Human-AI Teaming for COVID-19 Response: A Practice & Research Collaboration Case Study

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ABSTRACT

Practice and research collaborations in the disaster domain have the potential to improve emergency management practices while also advancing disaster science theory. However, they also pose challenges as practitioners and researchers each have their own culture, history, values, incentives, and processes that do not always facilitate collaboration. In this paper, we reflect on a 6-month practice and research collaboration, where researchers and practitioners worked together to craft a social media monitoring system for emergency managers in response to the COVID-19 pandemic. The challenges we encountered in this project fall into two broad categories, job-related and timescale challenges. Using prior research on team science as a guide, we discuss several challenges we encountered in these two categories and show how our team sought to overcome them. We conclude with a set of best practices for improving practice and research collaborations.

Keywords

Research, practice, crisis informatics, digital volunteers.

INTRODUCTION

The Information Systems for Crisis Response and Management (ISCRAM) community has long recognized the importance of collaborations between practice and research (Lorini et al. 2021; Peterson et al. 2018). These collaborations provide opportunities for disaster practitioners and researchers to partner to create more holistic solutions to emergency management challenges and opportunities. Practitioners bring deep knowledge and cultural understanding of the emergency management domain as well as access to the target population.

Researchers bring the ability and knowledge to conduct systematic research that can make sense of past disaster events and inform future disaster research and practice. When these partnerships work well, they can bring benefits that neither researcher nor practitioner can realize on their own. However, if the partnership has problems, it can leave misunderstandings, strained relationships, and missed opportunities to bring novel solutions to emergency management (Trainor et al. 2018).

In this paper, we use participant observations and a reflexive process to report on a 6-month practice/research collaboration, where our team (comprised of researchers and practitioners) worked together to craft a social media monitoring system for emergency managers in response to the COVID-19 pandemic. We outline this case study, the challenges we encountered related to timescale and job-related challenges when working together, and what worked well. We conclude with a set of best practices for others seeking to foster practitioner-researcher partnerships.

BACKGROUND

The Divide between Practice & Research

Tension between practitioners and researchers is not new nor is it unique to the disaster domain. This tension is often talked about as the divide between practice and research. We see examples of this divide in many disciplines, including foreign policy (Zelikow 1994), health (Owen 1995), education (Coburn and Stein 2010), management (Empson 2013), and tourism (Duxbury et al. 2021) among others. Institutions that engage in practice and research in these fields are often siloed. They have their own culture, history, values, incentives, and processes that rarely encourage or facilitate collaborations with those outside of the institution.

In the disaster domain, many have reflected on the divide between research and practice (Horita et al. 2017; Hughes et al. 2014; Lorini et al. 2021; Trainor et al. 2018). **One challenge is the mismatch between job-related incentives** for the two (Hughes et al. 2014; Trainor et al. 2018). Emergency managers are incentivized to solve problems in the present. Researchers are incentivized to study disaster events and phenomena and disseminate the results through academic publications. Both things can be at-odds with one another in terms of consequences if they fail to accomplish their objectives. For example, while researchers often strive to help the communities they study, they are not necessarily rewarded for that type of work and time invested; they are evaluated based on research outputs, funding acquired, and teaching and service activities. Practitioners, on the other hand, are not evaluated on any of those same outputs; emergency managers are proactive and reactive as they strive to minimize risk to lives and property before, during, and after an event with greater sensitivity to the time for actions. Those are harshly different evaluative criteria.

Another challenge is related to timescale and centers on relationship building. Relationships between researchers and practitioners need to be built before a crisis, disaster, or emergency event happens because once something occurs, practitioners are busy handling the event (Hughes et al. 2014). They do not have time to vet researchers and rarely want to inject an unvetted person, process, or technology into their time-sensitive workflow. They are focused on responding. For this reason, many research-practice relationships never even begin.

