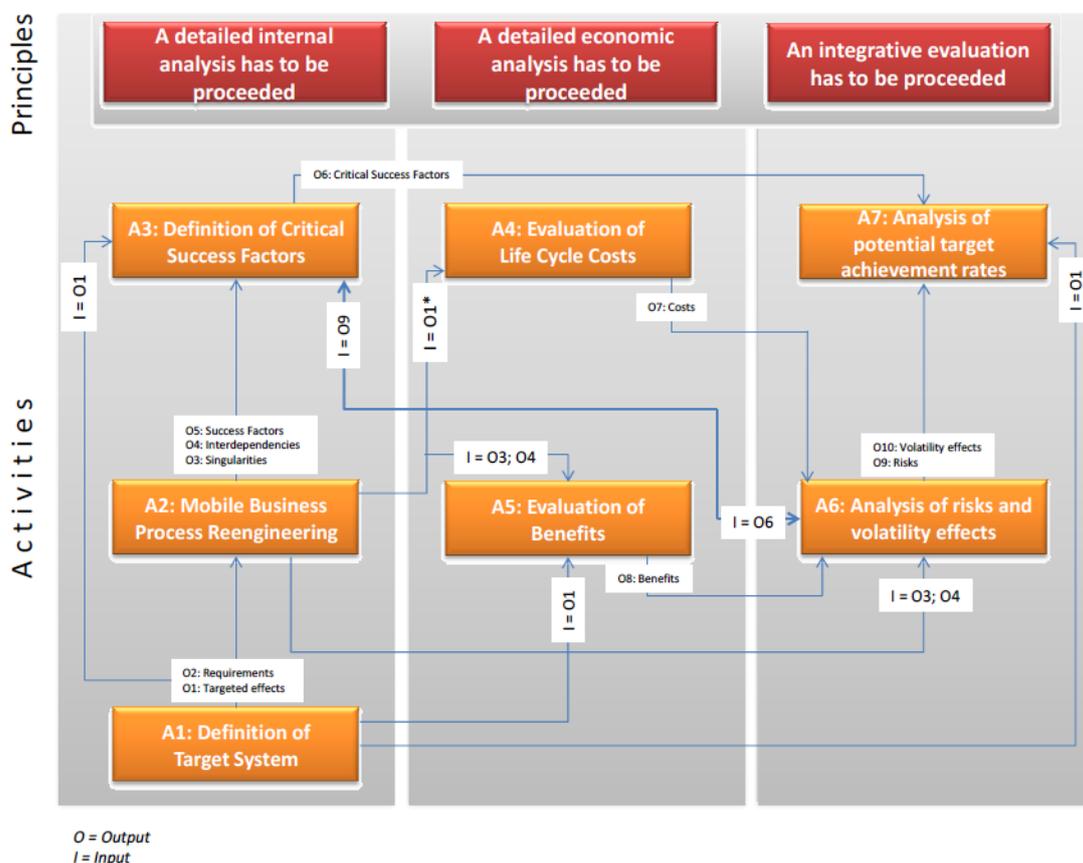

Figure 1: Integrative Framework for Mobile Systems (Högler et al., 2015)

A description of each of the activities from figure 1 is taken from Högler & Versendaal (2016):

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Technical Report

1. "Activity 1: Definition of the target system by following the multi-attribute decision making (Hwang & Yoon 1981); this activity outlines a procedure for defining the target system leveraging the Analytical Hierarchy Process (AHP) (Saaty 1996) which is extended by following activities (see figure 2), differing fundamentally from previous approaches:
   - interdependence analysis between individual objectives (Kirchmer 1999; Drews & Hillebrand 2010; Rückle & Behn 2007);
   - consideration of the effective strength of the objectives and the probability of occurrence of interdependencies (Klabon 2007; Charette 1991) and thus their respective value; and
   - weighting of objectives in the context of these latter two aspects.
   [...]
2. Activity 2: Mobile Business Process Reengineering as proposed by the authors builds upon Mobile Process Landscaping (Gruhn & Wellen 2001; Köhler & Gruhn 2004).
3. Activity 3: Definition of critical success factors, their interdependencies, correlation analysis and weighting (Iqbal et al. 2015; Nysveen et al. 2015; Hway-Boon & Yu 2006).
4. Activity 4: Evaluation of life cycle costs (Wild & Herges 2000; Berghout et al. 2011), performed by identifying costs during the whole lifecycle of mobile systems including the preliminary phase, utilization phase and disposal phase.
5. Activity 5: The evaluation of benefits, based on the total benefit of ownership model (Gadatsch & Mayer 2004), involves the capture of cost savings and non-monetary benefits or qualitative and strategic variables which are not considered in the traditional approaches of economic evaluation.
6. Activity 6: Sensitivity analysis: As an uncertainty of the results achieved in the previous steps remains, a sensitivity analysis is conducted to check the stability of results. Particularly the variables success factors (Corsten 2000; Rockart 1979), risks (Kronsteiner & Thurnher 2009) and the accompanying volatility effects (Kulk & Verhoef 2008; Singh & Vyas 2012) are analysed.
7. Activity 7: Analysis of potential target achievement rates: Based on the results of the sensitivity analysis, the potential achievement rates can be determined. To do so, results of activity 1 (target system), activity 2 (current and target processes incl. key (performance) indicators) and activity 6 (volatility effects) are merged." (pp 3-4).

