ORIGINAL PAPER

**Usability guidelines for developing and evaluating web-based
mental health interventions: Establishing a practical framework**

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Background: Even though problems with usability constitute a major challenge to the implementation of new eHealth technology, the field web-based interventions is lacking usability guidelines for development and evaluation of web-based intervention platforms.

Objective: The aim of present study is to create a set of eHealth-specific usability guidelines for the development and evaluation of web-based mental health interventions.

Methods: Knowledge about usability was gathered from peripheral fields of e-learning, emotional design, and human-computer interaction in a top-down approach. This knowledge was synthesized into usability guidelines for web-based interventions, which were then case-tested on an existing web-based intervention for patients with health anxiety, using the heuristic evaluation method.

Results: Nine broad guidelines were developed. The subsequent case-test of the web-based intervention showed that application of the guidelines was feasible and was able to identify several important usability issues with the intervention.

Conclusions: Health professionals should be included in intervention design. Future usability assessment should focus on the different usability attributes. The relationship between usability and adherence needs further investigation.

Keywords: eHealth; usability; web-based interventions; ISO; adherence; HCI; eMentalHealth

Introduction

According to the World Health Organization (WHO), eHealth is defined as the use of information and communication technologies for health [1]. eHealth is currently considered an integral part of delivering improvements in health worldwide, and many countries are making large investments in technologies for health purposes [2,3]. One particularly active field is the use of web-based interventions for mental health, which has seen a large body of literature on clinical effectiveness and implementation emerge over the past two decades [4]. However, one of the major challenges to the implementation of this is problems with usability [5].

According to the International Organization for Standardization (ISO), usability can be defined as the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use [6]. It is important to emphasize usability when designing or evaluating systems, as low usability may result in the intended users not being able or willing to use the system. Conversely, sufficient levels of usability will provide the intended personal, social, and economic benefits for the users and other relevant stakeholders [6]. In the following, a short outline of the usability attributes effectiveness, efficiency, and satisfaction is provided. In agreement with ISO [6], we emphasize the fact that these attributes are outcomes of the user's interaction with the object of interest, and, therefore, that usability relates to the outcome of interacting with a system, product or service – in this context, a web-based intervention. Hence, usability is not an attribute of a system per se, although appropriate system attributes (i.e. design characteristics) can contribute to the system being usable in a particular context of use [6].

Effectiveness is – in contrast to clinical effectiveness, i.e. the effectiveness of the intervention to improve outcomes – how accurate and completely users reach their specified

goals (e.g., the goal of entering mood scores in a diary). Accuracy can be understood as the extent to which an actual outcome matches an intended outcome (e.g. whether or not the outcome is correct), and it may be affected negatively by errors of use. Completeness represents the extent to which users of the system are able to achieve all intended outcomes [6].

Efficiency is defined as the resources used in relation to the results achieved, which may include measures such as time used, or human effort expended (i.e. mental and physical effort expended – e.g. how much time it took to enter mood scores) [6].

Satisfaction is defined as the extent to which the user's physical, cognitive and emotional responses that result from the use of a system meet users' needs and expectations; including physical responses such as feelings of comfort or discomfort. Cognitive responses include attitudes, preferences, and perceptions, which can be influenced by the experience of using similar systems. Furthermore, attitudes and perceptions can include measures such as trust or perceived degree of safety; this could include e.g. trust for a therapist or the system as well as privacy and data security. Emotional responses constitute affective components of satisfaction. Some interactive systems intentionally create rich emotional responses to the use of a system, such as excitement and fun, or trust [6].

A pioneer of usability, Nielsen [7] defines usability in terms of five attributes of the interaction experience: learnability, efficiency, memorability, errors, and satisfaction.

Learnability refers to the ease with which novice users can learn to use a system at a pre-specified level. Efficiency refers to the level of performance experienced users have in a system when they have learned how to use the system. This is operationalized as the time they need to perform specified tasks. Memorability refers to whether a casual user quickly remembers how to use a system when returning to it after a period of not using it. Errors are in this context defined

as actions that do not lead towards accomplishing the desired goal(s). Subjective satisfaction refers to the user's subjective experience of using the system.

Although the factors previously described may seem detailed and technical, even seemingly minor problems with usability can destabilize the implementation of otherwise highly engineered and valid eHealth technologies [8]. For this reason, sufficient usability is important for any system to work as intended, but it can be argued that it is especially important in web-based interventions as the clinical effectiveness of these depend on the ability and willingness of patients to properly engage and persist with them. For instance, Donkin et al. [9] found number of logins, which may be representative of participant's willingness to use a program, to be positively associated with outcomes in e-therapies targeting physical health. Furthermore, a recent meta-analysis found that interventions that appear more intuitive, (i.e., take little time to learn to use) are more likely to be clinically effective [10].

Non-adherence (non-usage attrition) is a well-known phenomenon in web-based interventions. Adherence can be defined as the extent to which patients follow the instructions they are given for prescribed treatments [11], and is important as it seems that program persistence and adherence to online therapies is correlated with physical and psychological outcomes [9]. The impact of non-adherence is underlined by a systematic review of 83 web-based interventions on mental health, lifestyle, and chronic diseases, that found an average adherence of 50% [12]. Evidence suggests that the design of web-based interventions is an important factor in improving adherence [12,13] - this likely includes usability of interventions. For instance, almost 15 years ago Eysenbach [14] cited usability as a factor that will have an impact on adherence to eHealth innovations, and analysis of log-data suggests that participants discontinuing use of a website may be caused by poor usability [15]. Despite this, very little

research has been done in the field concerning the relation between usability and intervention adherence – possibly due to the fact that for many interventions, users have no alternative intervention option when they encounter poor usability. However, one recent study that did examine this relationship, Baumel & Yom-Tov [16], found a negative association between usability and one adherence measure (total engagement time).

Another critical component of web-based interventions, trust [17], may also be influenced by the usability of the system [18]. One useful way to conceptualize the relationship between the usability of an eHealth intervention and its therapeutic potential was proposed in Baumel and Muench [19], who treated this as the relation between a measure's reliability and its validity. In this sense, an intervention can be usable without exhibiting any therapeutic potential, but it cannot have therapeutic potential without being usable.

