Enabling Effective Emergency Message Writing through Technology: A Participatory Design Approach

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Abstract

Emergency messaging is crucial in saving lives and avoiding property damage during natural or human-made disasters. Advancements in digital technologies have expanded the ability of emergency managers to reach citizens, particularly through the Wireless Emergency Alert (WEA) system, which notifies citizens in a specific geographic area via their own mobile devices. There have been studies from the perspective of citizens, but little research has been conducted from the perspective of the message senders and focusing on the technology they use. This study aims to better understand the perspective of alerting authorities by examining a case where a participatory design (PD) approach is utilized to create a digital technology that allows alerting authorities to write messages more efficiently and effectively. We seek to understand the processes for implementing effective PD in a technology application used for emergency messaging and also investigate stakeholders' needs and expectations, as well as the role of knowledge sharing during the design processes.

Keywords

emergency communication, alert, warning, participatory design, digital technology, mobile devices, information dissemination

1. Introduction

Emergency messaging plays a critical role in safeguarding lives and property during both natural and human-made disasters [3]. With the rapid advancements in digital technology in recent years, emergency managers now have a range of tools at their disposal to rapidly disseminate information to the public, including social media, mass notification software, and wireless emergency alerts, among others [2, 15, 23]. In particular, the Wireless Emergency Alerts (WEA) system, which leverages cell broadcast technology to deliver geographically targeted, text-like messages to compatible mobile devices, has emerged as a vital tool for emergency messaging worldwide, owing to its ability to push messages to all mobile devices in a specified geographic area [2]. In the United States, the WEA was established in 2012 as a collaboration among the Federal Communications Commission (FCC), the Federal Emergency Management Agency (FEMA), and wireless carriers. Since then, the system has undergone several changes and now allows authorized federal, state, local, tribal and territorial public alerting authorities to send out emergency messages in both 90 and 360-character formats [11].

Existing research on emergency messaging, especially in the US context, has provided valuable insights into what needs to be included in a message, how to present information to recipients, and how recipients react after receiving a message [3, 17, 19, 27, 32]. Despite these findings, some gaps and challenges still remain. First, very few studies have explored emergency messaging from the perspective of message senders, specifically the activities undertaken by alerting authorities to write emergency messages. In particular, according to the Department of Homeland Security, the need for

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message templates, which involve appropriate content for a range of hazards, is increasing among alerting authorities across the US [7]. However, there is a lack of evidence concerning how to use templates to create emergency messages. Second, although digital technology has increasingly played a dominant role in emergency messaging, the knowledge about how technology influences alerting authorities' ability to write messages is limited. This is particularly important because some technology applications have features that can specifically help alerting authorities to write better messages, while others might not be as effective.

In light of the identified gaps and challenges, this study showcases how a participatory design (PD) approach can help create a technology tool that enables alerting authorities to write messages more effectively and efficiently. More specifically, we seek to answer the following key questions: (1) What are the critical processes for implementing participatory design of a technology tool for emergency messaging? and (2) How to identify various stakeholders' needs and expectations as well as foster knowledge sharing during the design processes? Through this research, we aim to contribute to the literature on emergency messaging by adding insights into the use of technology by government agencies and provide practical insights for designing technology tools that are better suited to the needs and expectations of all stakeholders involved.

The rest of the paper is structured as follows: In section two, we provide a brief overview on emergency messaging. Section three describes the PD approach, including its benefits and core concepts. Section four introduces the background of our case study. Section five shows some preliminary findings. Section six presents some final comments and the next steps for this ongoing research.

2. Emergency messaging

Emergency messaging plays a vital role in providing life-saving information to citizens during disasters and other crises. As a result, a considerable amount of literature has been dedicated to studying this area, with a focus on two key aspects: message attributes and the interaction between messages and their recipients.

