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The Benefits of a Formative Evaluation for Developing a Highly Innovative Software: The Case of the HandoverEHR

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Abstract. Innovations are typically characterised by their relative newness for the user. In order for new eHealth applications to be accepted as innovations more criteria were proposed including "use" and "usability". The handoverEHR is a new approach that allows the user to translate the essentials of a clinical case into a graphical representation, the so-called cognitive map of the patient. This study aimed at testing the software usability. A convenience sample of 23 experienced nurses from different healthcare organisations across the country rated the usability of the handoverEHR after performing typical handover tasks. All usability scales of the IsoMetrics[L] questionnaire showed positive values (4 "I agree") with the exception of "error tolerance" (3 "neutral statement"). A significant improvement was found in self-descriptiveness as compared to an initial usability testing prior to this study. Different subgroups of users tended to rate the usability of the system differently. This study demonstrated the benefits of formative evaluations in terms of improving the usability of an entirely new approach. It thus helps to transform a novel piece of software towards becoming a real innovation. Our findings also hint at the importance of user characteristics that could affect the usability ratings.

Keywords. Handover, usability, evaluation, electronic health record

1. Introduction

Innovations are typically characterised by their low adoption rate and their relative newness for the user [1]. In order for new applications in eHealth to be accepted as innovations more criteria were proposed including "use" and "usability" [2].

The handoverEHR is a new approach that allows the user to translate the essentials of a clinical case into a graphical representation, the so-called cognitive map of the patient [3]. This electronic health record (EHR) system is geared to support time critical communication and cognition processes like patient handovers to ensure patient safety [4]. Residing on a conventional EHR, it is unique in terms of (i) integrating all three phases of the handover process, i.e. the preparation, the execution and the follow-up [5], (ii) of the graphical and list representation of information and (iii) finally in terms of its dedicated goal to enhance the perception, information storage, recall and decision making of the actors involved [3]. Despite its novelty, the handoverEHR has still to put its value as an innovation to the test, in particular its usability, use and thus

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its usefulness. Formative evaluation of the usability plays an important role in iterative software development projects to include the user's perspective in a continuous manner [6]. The handoverEHR prototype had been tested during the early development stages in terms of its usability and attractiveness [3]. These results were promising particularly regarding the suitability for the task but did not allow final conclusions about its innovation. The aim of this study therefore was to 1) improve the handoverEHR system towards greater adjustment to the handover processes themselves, 2) to measure the impact of these changes on the usability and 3) to investigate human factors that could exert an effect on how usable the system was perceived. These findings should allow a judgement on characteristics of the system as an innovation.

2. Methods

2.1. Changes of the handoverEHR

The handoverEHR incorporated an information model consisting of the classes problems, goals, medication, interventions and anticipatory guidance [7]. Patient data, which were clustered in these classes, could be structured in symbols using a visual syntax. The logic arrangement of these symbols was called the cognitive map of the clinical case [3]. In addition to the graphical presentation, the information could be also displayed in conventional lists. Drawing on the results of the initial usability testing [3], the software was stronger aligned with the handover process. A function to manage the user rights was implemented that entailed the display of selected tabs only and allowed a focussed access to patient data. Likewise, buttons enabling functions that had no meaning in a particular phase of the handover process were removed and data entries could be imported from the external conventional EHR.

2.2. Usability testing scheme

After having implemented these changes, a convenience sample of 25 nurses from different healthcare organisations throughout the country was recruited. Due to low data quality the results of two persons had to be discarded. The remaining 23 persons (3 males, 20 females) had an average age of 31.7 ($\pm$ 6.1) years and an average of 8.8 ($\pm$5.2) years of experience in their job. Usability was measured according to ISO 9241-110 and was operationalised in 75 variables using the IsoMetrics^{L} questionnaire [8,9]. These results were then compared with the findings of the initial usability testing [3]. Human factors were captured by asking the participants to rate their 1) experience using an EHR, 2) skills to handover patients, 3) ability to reason based on nursing diagnoses and 4) self-confidence when presenting the case.