In spite of the apparent importance of usability in eHealth, there is a lack of knowledge in the eHealth literature concerning usability regarding both development and evaluation of usable eHealth interventions. The System Usability Scale (SUS) is currently the most frequently used questionnaire for assessing usability in eHealth [20]. Although convenient and widely used, the SUS is a unidimensional instrument that assesses – by design - only a limited aspect of usability and appears to have low predictive power for actual task completion [21], however it seems that many researchers have simplified the various aspects of usability (as described earlier) into a single composite SUS score [22].

So far, with a few peripheral exceptions (e.g., [23]) few studies have tried to create guidelines for usability in eHealth, and due to issues with clarity and ambiguity in definitions of heuristics and usability, further knowledge on this matter is required. For instance, Kientz et al. [24] developed 10 heuristics for the evaluation of persuasive health technologies, however, they

incorporated heuristics unrelated to usability per se, such as “Educate Users” (i.e. users should understand why the actions they do promote positive behaviors, and how their goals are being met), which, together with a lack of clarity over data and definition of usability, means that new studies are required. Similarly, Kelders et al. [12] did not mention usability in their review concerning the effect of persuasive system elements on adherence to web-based interventions, which underscores the need for more knowledge about usability in eHealth. Furthermore, no eHealth studies have, to our knowledge, tried to create guidelines aimed at the different facets of usability.

The aim of the present study is to address the gap in literature mentioned above by creating a set of specific usability guidelines for web-based interventions. The guidelines are intended to be used as both a formative (during development) and summative (after development) tool for usability improvements in web-based interventions (in mental health). The guidelines will be synthesized by gathering knowledge from other fields in which usability has been investigated, and by synthesizing this knowledge into usability guidelines for web-based interventions. Furthermore, the aim is to provide a proof-of-concept of how these guidelines might be used in practice, through Heuristic Evaluation of an existing web-based intervention. Thus, the contribution of this study will be a framework from which to develop and evaluate usable web-based interventions, and furthermore to use as a point-of-departure for future usability research in eHealth.

The present study uses the usability attributes outlined by both the definitions by Nielsen [7] and ISO [6], in the sense that the scope is to develop usability guidelines related to the learnability, efficiency, effectiveness, memorability, and satisfaction that arise from interaction with an eHealth intervention. This is based on Bevan, Harker & Carter [25], who argued that

memorability and learnability adds important information. As evident, there are some similarities between the different definitions. However, describing the connections and historical changes within these attributes would be beyond the scope of this paper. In the following, a few comments are made regarding errors and effectiveness, two attributes we opted to modify slightly in the context of web-based interventions for mental health. Nielsen's attribute, errors, was omitted from present study as it can be argued that less serious errors are captured in efficiency scores (i.e. they will increase the resources users need to invest in order to reach their goals) and more serious errors captured in effectiveness scores (i.e. the accuracy and completeness of the users' goals may be affected negatively). Furthermore, the term "task effectiveness" will be used when referring to the attribute *effectiveness* outlined by ISO to avoid confusion with "clinical effectiveness", which could also refer to clinical outcomes. The focus on individual attributes is partly inspired by Hornbæk and Law [26], who found that correlations between the usability measures effectiveness, efficiency, and satisfaction are fairly weak (Pearson correlation coefficients ranging from .164 to .247). On this basis, we infer that usability guidelines and heuristics should be tailored to contribute to individual usability attributes.

A relatively novel direction in human-computer interaction (HCI) concerns personalization of the functionality and content of systems, and it was found that this can improve users' satisfaction, efficiency, and convenience [13]. Schade [27] divided this concept into two methods, customization and personalization, and defined the difference between these in terms of the relationship between user and system. *Customization* occurs when the user has the option of making changes in the interface in accordance with their own preferences. In contrast, *personalization* occurs when designers of the system or the system itself make changes tailored to accommodate specific users or user groups. In addition, it is suggested in Ludden et al. [13]

that a properly personalized or customized web-based intervention has the potential for improving intervention adherence, as well as feelings of control and well-being in the users. To sum up, personalization and customization are two methods that may contribute to certain usability attributes (satisfaction and efficiency) as well as help improve adherence to web-based interventions.

Finally, evidence suggests that it is important to consider the end-users cognitive level of functioning [28] and computer literacy [29] when designing for high usability in systems. Although the latter has been assessed in recent times [30], the former has received little attention even though it is known that e.g. patients with depression can suffer from severe cognitive impairment [31].

Heuristic Evaluation

Originally formalized by Jakob Nielsen, the heuristic evaluation method is an informal method of usability analysis conducted by a number of evaluators assessing the usability of an interface design [32].

Nielsen developed a small set of design heuristics related to the usability of interface designs, which according to Nielsen would explain many of the usability problems that usually occur [7,32]. These heuristics have provided a theoretical foundation for the entire field of heuristic evaluation since then [33]. Heuristic evaluations have several advantages, such as being inexpensive, intuitive, easy to motivate practitioners to do, and especially effective in early design processes. Furthermore, they have been described as being helpful for novices without extensive training in usability testing [34]. Recently, there has been a trend towards specializing the heuristics to specific technologies, and these heuristics have proven to be effective at identifying usability problems relevant for those technologies [35,36].

In addition to the usability heuristics described by Nielsen [7], present study used knowledge of usability from the fields of e-learning and emotional design in the creation of the eHealth specific usability guidelines.

E-learning

E-learning is defined as instruction delivered on a digital device that is intended to support learning [37]. Several guidelines have been developed to increase the usability of e-learning systems [22]. These guidelines are likely also relevant for the usability of web-based interventions since e-learning courseware and web-based interventions have some pedagogical elements in common, such as presenting relatively large amounts of text to teach certain skills. Moreover, most are modular (comprised of different lessons) and tunneled (i.e., one module needs to be completed before the next can be started).

Visual appearance and usability

Emotional design is a theory that deals with aesthetics in product design, and posits that attractive things work better because they produce positive affect in the user [38]. Aesthetics in the context of interface design has been described as the visual appearance of the interface, as it conforms to design principles such as symmetry and balance [39], and the complexity of the interface [40,41]. Furthermore, when designing for usability it is important to make considerations as to the users' preferences concerning layout features such as images, colors, text quantity, and font size and color [42], moreover, studies have shown a correlation between products that are aesthetically pleasing and their usability [43,44].

We refer readers to Table 1 for an overview of the usability guidelines we gathered from different fields and condensed into eHealth specific usability guidelines. In the following, we

present our methods and results, and conclude with a discussion of the research-related and practical implications of our findings.

Table 1. Overview of literature, respective fields, and associated guidelines/heuristics intended to increase the usability of various systems.