Studies on message attributes have helped to shed light on the content and style of emergency messages. In terms of message content, research indicates that a message typically involves five core elements: hazard (what is the hazard), location (where is the impacted area), protective action guidance (what actions should be taken), time (when is the message effective), and source (who is sending the message) [3, 9, 18]. With advancements in technology, other types of content, such as images, maps, and shortened links, have also been considered [2, 5, 21]. As for message style, studies suggest that specific, clear, and accurate messages that use formal language and proper punctuation are more effective [3, 17]. Additionally, it is worth noting that the length of emergency messages can vary across different platforms, creating both opportunities and challenges for communicators [3, 29].

Another crucial aspect of emergency messaging research is the interaction between messages and recipients. Studies in this area primarily investigate how message attributes influence recipients' interpretations, intentions, and actions [2]. To understand the factors that influence people's perceptions and actions after receiving a message, two models have been introduced: the Warning Response Model [22] and the Protective Action Decision Model [20]. Both models emphasize the need to consider the relationship between message design and the environmental, social, psychological, and physiological characteristics of the intended audience, as these factors significantly impact their perceptions and subsequent behaviors [29]. For example, research shows that recipients' willingness to take recommended actions depends on various factors, such as their past experiences with emergency messages, the punctuation and formality of messages, and environmental and social cues, including sights, sounds, and media [17, 19]. Additionally, messages providing more specific information to the recipients have been found to be associated with quicker intended responses [27, 28, 32].

Although researchers have gained significant insight into the attributes of emergency messages and their impact on recipients, there is limited understanding regarding the role of message senders and their use of technology in the emergency messaging process. Specifically, little is known about how alerting authorities create, write, and send emergency messages, as well as the challenges and opportunities they face during the process [4, 30]. In our view, an in-depth examination of these activities, enablers, and

challenges is essential in order to improve the effectiveness of emergency messaging, including message delivery speed and message quality. Also, while technology has become a crucial component of emergency messaging, current research tends to concentrate on particular technologies, like social media (e.g., [23]) and neglects the potential impact of other technologies. Accordingly, it remains unclear how technology facilitates or impedes the work of alerting authorities for emergency messaging. Given these critical gaps, this study takes a message sender perspective and investigates their use of technology in the emergency messaging process. By shedding light on these issues, we aim to improve our understanding of emergency messaging.

3. Participatory design

Participatory design (PD) is a collaborative design approach where technical experts work together with individuals from the targeted user communities to develop appropriate solutions [14]. In other words, it means giving a voice to those who will use a technology in its design [8]. This approach emphasizes the involvement of designers, users, and other stakeholders throughout different stages of project development, such as preparation (e.g., problem identification and defining objectives), development (e.g., technology design and demonstration), and evaluation [13, 16, 25]. By bringing multiple stakeholders together, PD offers several benefits. For example, it enables direct and frequent collection of end users' needs, which serves as the knowledge foundation for building technologies [1, 16]. It also helps end users develop realistic expectations about the technology and reduce their reluctance to change [1, 16]. Moreover, PD can enhance democracy in the workplace or society by providing members with the right to participate in the decision-making process [1, 6, 8]. In light of these benefits, PD has been widely deployed in the development of technology for emergency management [12, 25, 34].

Scholars have developed various concepts and approaches to examine PD, with varying emphasis on aspects such as the role and focus of users [16] and the specific participation process [25]. While PD can be studied in multiple ways, Drain [10]'s "PD Collaboration System Model" offers a rigorous approach to making sense of PD projects, as it adopts a systems view to scrutinize not only the collaboration between designers and participants but also the environment in which the collaboration takes place. The model comprises four major components, as illustrated in Figure 1.