Although both papers (Högler et al., 2015; Högler & Versendaal, 2016) provide an evaluation of this integrative framework for mobile systems to some extent, in both papers it is suggested that effort is needed in validating it more extensively. In this report we test the validity of the framework through a retrospective case study. As criteria for choosing such a case, we define:
- it should address a framework-wide validation;
- it should be a validation of an existing implementation (retrospective case);
- it should be representative

- the implementation should be considered successful;
- source material of the preparation of the implementation of the mobile system should be easily available for this case.

Nursemapp is a mobile app for nurses that allows for directly entering vital body functions of patients in hospitals, while nurses do their 'patients-round'. Nursemapp fulfills the mentioned criteria:
- In the Netherlands, Nursemapp is proclaimed as a show case of a native mobile app for the major Dutch hospital information systems vendor Chipsoft (https://www.zorgvisie.nl/ict/nieuws/2015/9/chipsoft-breidt-epd-uit-met-native-apps-2692177w/ and https://www.chipsoft.nl/oplossingen/147).
- Nursemapp has been developed and successfully implemented at Utrecht's academic hospital in the Netherlands (UMC Utrecht).
- The suggested implementation has been described in detail by Heerink (2014), with the addition that Heerink describes Nursemapp as a case study herself in the context of broader research.

In taking Nursemapp as our retrospective case study, we check the following:
1. Are all activities of the integrative framework identifiable in the Nursemapp implementation? Which activities are not explicitly mentioned? What does this imply?
2. To what extend are activities differently elaborated in Nursemapp, as compared to the integrative framework? What does this imply?

Validation protocol

We take the standard research design template of Maimbo & Pervan (2005) for describing our validation protocol, see Table 1.

Section	Protocol details regarding the Nursemapp case
Preamble	No particular preamble regarding confidentiality, publication etc. is set up for Nursemapp. We merely leverage existing already published documentation of Nursemapp.
General	Högler et al. (2015) describes an integrative framework for a priori evaluation of the effects of (mobile) IT system implementation. For further validating the integrative framework we choose an existing successful implementation of a mobile system (Nursemapp in this case), that was precisely described and that was implemented independently from Högler et al.'s (2015) integrative framework.
Procedures	In determining to what extent the activities of the 'integrative framework for a priori mobile system implementation' can be recognized in the preparation of the Nursemapp implementation, we study a thesis (Heerink, 2014; only its main text, not the appendices). First one researcher studies the thesis and codes the thesis; subsequently a second researcher checks the coding from the first researcher. If the second researcher questions a certain coding (or the absence of a certain coding), then the two of them discuss the discrepancy and make a decision to change that particular coding, or not.
Research instrument(s)	We perform a qualitative analysis of Nursemapp by coding the thesis of Heerink (2014). Therefor the marker-facility of Adobe Acrobat is used.
Data analysis guidelines	For coding the thesis we use the following a priori codes (in italics) that reflect the 7 activities of Högler et al.'s (2015) integrative framework: 1. Initial identification of *targets* for Nursemapp 2. (Mobile) *business process reengineering (BPR)*

	3. *Success factors* for the implementation and usage of Nursemapp 4. Evaluation of life cycle *costs* 5. Evaluation of *benefits* 6. *Risk analysis* 7. Determination of the degree of *target achievements* While coding we intend to apply a most detailed granularity. This implies that whenever a larger amount of text is coded, we investigate whether this code can be reasonably subdivided in multiple separate codes, e.g. when it deals with different sub-concepts for the same code.
Appendix	As there are no interviews held (only consultation of Nursemapp documentation), no participation request letters are provided.

Table 1: Validation protocol, using the template of Maimbo & Pervan (2005)

So we code Heerink (2014) in searching for answers to our two major validation questions: 1) are all activities of Högler et al.'s integrative framework identifiable in Heerink's (2014) description of Nursemapp, and 2) to what extend are there differences in the activities' details?

Validation results and analysis

The coding by the first researcher was in almost every situation confirmed by the second researcher. In the few situations that there was some discrepancy, this was always quickly solved, by, in general, following the second researcher's opinion, who is also the author of the integrative framework (Högler et al., 2015).

Table 2 describes the agreed upon results of the coding of Heerink's (2014) observation of the Nursemapp implementation.