Field	Source	Guideline/heuristic	Description
E-learning	[45]	Simplicity	The e-learning courseware should be simple, uncomplicated, and straightforward.
		Navigability	Users should easily navigate and get to where they want to go when using the e-learning courseware.
		Load time	Pages should load quickly in the e-learning courseware.
		Recognition	Users quickly identify the key points presented for carrying out tasks when they use e-learning courseware.
		Consistency	Consistency of appearance, terms, words, and action are present throughout the e-learning courseware.
		Understandability	The information in the e-learning courseware is understandable and easy to read.
		Relevancy	The information presented in the e-learning courseware is relevant to what users need to know.
		Adequacy	The information presented in the e-learning courseware is no more/no less than what users need to know.
		Right to the point	The information in the e-learning courseware is concise and right to the point.
		User guide	The e-learning courseware provides a simple user guide on “how to get started” with the courseware.
		Direction/Instruction	The e-learning courseware provides instructions and/or directions on various features in the e-learning courseware.
		Provision of basic information via Q&A	The e-learning courseware contains a frequently asked questions (FAQ) feature to attain common questions and answers.
	[46])	Navigational aids	Navigational aids intended to help readers viewing where they are in the lesson, navigating where they want to move any page in the lesson, and seeing which pages they have read or not read in the lesson are provided in the e-learning system.

		Signaling aids	Signaling aids intended to help readers viewing what is most important in the lesson, are provided in the e-learning system.
HCI	[7]	Simple and natural dialogue	Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility. All information should appear in a natural and logical order.
		Speak the users' language	The dialogue should be expressed clearly in words, phrases, and concepts familiar to the user, rather than in system-oriented terms.
		Minimize user memory load	The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
		Consistency	Users should not have to wonder whether different words, situations, or actions mean the same thing.
		Feedback	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
		Clearly marked exits	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue.
		Shortcuts	Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users.
		Good error messages	They should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
		Prevent errors	Even better than good error messages is a careful design that prevents a problem from occurring in the first place.
		Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, be focused on the user's task, list concrete steps to be carried out, and not be too large.
	[47] [27]	Customization	Users have the option to make changes in the interface in accordance with their own preferences.

		Personalization	Designers have designed the system for a specific target group, or the system itself makes changes to accommodate specific users or user groups.
	[28])	Cognitive functioning	Consider the end-users cognitive level of functioning
	[29])	Computer literacy	Consider the end-users level of computer literacy
Visual appearance	[42]	Use appealing colors and design	Make considerations as to the users' preferences concerning layout features such as images, colours, text quantity, and font size and colour

Methods

Literature search

As mentioned earlier, part of the rationale for this paper was based on a lack of eHealth-relevant usability literature. Therefore, the search for literature was initiated in dialogue with field experts, who directed our attention towards cognitive load theory, e-learning guidelines, Nielsen's usability work, and the field of HCI. With this knowledge in mind, we applied a top-down approach to our search strategy, i.e. the aforementioned fields were investigated through recommendations and reference checks until enough knowledge had been gathered to synthesize the data into eHealth-specialized guidelines.

Creation of guidelines

The process of creating the nine usability guidelines was done by extracting existing guidelines from the literature introduced earlier. All identified guidelines were organized in a table (see Table 1), to help detect any overlap between them. Subsequently, the guidelines were merged into eHealth specific usability guidelines through a process that involved identifying recurrent and/or important themes related to the usability of systems and discussing their utility in the context of web-based mental health interventions (i.e. their likelihood of affecting the

usability of interventions and thereby possibly their adherence or clinical effect). Any disagreements between the authors as to whether a specific guideline should be included in the final framework, were resolved through discussion. If no consensus was found, the authors voted on it. The formulation of each new guideline was done collectively in a manner trying to keep the essence of the original guidelines while making the adaption to a web-based intervention format, and each new guideline was compared against the definition of usability earlier introduced. Furthermore, each eHealth specific usability guideline was coupled with specific usability attributes, as shown in Table 2.

Heuristic Evaluation Method

The usability evaluation of the web-based intervention case, which was conducted in order to test the practical utility of the newly created eHealth specific usability guidelines (see Table 2), was carried out in concordance with the Heuristic Evaluation approach outlined in Hartson and Pyla [34].

Description of the web-based intervention

The web-based intervention used for the heuristic evaluation targeted patients with health anxiety and was based on Acceptance and Commitment Therapy [48]. When patients log-in for the first time they are asked to complete a questionnaire, which addresses their physical and mental health. After the questionnaire, patients are directed to the intervention menu, which provides an overview of the different components of the intervention. This includes the asynchronous chat function (i.e. the patients can message their therapist), a page containing different exercises, a function that provides acute help if needed, and seven lessons containing audio, video, and written material intended for treating health anxiety. In order to proceed to a new lesson, the previous one has to be completed (i.e., the intervention was tunneled).

Evaluation of the web-based intervention

Over the course of five days, three of the authors, all of which were novices with regard to usability evaluation but experienced in working with eHealth, independently assessed every part of the web-based intervention's design and content (lessons, questionnaires, menus, chat, exercises, help function etc.) in terms of potential usability problems, which were defined as contradicting the aforementioned usability guidelines. Every time a violation was encountered, each evaluator noted the location of the violation, which guideline was in violation, a short description of the problem and its scope, any additional comments, and, if possible, supplied a screenshot of the problem. After completing the independent evaluations, the evaluators convened and merged their problem lists. Each problem was discussed in terms of its severity, categorized in terms of its context (i.e. specific lesson, menu etc.), and repetitions were noted. Subsequently, a heuristic evaluation report containing 23 of the usability problems was compiled. Each problem in the report was chosen based on a collective discussion of the severity of the problem and the possible solutions to fix it, while weighing the practical attainability of that fix in the face of limited resources. As such, the heuristic report was a compilation of the usability problems that would be most feasible and useful to correct while providing the greatest improvements in usability. Its ultimate goal was then to be relayed to a design or development team as suggestions for improvement. Each problem in the report contained the following information: problem number, location of problem, screenshot, name of guideline in violation, short description of problem, scope of problem, severity (low, medium, or high), justification for severity rating, suggestions to fix, and possible trade-offs (why fix might not work or might cause other, new problems). Additionally, the top six most urgent usability problems were highlighted at the top of the report, which is customary information to include in heuristic

evaluation reports [34]. This was done to allow development teams to leverage the severity of the issue against restrictions in development resources, so that the most important issues could be prioritized and addressed first. The report was then forwarded to the project team behind the web-based intervention and later presented at a project meeting. An example from the heuristic evaluation report can be seen in Figure 1:

Figure 1. Example of usability problem presented in the heuristic evaluation report

Dated: 08/05/2018

Prepared by:

NAME: Evaluator 3

Evaluation of:

Name of system being evaluated:

Problem #: 6

Location of problem: Step 7, page 7

Screenshot:

Name of guideline: Navigability

Short description of problem: Navigational dots blink too slowly.