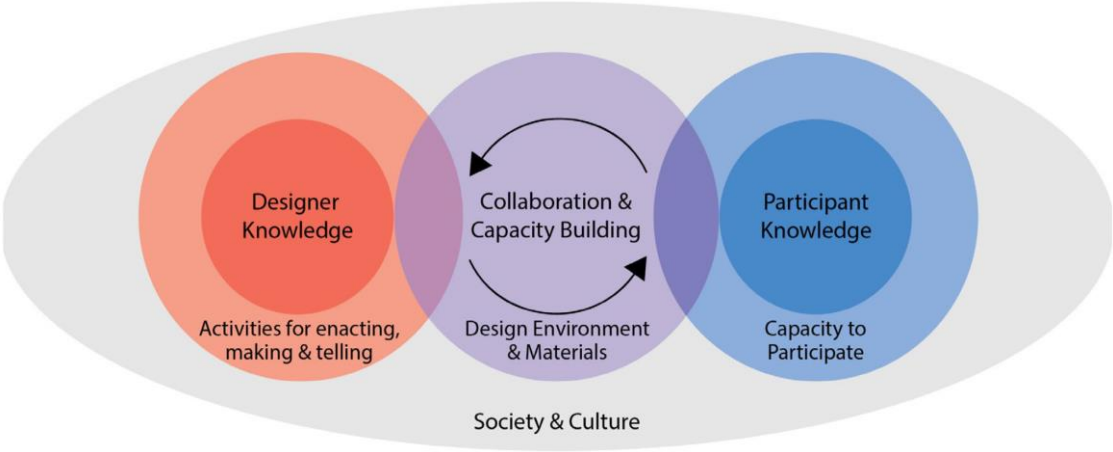

Figure 1: PD Collaboration System Model (Source: Drain (2019))

First, the *designer knowledge* component recognizes that designers possess greater knowledge about the process and design aspects of the project and technological development. However, to ensure that the design meets users' needs, designers must also understand the users, referred to as basic knowledge. To acquire such knowledge, designers can utilize various design activities such as making (e.g., building a sketch, model, or prototype), enacting (e.g., role play and prototype testing), or telling (interviews or group discussions) to collect knowledge from the participants. Second, the *participant knowledge* component recognizes that participants own more contextual information about the community characteristics and their needs (basic knowledge). They can also provide feedback on the

prototype (design knowledge). However, for the participants to share knowledge, they must have the capacity to participate, including the motivation to contribute and the necessary ability and skills to generate and express their ideas. Third, the *collaboration* component highlights the interactions between designers and participants. The model stresses that proper identification of the design space and the user space is crucial for exchanging ideas and building technologies. Finally, the *society and culture* component acknowledges the social and cultural backgrounds of the participants, which may vary by region, country, local area, age, and gender. The model indicates that PD activities may need to adjust to these social and cultural differences.

Some key ideas in the model have been utilized in various fields such as education and design [24, 31]; however, its application in the context of emergency management is yet to be explored. In our view, PD, and Drain's PD collaboration system model, in particular, could be highly useful for studying or implementing technology design for emergency messaging. It helps identify the interests, needs, and practices of alerting authorities while accounting for their social and cultural backgrounds. The model also provides clear guidance on how to observe the exchange of knowledge via various design activities to ensure that the resulting emergency messaging technology tool meets the needs of authorities. In sum, the model offers a comprehensive and structured approach to designing effective and contextually appropriate technology solutions for emergency messaging.

4. Case study: the Message Design Dashboard (MDD) project

To answer our research questions, we have adopted the case-study approach to examine the case of the Message Design Dashboard (MDD) project in the United States. Defined as an empirical inquiry that "investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (p14) [33]", the case-study approach is well-suited for our investigation because it enables us to analyze the decision-making activities around emergency messaging, including the reasoning behind specific decisions, the strategies used for implementation, and the outcomes achieved [26].

The MDD project has been developed with the objective of assisting local alerting authorities across the United States in writing effective WEA messages. The project specifically seeks to provide alerting authorities with a lexicon of research-tested message content that includes information on impacts and protective actions associated with specific hazards. One of the core tasks of the project is to create a software prototype that will guide alerting authorities in writing messages step-by-step. To develop and evaluate this prototype, a PD approach was utilized.

The co-creation of the MDD project involved two types of stakeholders, namely the university researchers and government employees (Table 1). On the university side, the lexicon team is primarily responsible for developing emergency message templates and testing their effectiveness, while the technology team is focused on creating and evaluating the software prototype. On the government side, local emergency management agencies played a crucial role in sharing information on their emergency messaging practices as they are the main target audience of the project. In addition, FEMA provided guidance on project implementation and facilitated contact between the university researchers and local alerting authorities.