The mismatch between job-related incentive and timescales can lead to distrust and misunderstandings. Practitioners often feel that researchers do not understand their concerns and their work practices, while researchers get frustrated that practitioners are unwilling to give them access to the data they want to collect. Building mutually beneficial partnerships is key, but those take time, multiple conversations, and low-risk shared experiences to build confidence in one another. They need to become a team by developing shared visions, detailed action plans, and mechanisms where each collaborator can receive the incentives they need (Duxbury et al. 2021; Reback et al. 2002).

Most research and commentary on the relationship between practitioners and academics in the disaster domain focuses on the divide between the two (Fothergill 2000; James 2007; Quarantelli 1993). Trainor and colleagues (2018) find this focus on the "divide" to be limiting. Instead, they are optimistic that researchers and practitioners can work together well and they document several efforts in disaster science that do just that (Trainor et al. 2018). We too are optimistic that this perceived "divide" need not hold us back. To that end, we share our experiences and learned best practices when bridging the practice and research divide for this project.

Team Science: Toward Successful Collaborations

The National Hazards Center and CONVERGE (Peek et al. 2020), the National Research Council (2014), and national funding agencies, such as the National Institute of Health (Bennett et al. 2010), and National Science Foundation (2019) have all stressed that interdisciplinary and transdisciplinary teams are essential to address

major societal problems found in areas like emergency and disaster domains. While organizational and team communication scholars have studied teams for many decades, (e.g., Beck et al. 2021), now national funding agencies (e.g., Bennett et al. 2010; National Science Foundation 2019) are encouraging the use of team science approaches to tackle more complex challenges. In the disaster domain, these convergence-like approaches are viewed as a way to "mitigate the unintended consequences of issuing technical fixes for what are fundamentally human problems" (Peek et al. 2020 p. 4).

Some of the most important factors found in successful interdisciplinary teams include: effective communication, meaningful shared goals, clear roles, recognition, ways to handle conflict, feeling empowered to make an impact to the work of the team, having reliable team members, and feeling psychologically safe (Beck et al. 2021; Bennett et al. 2010; Love et al. 2021; National Research Council 2014). Many of the job-related incentives and timescale differences found between researchers and practitioners are like the macro-level challenges faced by transdisciplinary teams (e.g., National Research Council 2014). Furthermore, at the micro-coordination level, recent research has found that much of the success of interdisciplinary teams is centered around the interpersonal relationships between team members; when they know one another and enjoy working together, they are more likely to accomplish their scientific objectives (Love et al. 2021).

Our case study aims to present lessons learned as we identified and strived to address challenges in our practice/research collaboration and build a more successful team. Using the prior research on team science as a guide to assess and reflect upon our own successes and challenges, we can better understand how to overcome the job-related incentives and timescale differences inherent in this researcher/practitioner collaboration.

THE CASE STUDY: HUMAN-AI TEAMING FOR MINING SOCIAL MEDIA DATA FOR COVID-19

We began our collaboration in 2018 when we created a framework for finding useful information for emergency responders from social media data (Peterson et al. 2019). The framework outlined a series of interdependent steps for filtering, processing, and identifying helpful information (Figure 1). When the COVID-19 pandemic started, we saw it as an opportune time to implement and evaluate this framework on a live crisis event.