Scope of problem: All questionnaires and all intervention steps.

Severity of problem (high/medium/low): Medium

Justification for severity rating: At a quick glance, a user might get a wrong impression about questionnaire or intervention progress.

Suggestions to fix: Change from blinking to differing colours. For instance, make passed pages faded, current step a strong colour and future steps white.

Possible trade-offs (why fix might not work):

Results

eHealth usability guidelines for web-based interventions

Table 2 displays the nine eHealth specific usability guidelines which were created as a result of analysis and merging of existing guidelines from other fields.

Table 2. Overview of eHealth specific usability guidelines.

	Guideline	Description	Attributes
1	Communicate in a simple and suitable manner	Information in an intervention should be presented in a simple and suitable manner, and the language used should be understandable for the particular user-group.	Task effectiveness, learnability, efficiency, satisfaction
2	Navigability	Interventions should be designed in a way that makes it easy for users to navigate in the platform, and that provide them with sufficient navigational aids to advance in the intervention and follow intervention instructions.	Efficiency, satisfaction
3	Accentuate relevant content and design features	Relevant content and design features are highlighted and signaling aids used, in order to draw the user's attention to the most important information in an eHealth intervention.	Task effectiveness, efficiency, learnability, memorability
4	Consistency and predictability	Appearance, language, and actions of the design should be presented with consistency throughout the intervention.	Task effectiveness, efficiency, satisfaction, learnability, memorability
5	Provide feedback	When a user performs an action, it has to be apparent immediately how the intervention responds to this action.	Task effectiveness, efficiency, satisfaction, learnability
6	Provide help and support	Help and support is provided in an intervention, and the help is presented as simply as possible.	Satisfaction, task effectiveness, learnability

7	Flexibility	The intervention should be able to adapt to the specific user and/or user group (personalization), as well as allowing users to customize the intervention in a manner that does not interfere with fundamental intervention features (customization).	Learnability, task effectiveness, efficiency
8	Visually pleasant and appealing	eHealth interventions should adapt the colours and visual appeal of a design to the intended end-users by including them in the design process.	Satisfaction
9	Consider the end-user	Be aware of the user-group, as these might vary within or between eHealth interventions.	All attributes affected

In the following, a brief description of each of the guidelines is provided together with the usability attributes we posit they will affect.

1. Communicate in a simple and suitable manner

Information in an intervention should be presented in a simple and suitable manner, and the language used should be understandable for the intended user group. It follows that the amount of information presented should be adequate, and that the language in which it is presented should be informal and easy to understand. Furthermore, it is important to consider which media is most suitable for each message or point – for instance, it would be preferable to make an instructional video for explaining a physical exercise compared to explaining it in text.

Users interacting with an intervention that communicates in a simple and suitable manner will not have to spend as many cognitive resources on understanding the interaction. This will steepen the learning curve (learnability) and make task completion easier (task effectiveness) and quicker (efficiency). Furthermore, informal language makes the user feel more personally connected to the system [37]. This will invoke trust, which increases satisfaction.

2. Navigability

Interventions should be designed in a way that makes it easy for users to navigate in the platform and provides them with sufficient navigational aids to advance in the intervention and follow intervention instructions, without extensive prior instruction. This could include an overview of how far they have come in the intervention, which lessons they have completed or not completed, how many lessons an intervention contains, short descriptions of lessons, as well as clearly marked exits, back/forward buttons, shortcuts, and signaling cues as to what exercise the learner is currently engaged with among a range of options.

A highly navigable eHealth platform will lead to higher user efficiency, as users will more quickly be able to navigate the intervention. In addition to this, good navigability will affect satisfaction, as avoidance of frustration is another outcome of navigability.

3. Accentuate relevant content and design features

Relevant content and design features should be highlighted and signaling aids should be used in order to draw the user's attention to the most important information in an eHealth intervention. This could for instance be achieved by underlining key words in a session, having small sections with important descriptions or definitions of central concepts, or highlighting the most likely next step in navigating. This guideline appeals to multidisciplinary use, as it most likely will take both content- and design-experts to identify and accentuate which content will be contextually the most important at any given stage in the intervention.

Accentuating important content most likely helps users reach their goals with task effectiveness and efficiency in addition to increasing learnability and memorability.

4. Consistency and predictability

Appearance, language and actions should be presented with consistency throughout the intervention. For instance, information about intervention progress or actions should always be located the same place on the page, the same wording should be used every time the same check-up question is asked, and pressing a button labelled “forward” should always mean the same across different contexts of the intervention.

A predictable intervention will help users reach goals with task effectiveness, efficiency and satisfaction. Also, a consistent platform will have high learnability and memorability, as users will comprehend the presented information easier.

5. Provide task-related feedback

The intervention should clearly and continually state how it interprets the user’s actions. Thus, when a user performs an action, it has to be apparent immediately how the intervention responds to this action. In case of actions that might have a large impact on the user’s progress, such as overwriting saved data or deleting old entries, additional feedback (e.g. a warning message) needs to be provided to make sure that all actions are performed with proper information available.

In terms of feedback’s influence on the usability attributes, especially task effectiveness will be affected, as insufficient feedback can cause serious errors such as loss of data or progress. Consequently, this will also influence efficiency and satisfaction. A general lack of feedback might also harm learnability, as users would have to spend more cognitive capacity figuring out the intervention’s responses, which, based on cognitive load theory, would take up learning potential [49].

6. Provide help and support

Help and support should be provided throughout the intervention and this should be presented as simply as possible. Examples of support in an intervention could involve synchronous (real-time) or asynchronous (delayed) chats, FAQs or manuals. When the support is in form of a manual, it is helpful to include a search function to enable the users to better navigate this manual. The characteristics of a given intervention need to match the choice of support to improve the impact of the provided help. In the context of an eHealth intervention, the help needed is sometimes of therapeutic nature, which can make the solution more complex, and therefore personal support is often preferred. This could also have an effect on adherence to the intervention. Conversely, time normally spent on therapeutic messages could be spent trying to solve issues that originated in poor usability, which decreases the effectiveness of the therapist.