Table 1
Stakeholders in the MDD project

Type	Stakeholder
University	Lexicon team
	Technology team
Government	Federal Emergency Management Agency (FEMA)
	Local emergency management agencies

5. Preliminary results

This section presents the preliminary results of our case study, particularly on the process of PD implemented for the MDD prototype. The main process and relevant tasks are summarized in Table 2.

Table 2
Overview of the MDD prototype participatory design process.

Phase	Description
Current practices review	Reviewing the common off-the-shelf packages for alerts and warnings and identifying similarities and differences.
Needs assessment	Evaluating existing practices of emergency messaging and the specific needs of alerting authorities.
Message template design	Creating hazard-specific message templates and assessing their effectiveness.
Prototype design	Designing the MDD software prototype
Prototype evaluation	Evaluating the MDD software prototype

The first phase was a *current practices review*, conducted by the technology team. This phase aimed to understand the current technological landscape for emergency messaging. The primary objective was to identify the features and limitations of the off-the-shelf packages available for alerts and warnings to inform the development of the MDD prototype. The review has helped identify what information users must provide to reduce redundancy in completing the required information in the MDD. Additionally, the review of ease of use provided insights into the workflow and interface capabilities used by different applications. The information on template creation and management highlighted limitations in the existing applications, such as inconsistent naming conventions and a lack of tracking for template creators. Finally, the details about site navigation and message design offered various design patterns that the MDD could adopt to improve its usability.

The second phase was a *needs assessment*. In this phase, the technology team conducted semi-structured, in-depth interviews with 19 local alerting authorities, varying in geographic location, type of government, population size, and experiences of sending WEAs, to understand the existing practices for emergency messaging, including the process of writing messages, the technological tools used for message writing, the use of information, and the organizational factors affecting message writing. In this phase, the technology team also asked interviewees to share templates or any other aids they used to write more effective messages.

The third phase was the *message template design*. The primary objective was to create a comprehensive list of message contents, the MDD lexicon, for communicating hazards, including impacts and associated protective actions. The lexicon team utilized a multi-step process to analyze existing hazard messages and documents and conducted subject matter expert interviews and reviews. The information gathered from this analysis served as the foundation for the MDD software.

The fourth phase was the *prototype design*. In this stage, various stakeholders were engaged. The technology team developed the prototype's system architecture and web storyboard layouts using results from previous tasks. Throughout the design and refinement process, the lexicon team provided feedback on the layout and assisted in addressing any issues related to the usage of technical terms and the MDD lexicon database. In addition, scenario-based follow-up interviews were conducted with local alerting authorities to gain insight into their message writing process in real-life situations and the choices they make, such as when describing a location. The information gathered was used to further refine the MDD prototype.

Finally, the fifth phase will be the *prototype evaluation*. The technology team will conduct interviews and a survey to collect feedback from alerting authorities on the MDD prototype to improve the software. Participants will be selected based on specific criteria such as location, experience with sending WEAs, and previous participation in the project. Participants will be asked to perform scenario-based tasks designed to assess the effectiveness, usability, and clarity of the MDD prototype, as well as provide suggestions for refinement. The user testing and evaluation will help gain insight into the

perceptions and experiences of emergency managers when utilizing the MDD prototype to write WEA messages.

6. Final comments and next steps

Our preliminary findings outline the steps taken to implement the PD approach in creating and evaluating the MDD software prototype. Multiple stakeholders from the university and local alerting authorities were engaged in the design process, and a range of methods, including software analysis, in-depth interviews, and scenario-based interviews, were employed to gather information and promote knowledge sharing.

Moving forward, we aim to conduct a more detailed analysis of the case. Specifically, we will provide a comprehensive account of the activities undertaken in each stage of the process. Also, evaluation interviews and surveys will be conducted to collect user feedback on the MDD prototype. Moreover, we will employ Drain [10]'s PD collaboration system model to characterize our findings, tracking the knowledge possessed by designers and users, the dynamics of the collaboration process, and contextual factors influencing the design of the MDD software. Finally, based on our detailed analysis, we will draw implications for both the academic literature and practice of emergency messaging.

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