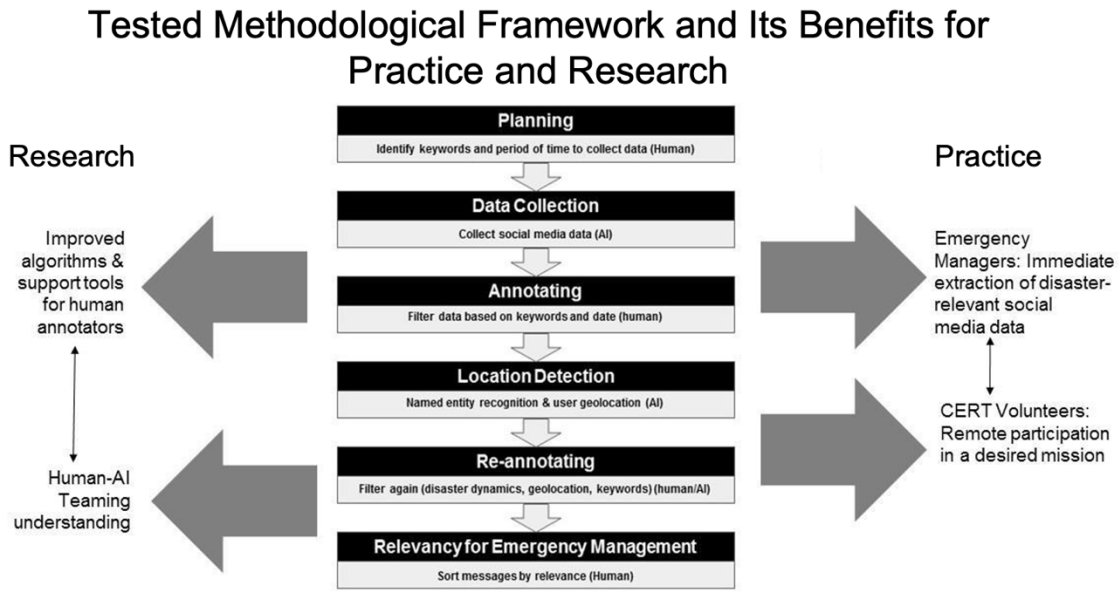

Figure 1: Framework for Finding Useful Information from Social Media using Human-AI Teaming during a Disaster Event and the Benefits to Practice and Research

The goal of the project was to find information that could be useful to emergency management in the National Capital Region (NCR – the metro area surrounding Washington D.C.) of the United States (US) as they responded to the COVID-19 pandemic. The project began in March of 2020 and lasted for 6 months. It involved a diverse group of researchers (10 from 3 universities), practitioners (3), and volunteers (120). Volunteers came from 8 Community Emergency Response Teams (CERTs) in the NCR, several NGOs, and students from our universities.

As shown in Figure 1, we generated keywords in the first phase with the help of practitioners that could be used to broadly filter social media data streams. These keywords were then used by a real-time data analytics system, *CitizenHelper* (Pandey and Purohit 2018), to extract potentially relevant data for COVID-19 pandemic from online streams of Twitter messages (*tweets*) coming from the NCR region. The Twitter microblogging service

provides the ability to collect data streams from a geographically bounded area. We chose to focus on the NCR because our practitioners and the lead CERT team working on the project were based in this area.

Once we had collected tweets that had been filtered at a high-level for relevancy to COVID-19 and the NCR using keyword-based rules, we assigned volunteers to label the data. Volunteers were asked to mark whether the tweets were relevant to the COVID-19 pandemic, and then if they were related to preventative measures, risky situations, or behaviors. They also labeled whether the messages contained negative or positive sentiment. These classes of interest for labeling were determined after speaking with emergency managers in the NCR. The labeled data was then used to train a machine learning classifier to automatically classify messages for behaviors of risk and prevention related to COVID-19 pandemic response (Senarath et al. 2021). Specifically, we trained two classification models, structured hierarchically to first classify the relevancy of a tweet message and then, to classify the behaviors of risk and prevention expressed in the tweet. We experimented with different machine learning algorithms to train the classification model including Support Vector Machine and Logistic Regression. The learned models were based on lexical features and distributional semantics-based neural embedding features extracted from the tweet text. The best-performing model for the relevancy classification task had an F1-score of 0.73 and an AUC score of 0.88 while scores for the behavior classification task were 0.81 and 0.77 respectively (Senarath et al. 2021). These performance scores demonstrate the potential for an automated classification ability to process tweets at large-scale, yet they also show the complexity in inferring behaviors from natural language text using machine learning models alone.