All study participants were asked to form twelve clusters with persons of similar background and had to write down essential, handover relevant information about a clinical case they had recently seen. This setting was chosen to create a realistic handover atmosphere. After about 105 minutes of training and practicing how to use the handoverEHR each person prepared the handover of her or his case by designing a cognitive map and presented it to the other participants of the group on a 52" wide screen. Statistics (t-tests for metric data and Mann-Whitney test for ordinal data) were calculated using SPSS V22. The alpha level was set at 0.05. The Bonferroni method was used to adjust for multiple testing.

3. Results

The medians of IsoMetrics^L scales *suitability for the task*, *self-descriptiveness*, *controllability*, *conformity with user expectations*, *suitability for individualization* and *suitability for learning* were all "I agree" (4) on a scale from 1 to 5 with 3 denoting the neutral position. Only *error tolerance* was rated lower with a median of "so – so" (3). Q1 and Q3 ranged from "so – so" (3) to "I agree" (4) and to nearly "I fully agree" (5) as Fig. 1 shows. The following global statements illustrated the free text comments "good visualisation", "easy to handle software", but also "eye contact among the persons decreased" and details like "the grid was not user friendly".

As there were no significant differences between the study participants of the initial and this study with regard to age, gender, job experience and type of education (Tab. 1), the results of the two usability tests could be compared. As Fig. 1 shows the median in the scales *suitability for learning* and *self descriptiveness* rose from "so – so" to "I agree". This increase was significant for *self-descriptiveness* (p=0.03) in a Mann-Whitney U-Test. Based on analysing the 75 individual items, four of them showed a significant improvement. Among them were "Even when using the software scarcely, it is not a problem to re-familiarize oneself with it." ($n_{initial}$=28, Median=3; n_{curr}=15, Median=4; p=0.00), "The messages of the software were immediately understandable." ($n_{initial}$=28, Median=3; n_{curr}=20, Median=4; p=0.01). There was also one item with a significant deterioration. This was: „I receive support on demand, which helps me to learn the software." ($n_{initial}$=28, Median=4,5; n_{curr}=14, Median=3; p=0.01). When adjusting for multiple testing none of the significances remained.

Table 1. Sample characteristics in both data sets (initial [3] and current study)

Variable	**Test**	$n_{initial}, \bar{x}, s$	$n_{curr}, \bar{x}, s$	p
Age	t-test	28, 31.61, 8.34	23, 31.87, 6.05	0.90
Job experience	t-test	28, 7.61, 6.83	23, 8.77, 5.17	0.50
Variable	**Test**	$n_{initial}$, **Mode**	n_{curr}, **Mode**	p
Type of education	χ^2-test	28, general nursing	23, general nursing	0.55
Gender	χ^2-test	28, female	23, female	0.64

The human factors were employed to split the sample of this study into contrasting subgroups, which were tested for differences regarding the seven main scales of IsoMetrics^L. The group with higher rates in the ability to perform reasoning based on nursing diagnoses also rated the *suitability for learning* higher than the group with low rates in reasoning (n_{easy}=15, Median=4.5; n_{quite_easy}=6, Median=3; p=0.01). In contrast, nurses who had experience using an EHR at work thought the *suitability for learning* to be lower than the nurses without experience (n_{yes}=15, Median=3; n_{no}=6, Median=4.5; p=0.02). Likewise, *conformity of user expectations* was lower in participants with a high self-confidence in handovers as compared to those with quite high self-confidence ($n_{confident}$=13, Median=3.5; $n_{quite\_confident}$=6, Median=4.25; p=0.01) and similarly *suitability for the task* was lower in nurses who rated their handover skills as very good (n_{very_good}=9, Median=3; $n_{good\_or\_satisfactory}$=13, Median=4; p=0.000). When adjusting for multiple testing only the effect of self-confidence remained significant.