A priori code	# Times a code is identified through a text fragment	Text fragments referring to the particular code in Heerink (2014), examples
Targets	25	• "To make work processes predictable and manageable [...]" (p 27) • "[...] and provide information access at the point of care [...]" ((p 27)
BPR	47	• "During a patient assessment, nurses inspect at least one patient. Vital values like blood pressure, temperature and saturation are being measured. During the traditional way of working nurses generally use an A4 printed patient list, sometimes accommodated with a pad, to write down their measurements. After every patient in a round was checked upon, nurses walk to a workstation, log on to the electronic health record and enter all scores per patient. With the use of NurseMapp, a nurse will log on in the beginning of a clinical round of assessments. While assessing a patient, the nurse will select the respective patient and enters every vital value. The input will automatically be imported in the electronic health record." (p 18) • "Users saw potential for mobile [Nursemapp] documentation during rounds, where paper-

		based methods are currently in use." (p 38)
Success factors	212	• "[...] obstacles concern the Wi-Fi connection and choice of device [...]" (p 91) • "[...] projects fail due to the lack of a high-esteem physician buy-in." (p 28)
Costs	0	
Benefits	90	• "Almost one and a half minute per patient was won by using NurseMapp and health records are more complete since its release." (p 91) • "Using NurseMapp, compared to using pen and paper, significantly differs in the amount of vitals entered in ward A (0.734, p < .0005, d = 0.29) and in ward B (0.184, p = .042, d = 0.10)." (p 83)
Risk analysis	57	• "[...] technical inabilities as crashing or freezing is seen as obstacle and unusable and will cause frustration." (p 94) • "[...] inaccurately or omitted vital sign data can result in inappropriate, delayed or missed patient treatment." (p 19)
Target achievements	7	• "To what extent [...] can a mobile health record application support process and quality improvement within hospitals?" (p 9) • "The more obstinate obstacles are, the less strong the effects experienced." (p 89)

Table 2: Coding overview of Heerink (2014)

We observe the following from Table 2 and the coding in the original work of Heerink (2014):
1. Except for 'Costs', which is not explicitly found in the text of the thesis, all other activities are found in text fragments of the thesis;
2. Some codes are only found few times (particularly 'Target achievements'), whereas others are much more often found (e.g. 'Success factors');
3. The first three activities of Högler et al.'s (2015) integrative framework can be particularly found in the early chapters of Heerink (2014);
4. The activities' details as described by Heerink (2014) are in many cases comparable to what is described and exemplified in Högler et al. (2015) and Högler & Versendaal (2016); e.g. by Technology Acceptance Model is in both cases used for the activity related to success factors. Yet, particularly the first activity (identification of targets/goals), is quite differently worked out by Heerink for the Nursemapp case.

ad 1) This is probably due to the character of Heerink's (2014) thesis: the research question of the work of Heerink (also defined under 'Target achievements') is defined as "To what extent, and how, can a mobile health record application support process and quality improvement within hospitals?"; this makes costs not an explicit searched for factor. On the other hand, the coding of text fragments related to *funding* (7 times coded) are now categorized under 'Risk management' and 'Success factors). One could argue that these might also be categorized under 'Costs'. This identifies a possible weakness of the integrative framework: the difficulty in determining what is precisely meant by

an activity as shown in the published papers, and consequently, how to exactly execute on the activities.

ad 2) The limited number of references to 'target achievements' can be explained as follows: the integrative framework differentiates between different hierarchy levels of objectives: Key, Basic and Process objectives. Key objectives are seen as benefits that should be achieved and Process objectives describe *how* to achieve the benefits. In contrast, Heerink´s thesis does not clearly distinguish between benefits and targets / target achievements.

ad 3) The broader context of Heerink's (2014) work (the Nursemapp implementation is for Heerink just a case study for validating her own defined framework of adoption and implementation drivers/barriers for effective implementation of e-health systems) could explain finding that many references in the first chapters of the text, related to the first three activities of Högler et al.'s (2015) framework.

ad 4) Especially the operationalization of the first activity by Högler et al. (2015) should be further investigated; it may result in the fact that the contribution to both science and practice is especially in this first activity.

Conclusions

Nursemapp is a mobile app for helping nurses in registrating patient's vital functions, when they are doing their patients rounds. Heerink (2014) has investigated the effects and drivers and barriers of such mobile apps, taking Nursemapp's implementation as a case study.

For validation of Hölger et al.'s (2015) integrative framework for mobile system evaluation, Heerink's (2014) thesis was successfully coded. Based on the two questions we addressed for validating the integrative framework (i.e. 1) "are all activities of the integrative framework identifiable in Heerink's (2014) description of Nursemapp", and 2) "to what extend are there differences in the activities' details?") we conclude that:

- The activities as mentioned in the integrative framework are no awkward activities; they are activities that are easily identifiable in Nursemapp;
- The operationalization and detailing of the activities of the integrative framework are to some extent identifiable in Nursemapp. The specificity of the first activity ('Defining upfront targets/objectives/goals' of the mobile system) as described by Högler et al. (2015) makes it a candidate for further explicit validation.

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