In parallel, we obtained funding to study how digital volunteers could help sort and sift through social media data for disaster response. We conducted interviews with volunteers while they used the above system to label tweets (Stephens et al. 2021). Interviews were conducted remotely over Zoom. Volunteers shared their screen with us as they labeled data. We asked them to talk aloud as they used the system so that we could understand how they labeled messages. Each volunteer labeled a set of 500 tweets. Interviews lasted for 1 hour each, and each participant did three interviews in the first round. In a second round of interviews, volunteers were given tweets that had already been coded by the trained classification model and they were tasked with relabeling them. We conducted a total of 61 interviews during the summer of 2020 for this project including both the first and second round of interviews, and we published our online interview and observational protocol along with best practices (Stephens et al. 2021).

METHOD

Findings in this paper are based on participant observation (Kawulich 2005) as we conducted research and participated in this project. We also draw on practices of reflexivity in qualitative research, where the researchers (and practitioners in the case of this study) reflect on their own role in the process of being part of the research study (Lumsden 2019; Watt 2007). When using a reflexive method, the research is not complete until we, as participants in the study, reflect and make meaning of our experiences. This reflection process was aided by weekly team meetings over the course of the project where we would discuss and document challenges and think on ways to improve our process both for us and for our participants, a practice consistent with best practices in team science (Bennett et al. 2010). This paper also afforded the opportunity for us to reflect on the project as a whole and what worked well and what did not. The reflexive observations in this paper have been refined over time through multiple presentations to both research and practitioner audiences, as well as refinement as we sought additional funding to continue our collaborative efforts. The practice of co-writing grants with researchers and practitioners has allowed us to sharpen our ideas, develop a shared vision, and focus on improving practice-research experiences.

FINDINGS

The results of this paper are organized around two overarching themes that we encountered in our study, namely job-related and timescale challenges. We do not claim these themes are comprehensive in covering all possible types of challenges found in research and practice partnerships. In each section, we reflect on different aspects of these challenges and how we sought to overcome them in our practice/research collaboration. We present these themes here.

Job-Related Challenges

Two categories of challenges emerged that illustrate how our team worked to overcome the inherent differences between the incentives and job responsibilities found in academia and emergency management. First, we look at fundamental differences in the ways that researchers and practitioners perform their jobs and the responsibilities and commitments that can make collaboration difficult. We then discuss the challenges of creating an equal

partnership where both researcher and practitioner are respected and realize benefits from the collaboration.

Overcoming Academic/Practitioner Process Differences

To conduct research with practitioners, researchers usually need to have their research reviewed by an institutional review board that ensures that the research involving humans is conducted ethically. This review process often takes several weeks or more and research cannot begin until the review process is complete. This delay in approval can often prevent timely research. In the case of this study, COVID-19 was a prolonged disaster that allowed us time to get approvals before doing the research. Other disaster types do not have this type of lead time and getting approvals can be problematic for conducting timely research. To address this issue, the National Institute of Environmental Health Sciences (NIEHS) formed a Best Practices Working Group for Special IRB Considerations in the Review of Disaster Related Research consisting of a diverse collection of disaster researchers (Packenham et al. 2017). The working group documented recommendations to address ethical challenges of research involving human subjects after public health emergencies. Although this working group focused on ethical challenges in human subject research after an emergency, one recommendation highlights the importance of establishing relationships between research and practice (*Recommendation 7: IRBs that are likely to receive disaster research protocols for review should engage the disaster researcher and responder community prior to disaster events*). This recommendation is reflective of our experience. Establishing our collaboration early allowed us to respond quickly to the COVID-19 pandemic with our human-AI teaming project.

Another challenge we faced is that academic institutions operate around set times where students are on campus and times with extended breaks, and these schedules can be very different from industry, government, and nonprofit organizations. Students are often integral to projects, providing labor as well as receiving training and mentoring in a real-world environment. There is also extreme turnover when involving students in projects, so there is constant ongoing training to maintain projects over time. In addition, many bureaucratic rules and processes exist that govern how and when students can be actively involved in projects. Researchers must navigate these internal processes, while also being responsive to practitioner partners who have very different internal processes and labor practices. Our project activities were conducted with heavy effort during summer where students generally do not have classes, and thus, they could primarily focus on research work. In addition, our research team leads prioritized the matching of students' ongoing research directions with the activities of project goals, which helped us partially overcome this challenge to minimize additional efforts on students' part. For example, one graduate student wrote her Master's thesis based on her involvement with the project.