When support is adequately applied, and the user feels a sense of resolution this will lead to higher satisfaction, task effectiveness, and learnability.

7. Flexibility

The intervention should be tailored to the specific user and/or user group (personalization) and allow users to customize the intervention in a manner that does not interfere with fundamental intervention features (customization). This could for instance be achieved by providing users with the option to customize menus by moving items to make it more manageable or providing the user the ability to specify his or her preferences, e.g. by deselecting certain forms of physical exercise in a weight management intervention. It is important that customization is kept on an appropriate level, however, as the ability to change critical parts of validated intervention content should be left to professionals.

Flexibility of interventions mainly affects the usability attribute satisfaction, as frustration may be avoided, and well-being achieved by making the user feel in control. However, removing irrelevant content can also help the user focus on specific tasks, and might consequently influence learnability, task effectiveness and efficiency. This could especially be relevant in interventions aimed to reach a very broad audience, such as transdiagnostic interventions or those aimed at multimorbid patients.

8. Visually pleasant and appealing

The colors and visual appeal of the intervention should be adapted to the intended end-users by including them in the design process. This is important, as end-users may have very differing opinions on what is pleasant and appealing. Moreover, web design trends continue to change rapidly. Therefore, it is important to consider the current trends and end-user preferences when designing an intervention.

This guideline's focus on visual appeal is closely related to the usability attribute satisfaction, as visual appeal has been shown to increase positive emotions, which is a part of satisfaction.

9. Consider the end-user

As a final and overarching guideline, the design of the intervention should consider the intended end-users, which may vary within and between web-based interventions. This includes taking into account the end-users' cognitive level of function [21], which may be affected by psychopathological or similar diagnostic factors, as well as the end-users' level of computer literacy. The latter may vary greatly as people without much technological experience live alongside younger generations, who have grown up using technological applications and may

have much higher standards for interacting with digital platforms. Participatory design will often be a relevant tool when adapting the design of interventions to the intended end-user [50].

Considering the end-user is important in all aspects of both intervention design and development, and will lead to higher task effectiveness, efficiency, satisfaction, learnability, and memorability.

Heuristic evaluation of a web-based intervention for patients with health anxiety

Table 3. Overview of usability problems identified according to each guideline.

Guideline	Problems identified	High severity problems identified
Communicate in a simple and suitable manner	5	0
Navigability	10	6
Accentuate relevant content and design features	3	1
Consistency and predictability	2	0
Provide feedback	1	1
Provide help and support	1	1
Flexibility	1	0
Visually pleasant and appealing	0	0
Consider the end-user	0	0
Total	23	9

Discussion

This study merged existing usability guidelines from several different fields, including HCI, e-learning, and emotional design to form a new set of guidelines relevant for usability evaluations in eHealth. Furthermore, the practical utility of the guidelines was tested on a web-

based intervention for patients with health anxiety. Nine usability guidelines relevant for web-based interventions were created through a synthesis of relevant literature. This process included identifying recurrent and/or important themes related to the usability of systems and discussing their utility in the context of eHealth interventions (i.e. their likelihood of affecting the usability of interventions and thereby possibly their adherence or clinical effect). The subsequent analysis of an existing web-based intervention showed that the guidelines were applicable on an actual intervention and were able to reveal several important usability problems.

Implications for research

The guidelines proposed in present study attempt to close the gap that currently exists in the field of eHealth concerning the usability of web-based interventions. They were created through a top-down approach, where existing guidelines from other fields were selected according to their relevance for web-based interventions, modified, and combined in a new framework. Thus, these guidelines are not the result of a systematic review of the literature, nor have they been empirically validated beyond their practical utility for the authors in the evaluation of an existing web-based intervention. However, they are meant to serve as a point of departure for future research endeavors on usability in eHealth. Thus, we intend for them to be adapted and used by other researchers. For instance, some of the guidelines might not be relevant for some development/evaluation efforts, in which case we recommend leaving them out. Furthermore, due to their breadth, some of the guidelines might need modification in order to be of practical use with certain web-based interventions. Additions might also prove to be necessary as further eHealth specific usability considerations may be uncovered.

As it appears in Table 2, each usability guideline created in this study has a proposed set of usability attributes that it might affect. These attributes stem from Nielsen [7] and ISO [6], and

include task effectiveness, efficiency, satisfaction, learnability, and memorability. This line of reasoning is inspired by Hornbæk and Law [26], in which it was found that measures of the usability attributes effectiveness, efficiency, and satisfaction have weak correlations and thus each contribute with unique information in usability evaluations. Therefore, they concluded that any attempt to reduce usability to one score is not beneficial as this might lead to loss of important information. To our knowledge, no such correlation analysis has included the usability attributes learnability and memorability, however it is likely that they similarly contribute with unique information during usability evaluation. As such, this study argues that future research on usability in eHealth (and in general) should measure usability as a multifaceted construct, consisting of several usability attribute measures. This differs from the conception of usability that is often used in the current literature, where it is customary to produce a single score following usability evaluation, which is often done using the SUS. It is important to stress, however, that we do not recommend replacing the SUS altogether as this scale is widely used in research and has proven very useful and perhaps has attained status as a de facto gold standard. In line with other recent findings [21], we do recommend supplementing SUS scores with more nuanced usability attribute measures to identify what design guidelines might prove useful in order to increase the usability. As stated in Finstad [51], the SUS items do not map well onto effectiveness, efficiency, and satisfaction, which means that the scale can indicate whether there is a problem with a system's usability but not what those problems actually are – this is more effectively done using think-aloud protocols [21].