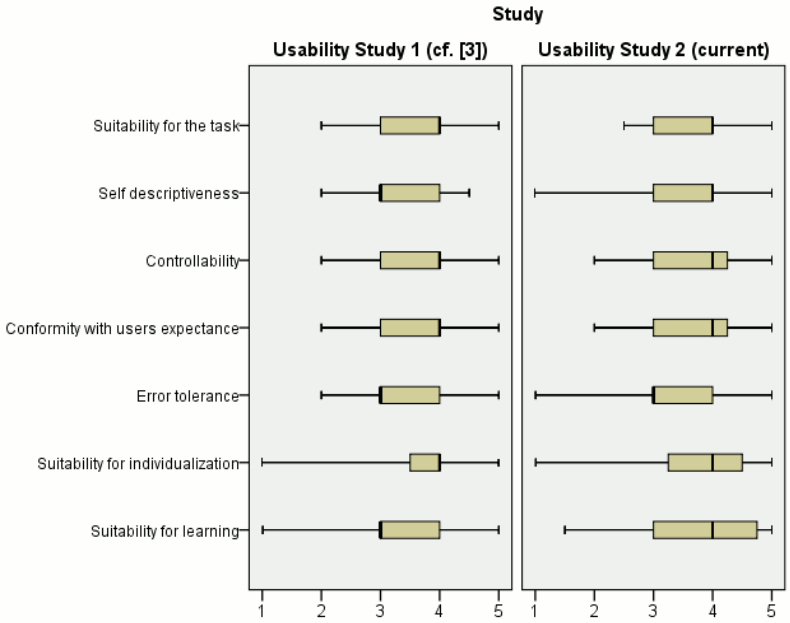

Figure 1. Results of the seven scales in the initial study (1) and in the current study (2)

4. Discussion

This study showed that the usability ratings could be increased after modifying the handoverEHR system according to hints from the usability testing and the feedback of the users in the initial study. These increases became significant in one scale, the *self-descriptiveness*. These findings also corroborate the initial impression about the handoverEHR as a usable piece of software to support handovers. Interpreting these results in the context of innovation, the handoverEHR thus seems to be well on the way to fulfil the innovation criterion "usability" [2]. However, there is room for betterments as the software did not on the average reach the highest rating possible (5) in any of the scales in this particular formative testing. Apart from these conclusions, "usability" itself has to be further investigated. Usability was not rated uniformly across the nurses in this study. Previous experience, own skills, self-confidence and the cognitive ability of clinical reasoning seemed to moderate the perception of usability both in an inhibiting or a facilitating manner as was shown by this study. The interpretation of this study is limited with regard to clarifying the role of these human factors influencing usability due to the small subgroups. However, the influence of users as persons on perceiving and rating usability is also stressed by other publications [10, 11]. More research is needed with regard to facilitators and inhibitors. Previous experience, self-confidence and task skills seem to make users more critical towards a piece of software and its usability.

So far, the criterion "use", the other of the twin concepts "use and usability" to prove the acceptance of the innovation by practice could not yet be demonstrated. In the light of the Rogers' criterion "relative novelty" [1], use is somewhat harder to prove than usability because there is only a small group of institutions actually using EHRs

for handovers [12] and this particular system has not yet been implemented in a healthcare organisation.

Ultimately, "use" and "usability" are indicators of "usefulness" also in the sense of "advanced clinical practice" as a yardstick for innovation [2]. Therefore, more studies have to follow which address the clinical usefulness of a usable handover tool. In principle, the handoverEHR possesses the potential to strengthen measures of patient safety by establishing information continuity. It thus may entail greater continuity of care in a process that is otherwise highly fragmented through shifts.

5. Conclusions

This study demonstrates the benefits of formative evaluations in terms of improving the usability of an entirely new approach to presenting clinical cases in patient handovers. It helps to transform a novel piece of software towards becoming a real innovation. Our findings also tend to support the notion of subgroups of users perceiving usability differently.

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