Researchers do not always have control over how and when they receive funding, which means they may get a project funded that requires their full-time effort while in the middle of working to build a long-term relationship with a practitioner. Working with a team of researchers provides a buffer when these unexpected commitments manifest. In our team of four core researchers, we have all worked with the same lead practitioner, at different times, and in different ways, to conduct smaller projects and publish together. We have a fluid team structure with times of intense collaboration with the full team, and other times when there is less collaboration.

Establishing Equal Partnerships

To overcome some of the challenges of blending the varying work practices of practitioners and researcher, we found it important that both researchers and practitioners felt like they were contributing to the success of the project. We wanted an equal partnership. When making decisions on the project we sought buy-in from both researchers and practitioners. We also tried to make our partnership visible to our participants. Researchers attended the trainings given by the lead practitioner and they made themselves available and responsive to participants. Researchers and practitioners both created thank-you videos and participated in creating materials to update the volunteers on the value of their work.

Communicating about science can be challenging in a transdisciplinary team that involves researchers and practitioners, and can often become one-sided with only the researchers presenting and publishing on the work. Our team approached this challenge by taking time to teach one another about our specific areas of scientific expertise (Bennett et al. 2010). We also shared recognition and credit through co-authoring, and sharing author leadership. Specifically, the lead practitioner on our team is the first author on one of our academic articles, and every member of the team has been able to demonstrate their expertise through first authorship.

Timescale Challenges

Three categories of challenges emerged that illustrate this overarching theme of timescale challenges. We first discuss a frequent disconnect, where practitioners are focused on finding solutions to disaster-related problems in the present, whereas researchers tend to focus on ways to improve tools and processes for future events. We then

discuss challenges of reporting progress and results in a timely way. Finally, we share thoughts on staying connected and engaged with a team over time.

Helping Now versus Future Understanding

Often there is tension between the need to respond to the current event with the best information, technology, and insight possible (the emergency management perspective) and the need to carefully analyze data in a systematic way to discover insights that likely will not help until future events (the researcher perspective). This requires a different frame of mind than is typical in much research. Much research involves the careful analysis of data; this takes time and the results are rarely available quickly.

In our project we tried to balance this work. As we discovered things that needed to be improved, we made these improvements quickly, rather than waiting for formal analysis. One example was the swear word filter. During our interviews of participants who were performing analysis on tweets, several expressed surprise and shock at the volume of profanity found in the tweets. As a result, as well as the irrelevance of swear words in contextual analysis of preventative measures and risk relevant to COVID-19, our system engineers designed a filter that replaced a large portion of commonly known profanity with the phrase "[swear word]". This allowed the participants to see there was a swear word previously found within the tweet that had been removed. Despite the removal of the profanity, this allowed the volunteer to understand and make sense of the entire tweet without having to be disturbed by the harsh language. This was an example of how an AI-based system design (particularly, modules for a data labeling task) could be informed and shaped by lessons learned from the experiences of practitioners, mediated by the qualitative study approaches.

We also updated the navigation features on the labeling interface of the system to address struggles that participants were having with the interface. Participants provided feedback to the practitioner lead who in turn relayed the issues and recommendations for improvements, to the system engineers who quickly made the interface changes allowing for a smoother navigation.

Through our project and the quick adaptations described above, we provided near real-time situational awareness on prevention and risk for COVID-19. This allowed for practitioners to mitigate risk, and it provided a tool for public information officers to monitor what was happening in the National Capital Region during this event. We note that it may not be possible to achieve the same real-time change and improvement described in this project for other events. The response phase of many disasters is short-lived. Fortunately, the slow-moving nature of the pandemic allowed for more time to implement change in this project.