Part of the rationale for creating usability guidelines for web-based interventions in present study can be found in the problems with non-adherence the field has been facing over the past decades [16]. Designing for higher usability in web-based interventions could be one

contributing factor to higher adherence, as usability in general is associated with users' ability or willingness to use a system [6]. Indeed, sufficient levels of usability may be equated with the patients being able to use the web-based intervention as intended and expected, which most likely affects the extent to which they follow the instructions they are given for treatment (e.g. filling out exercise sheets and completing certain intervention steps within a given amount of time). Research suggests that the design of web-based interventions is an important factor in improving adherence [12,13], however few studies have examined the relationship between usability and adherence to web-based interventions. As mentioned above, Baumel & Yom-Tov [16] found a negative association between usability and an adherence measure (total engagement time). However, this negative association can be explained by the way usability was measured. Usability ratings, which were made up of a single, aggregated score, were obtained through three items in the Enlight Quality Assessment: 1) *Is it easy/natural/frictionless to navigate through the eHealth intervention Program (EHP)?* 2) *How easy is it to learn how to use the EHP at first? Is it self-explanatory?* and 3) *How easy is it to use the EHP? Does the operator need to exert only the least possible effort to activate the desired features?* According to the authors, high usability scores were associated with lean programs with very limited content and engaging features [16], explaining the low amounts of engagement time. Furthermore, it can be argued that the usability scores were very simplified, aggregating what seems like perceived efficiency and perceived learnability ratings, produced by two raters. Such a conception of usability puts a high focus on ease of learning and use while not taking into account measures such as satisfaction or effectiveness (i.e. do patients achieve their goals with accuracy and completeness?). We recommend that future research should use the usability attributes outlined in present study, and measure them accordingly, when examining the relationship between usability and adherence.

This could likely document the predicted positive relationship between the two concepts or shed light on the relationship between adherence and individual usability attributes.

Implications for clinical practice

This study argues that sufficient usability in web-based interventions is necessary in order for them to have any clinical effect. If patients are not willing or able to use an intervention, chances are that they will not follow the instructions they are given for treatment. This is the case even when the intervention content is based on principles from clinical psychology that have proven useful in face-to-face therapy. However, what is often seen in practice is the notion that eHealth works as long as the content is based on clinical strategies, and thus, that the medium is but an empty shell. We encourage practitioners to view content and design in eHealth as two inseparable entities. This position has also been brought up in earlier eHealth research. It has been argued that web-based mental health interventions require integration of knowledge from both computer science and clinical psychology [3], and that technology can be both a catalyst or a filter for the delivery of interventions - as an extension, this also goes for usability, where poor usability can hinder an otherwise effective intervention, and excellent usability can help users persist with a suboptimal intervention.

Many of our guidelines, such as 3. *Accentuate relevant content and design features* or 7. *Flexibility*, set the scene for collaboration between health professionals and designers.

Accentuating relevant content and design features requires health professionals, e.g. psychologists, to determine what needs to be accentuated, typically in the context of a certain model of treatment, as well as designers to determine the feasibility of these accentuations and carrying them out in practice. Oftentimes, psychologists possess knowledge about the end-users who will participate in the web-based intervention, e.g. their cognitive level of functioning, and

thus, which demands they would have for the design of an intervention in terms of its usability. Furthermore, psychologists are usually trained in both qualitative and quantitative methods. They know how to facilitate user-involvement during design and evaluation, and how to obtain feedback which could inform optimization of the web-based intervention. Designers, on the other hand, know how to carry out ideas in practice and can determine the feasibility of doing so. Thus, in eHealth, optimally designed and usable interventions are the result of collaboration between these two groups of professionals, and we argue that health professionals should be included in intervention design, not just in formulating the content.

As mentioned earlier, the guidelines are intended to be used as both a formative (during development) and summative (after development) tool for usability improvements in web-based interventions. Especially their possible use during development of web-based interventions might prove useful in clinical practice. Anecdotally, the authors have experienced that usability is often considered at the end of a research project to evaluate the final product [52], but rarely discussed in the formative stages. The result is that usability evaluations often end up as a post-mortem analysis of why an intervention was lacking in engagement, which means that the evaluation often only leads to minor changes at best [23], if any at all. A recent paper on mHealth usability, [53], presents a questionnaire to assess usability, but no guidance on how to use it in the formative stage of intervention development. Conversely, the usability guidelines created in this study can be used to prioritize usability in the formative stages of web-based interventions. They could also prove useful for analyzing “failed” web-based interventions for possible usability problems, and thus point to future improvements.

As a rule of thumb, the guidelines are aimed at web-based interventions because the literature on which these guidelines are based is all web-related. However, this does not exclude

the guidelines from being relevant to e.g. apps or virtual reality, but making the argument that they are would require further knowledge of these media.

Limitations and future directions

This study was not based on a systematic review of the literature, but rather on a top-down approach to gathering what we deemed a sufficient amount of usability design guidelines/heuristics and recommendations from other fields, to create a set of specific usability guidelines for web-based interventions. Thus, it is possible that relevant information was missed, and relevant fields overlooked, although we did spar with experts in HCI and eHealth, who gave advice on where to begin our investigation. Future research should systematically investigate different parts of the usability literature, e.g. isolating e-learning or HCI in order to map each field. This would make it less difficult for other fields (eHealth or other) to adapt theories and guidelines.

The new guidelines were not empirically validated beyond their practical utility for the authors in the evaluation of an existing web-based intervention. This evaluation, which was guided by the heuristic evaluation method, was carried out by three of the authors, a few less than recommended in the established usability literature, which normally would recommend at least five usability experts [33,54]. Furthermore, the evaluators all have backgrounds in psychology and not technical backgrounds, which traditionally has been the norm for usability evaluators. Thus, in order to firmly establish the utility of the new guidelines, future research should seek to empirically validate them. This could include experimentally examining the relationships between individual guidelines and the usability attributes outlined in present study. Also, we recommend that other evaluators of varying numbers, backgrounds, and levels of expertise test the practical utility of our guidelines for heuristic evaluation of web-based

interventions. This would allow us to see if our guidelines would be of use to others, as well as which and how many usability problems they would be able to identify. Also, the judgment as to which problems would be most feasible to correct would likely vary for different evaluator groups.

Conclusions

On the basis of usability theory and guidelines from other fields, nine guidelines for formative and summative usability improvements in web-based interventions were created. Using the heuristic evaluation method, these guidelines were found to be applicable by the authors, and able to reveal several usability problems in a web-based intervention. Furthermore, it can be concluded that health professionals should be included in intervention design, not just formulating the content, as design and content should be viewed as inseparable entities.

Although several useful usability assessment tools currently exist (e.g. SUS), we argue that future usability assessment should focus on the different usability attributes, as they provide important information in terms of what aspects of usability might need improvement. Future researchers are encouraged to use and adapt the nine guidelines, as the guidelines are intended to be a point of departure for future usability research. Finally, we strongly encourage future research in the field to investigate the relationship between usability and adherence.

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Conflicts of Interest

The authors declare that no conflicts of interest exist.