Reporting Progress in a Timely Way

Research can often take years to produce a final published product, which can be frustrating to practitioners and participants involved in a project. We learned early in our project that we needed to report progress frequently and early to help the practitioners and our volunteer participants feel appreciated and that their time and efforts were worthwhile. One way to show our appreciation was to create short videos where the researchers would report on what we had discovered in the research and thank the participants for their time. Our lead practitioner also contributed to this effort by sharing short presentations with our volunteers that talked about the collective efforts of the volunteers and how these efforts were contributing to emergency management. Instead of waiting to share results in published peer-reviewed academic venues, we sought to present early insights from our work at conferences, seminars, and workshops that facilitate and value the exchange of ideas between practitioners and researchers.

Sharing the results of our work with a larger practitioner audience in a timely way was also important to the project. We wanted our work to be helpful to emergency managers and policy makers as they were making decisions on how to respond to COVID-19. Over an 8-week period beginning in late March 2020, our work was briefed by the lead practitioner at the Federal Emergency Management Agency's (FEMA) COVID-19 Crowdsourcing Unit Coordination Meeting. This meeting was conducted twice a week and was attended by numerous NGOs around the U.S. who provided updates on their pandemic-related initiatives. We were in discussions with a FEMA representative about sharing our best practices and lessons learned with Local Emergency Planning Committees (LEPC) in FEMA Region IV. However, FEMA elected to stop conducting the bi-weekly coordination meetings and our joint effort with FEMA was not able to be presented to the LEPC. Nonetheless, our work received attention in other meetings and forums. For example, in December 2020, we presented initial research findings to the White House Office of Science and Technology Policy and the National Institutes of Health (NIH) Intra-NIH Disaster Interest Group.

Engaging & Communicating Regularly

A common challenge in practice/researcher relationships is a lack of communication and regular engagement (Duxbury et al. 2021; Reback et al. 2002; Trainor et al. 2018). To combat this challenge, we had regularly scheduled weekly meetings throughout the project. These meetings helped us stay on track and work through issues quickly.

During the project, we had students and researchers "on call" when we were running interviews and the training sessions. They were available to work through issues with the interface or technology that we were using for the interviews. We also had mobile phone numbers of those that could do things like reset passwords and make sure that participants had the data they needed to login to their system.

An important part of being an effective team and keeping engagement high is celebrating successes, not only of the team, but also of the individual team members. Figure 2 is a photo of our team celebrating when the lead graduate research assistant (Anastazja Harris) received her NSF dissertation award, and we have similar photos and celebrations for all the major personal milestones our team members achieved. Two members achieved tenure, one became a full professor, and our practitioner successfully led a proposal for us to speak at the most prestigious emergency managers conference. We could not meet in person, so we celebrated over Zoom with congratulatory backgrounds, fun visual effects, and making those accomplishments visible through social media and websites.