Abbreviations

References

1. WHO. eHealth at WHO [Internet]. 2019. Available from: <https://www.who.int/ehealth/about/en/>
2. World Health Organization. Global diffusion of eHealth: Making universal health coverage achievable. Report of the third global survey on eHealth. Geneva; 2016.
3. Ruwaard J, Kok R. Wild West eHealth: time to hold our horses? *Eur Health Psychol* 2015;17(1):45–49.
4. Andersson G, Titov N, Dear BF, Rozental A, Carlbring P. Internet-delivered psychological treatments: from innovation to implementation: Internet-delivered psychological treatments: from innovation to implementation. *World Psychiatry* 2019 Feb;18(1):20–28. [doi: 10/gf4m52]
5. Maramba I, Chatterjee A, Newman C. Methods of usability testing in the development of eHealth applications: A scoping review. *Int J Med Inf* 2019 Jun;126:95–104. [doi: 10.1016/j.ijmedinf.2019.03.018]
6. ISO. Usability: Definitions and concepts. *Ergon Hum-Syst Interact* Brussels: ISO; 2018. p. 1–29.
7. Nielsen J. Usability Engineering. California: Morgan Kaufmann; 1993. ISBN:1-12-518406-9
8. Pagliari C. Design and Evaluation in eHealth: Challenges and Implications for an Interdisciplinary Field. *J Med Internet Res* 2007;9(2):1–14. [doi: <https://doi.org/10.2196/jmir.9.2.e15>]
9. Donkin L, Christensen H, Naismith SL, Neal B, Hickie IB, Glozier N. A systematic review of the impact of adherence on the effectiveness of e-therapies. *J Med Internet Res* 2011;13(3):1–12. [doi: <https://doi.org/10.2196/jmir.1772>]
10. Van Genugten L, Dusseldorp E, Webb TL, Van Empelen P. Which combinations of techniques and modes of delivery in internet-based interventions effectively change health behavior? a meta-analysis. *J Med Internet Res* 2016;18(6). [doi: 10.2196/jmir.4218]

11. Haynes RB, Ackloo E, Sahota N, McDonald HP, Yao X. Interventions for enhancing medication adherence. *Cochrane Database Syst Rev* 2008; [doi: 10.1002/14651858.CD000011.pub3]
12. Kelders SM, Kok RN, Ossebaard HC, Van Gemert-Pijnen JE. Persuasive system design does matter: a systematic review of adherence to web-based interventions. *J Med Internet Res* 2012;14(6). [doi: <https://doi.org/10.2196/jmir.2104>]
13. Ludden GD, van Rompay TJ, Kelders SM, Van Gemert-Pijnen JE. How to increase reach and adherence of web-based interventions: a design research viewpoint. *J Med Internet Res* 2015;17(7):1–14. [doi: <https://doi.org/10.2196/jmir.4201>]
14. Eysenbach G. The law of attrition. *J Med Internet Res* 2005;7(1):1–9. [doi: <https://doi.org/10.2196/jmir.7.1.e11>]
15. Morrison C, Doherty G. Analyzing engagement in a web-based intervention platform through visualizing log-data. *J Med Internet Res* 2014;16(11):1–16. [doi: 10.2196/jmir.3575]
16. Baumel A, Yom-Tov E. Predicting user adherence to behavioral eHealth interventions in the real world: examining which aspects of intervention design matter most. *Transl Behav Med* 2018 Sep 8;8(5):793–798. [doi: 10.1093/tbm/ibx037]
17. Van Velsen L, Wentzel J, Van Gemert-Pijnen JE. Designing eHealth that matters via a multidisciplinary requirements development approach. *JMIR Res Protoc* 2013;2(1). [doi: <https://doi.org/10.2196/resprot.2547>]
18. Sillence E, Briggs P, Harris P, Fishwick L. A framework for understanding trust factors in web-based health advice. *Int J Hum-Comput Stud* 2006;64(8):697–713. [doi: <https://doi.org/10.1016/j.ijhcs.2006.02.007>]
19. Baumel A, Muench F. Heuristic Evaluation of Ehealth Interventions: Establishing Standards That Relate to the Therapeutic Process Perspective. *JMIR Ment Health* 2016;3(1):1–12. [doi: <https://doi.org/10.2196/mental.4563>]
20. Maramba I, Chatterjee A, Newman C. Methods of usability testing in the development of eHealth applications: A scoping review. *Int J Med Inf Elsevier*; 2019;126(February):95–104. [doi: 10.1016/j.ijmedinf.2019.03.018]
21. Broekhuis M, van Velsen L, Hermens H. Assessing usability of eHealth technology: A comparison of usability benchmarking instruments. *Int J Med Inf* 2019 Aug;128:24–31. [doi: 10.1016/j.ijmedinf.2019.05.001]
22. Harrati N, Bouchrika I, Tari A, Ladjailia A. Exploring user satisfaction for e-learning systems via usage-based metrics and system usability scale analysis. *Comput Hum Behav* 2016 Aug;61:463–471. [doi: 10.1016/j.chb.2016.03.051]

23. Ahmad N, Rextin A, Kulsoom UE. Perspectives on usability guidelines for smartphone applications: An empirical investigation and systematic literature review. *Inf Softw Technol Elsevier*; 2018;94(September 2016):130–149. [doi: 10.1016/j.infsof.2017.10.005]
24. Kientz JA, Choe EK, Birch B, Maharaj R, Fonville A, Glasson C, Mundt J. Heuristic evaluation of persuasive health technologies. *Proc 1st ACM Int Health Inform Symp* 2010. p. 555–564. [doi: <https://doi.org/10.1145/1882992.1883084>]
25. Bevan N, Carter J, Harker S. ISO 9241-11 Revised: What Have We Learnt About Usability Since 1998? *BT - Human-Computer Interaction: Design and Evaluation*. 2015;143–151.
26. Hornbæk K, Law EL-C. Meta-Analysis of Correlations Among Usability Measures. *Proc SIGCHI Conf Hum Factors Comput Syst California: ACM*; 2007. p. 617–626. [doi: <https://doi.org/10.1145/1240624.1240722>]
27. Schade A. Customization vs. Personalization in the User Experience [Internet]. 2016 [cited 2019 Aug 7]. Available from: <https://www.nngroup.com/articles/customization-personalization/>
28. Rotondi AJ, Sinkule J, Haas GL, Spring MB, Litschge CM, Newhill CE, Ganguli R, Anderson CM. Designing websites for persons with cognitive deficits: Design and usability of a psychoeducational intervention for persons with severe mental illness. *Psychol Serv* 2007;4(3):202–224. [doi: 10.1037/1541-1559.4.3.202]
29. Darejeh A, Singh D. A review on user interface design principles to increase software usability for users with less computer literacy. *J Computuer Sci* 2013;9(11):1453–1450. [doi: 10.3844/jcssp.2013.1443.1450]
30. van der Vaart R, van Deursen AJ, Drossaert CH, Taal E, van Dijk JA, van de Laar MA. Does the eHealth Literacy Scale (eHEALS) Measure What it Intends to Measure? Validation of a Dutch Version of the eHEALS in Two Adult Populations. *J Med Internet Res* 2011 Nov 9;13(4):e86. [doi: 10.2196/jmir.1840]
31. Rock PL, Roiser JP, Riedel WJ, Blackwell AD. Cognitive impairment in depression: a systematic review and meta-analysis. *Psychol Med Cambridge University Press*; 2014 Jul 29;44(10):2029–2040. [doi: 10.1017/S0033291713002535]
32. Nielsen J, Molich R. Heuristic evaluation of user interfaces. *Proc SIGCHI Conf Hum Factors Comput Syst* 1990. p. 249–256.
33. Jaspers MW. A comparison of usability methods for testing interactive health technologies: methodological aspects and empirical evidence. *Int J Med Inf* 2009;78(5):340–353. [doi: <https://doi.org/10.1016/j.ijmedinf.2008.10.002>]

34. Hartson R, Pyla P. *The UX Book: Process and Guidelines for Ensuring a Quality User Experience*. Waltham, MA: Morgan Kaufmann Publishers Inc; 2012. ISBN:978-0-12-385241-0
35. Pinelle D, Wong N, Stach T. Heuristic evaluation for games: usability principles for video game design. *Proc SIGCHI Conf Hum Factors Comput Syst* New York: ACM; 2008. p. 1453–1462. [doi: <https://doi.org/10.1145/1357054.1357282>]
36. Clarkson E, Arkin RC. Applying Heuristic Evaluation to Human-Robot Interaction Systems. *Flairs Conf* 2007. p. 44–49.
37. Clark RC, Mayer RE. *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*. 4th ed. Hoboken, NJ: John Wiley & Sons, Inc.; 2016. ISBN:9781119158660
38. Norman D. *Emotional design*. New York: Basic Books; 2004.
39. O'Brien HL, Toms EG. What is user engagement? A conceptual framework for defining user engagement with technology. *J Assoc Inf Sci Technol* 2008;59(6):938–955. [doi: <https://doi.org/10.1002/asi.20801>]
40. Reinecke K, Yeh T, Miratrix L, Mardiko R, Zhao Y, Liu J, Gajos KZ. Predicting users' first impressions of website aesthetics with a quantification of perceived visual complexity and colorfulness. *Proc SIGCHI Conf Hum Factors Comput Syst* Paris: ACM; 2013. p. 2049–2058. [doi: <https://doi.org/10.1145/2470654.2481281>]
41. Um E, Plass JL, Hayward EO, Homer BD. Emotional design in multimedia learning. *J Educ Psychol* 2012;104(2):485–498. [doi: <https://doi.org/10.1037/a0026609>]
42. Nielsen AS, Wilson RL. Combining e-mental health intervention development with human computer interaction (HCI) design to enhance technology-facilitated recovery for people with depression and/or anxiety conditions: An integrative literature review. *Int J Ment Health Nurs* 2019;28(1):22–39. [doi: 10.1111/inm.12527]
43. Tractinsky N, Katz AS, Ikar D. What is beautiful is usable. *Interact Comput* 2000;13(2):127–145. [doi: [https://doi-org.proxy1-bib.sdu.dk/10.1016/S0953-5438\(00\)00031-X](https://doi-org.proxy1-bib.sdu.dk/10.1016/S0953-5438(00)00031-X)]
44. Sonderegger A, Sauer J. The influence of design aesthetics in usability testing: Effects on user performance and perceived usability. *Appl Ergon* 2010;41(3):403–410. [doi: <https://doi.org/10.1016/j.apergo.2009.09.002>]
45. Koohang A, Paliszkiwicz J. E-Learning Courseware Usability: Building a Theoretical Model. *J Comput Inf Syst* 2016 Jan;56(1):55–61. [doi: 10.1080/08874417.2015.11645801]

46. Sung E, Mayer RE. Affective impact of navigational and signaling aids to e-learning. *Comput Hum Behav* 2012;28(2):473–483. [doi: 10.1016/j.chb.2011.10.019]
47. Ludden GD, van Rompay TJ, Kelders SM, van Gemert-Pijnen JE. How to Increase Reach and Adherence of Web-Based Interventions: A Design Research Viewpoint. *J Med Internet Res* 2015 Jul 10;17(7):e172. [doi: 10.2196/jmir.4201]
48. Hoffmann D, Rask CU, Hedman-Lagerlöf E, Ljótsson B, Frostholm L. Development and Feasibility Testing of Internet-Delivered Acceptance and Commitment Therapy for Severe Health Anxiety: Pilot Study. *JMIR Ment Health* 2018 Apr 6;5(2):e28. PMID:29625957
49. Sweller J. Cognitive load during problem solving: Effects on learning. *Cogn Sci* 1988;12(2):257–285. [doi: 10.1207/s15516709cog1202_4]
50. Kushniruk A, Nøhr C. Participatory Design, User Involvement and Health IT Evaluation. *Stud Health Technol Inform* 2016;139–151. [doi: 10/gf4nsp]
51. Finstad K. The Usability Metric for User Experience. *Interact Comput* No longer published by Elsevier; 2010 Sep 1;22(5):323–327. [doi: 10.1016/J.INTCOM.2010.04.004]
52. Morrison C, Doherty G. Analyzing Engagement in a Web-Based Intervention Platform Through Visualizing Log-Data. *J Med Internet Res* 2014 Nov 13;16(11):e252. [doi: 10.2196/jmir.3575]
53. Zhou L, Bao J, Setiawan IMA, Saptono A, Parmanto B. The mHealth App Usability Questionnaire (MAUQ): Development and Validation Study. *JMIR MHealth UHealth* 2019 Apr 11;7(4):e11500. [doi: 10.2196/11500]
54. Nielsen J. Finding usability problems through heuristic evaluation. In: Bauersfeld P, Bennet J, Lynch G, editors. *Proc ACM CHI'92 Int Conf Hum Factors Comput Syst* New York, NY: ACM; 1992. p. 373–380.