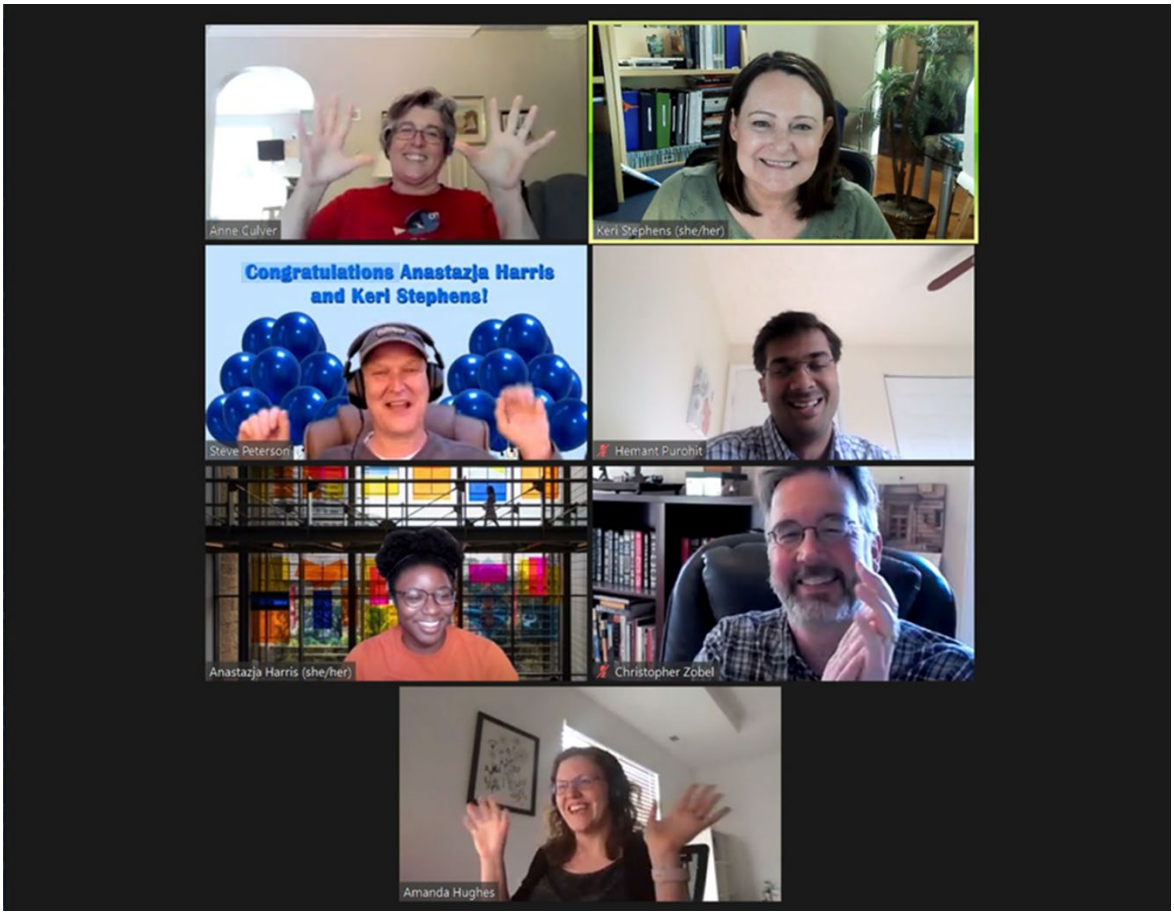

Figure 2: Zoom Photo of Project Team Celebrating when Anastazja Harris (Lead GRA) Received Her NSF Dissertation Award

After the completion of the project, the lead practitioner ordered challenge coins. These coins are imprinted with the insignia of the lead CERT organization and act as proof of one's involvement in a significant emergency management effort. Challenge coins were sent not only to the group of CERT volunteers and other volunteers associated with the project, but also to the researchers as well. In this way, the researchers were brought into the culture of the emergency response community though a shared symbol and token reflecting the success of the collaborative effort.

DISCUSSION

Many of our team structures and practices have been emergent. We did not sit down as we started to work together and create a collaboration agreement, clearly define shared goals, and engage in other activities deemed important

for effective teamwork as suggested in most team science protocols (e.g., Bennett et al. 2010). We did not even know one another as we started building our team, and team members joined at different times throughout the three-year timeframe during which we have been working together. But over time, we found that we have shared goals, have worked to create opportunities for open communication practices, and we have deep mutual respect for one another's expertise and as a person. We engaged in low-risk prototyping where we co-authored together (Hughes et al. 2014; Peterson et al. 2019; Purohit and Peterson 2020)—in small groups and as a full team—before we began this major long-term project. We have had conflict, and through resolving issues, we have developed new team structures that have helped sustain us.

In our practices of presenting our full project together, we have achieved a broad understanding of what all our team members do, and any one of us could provide an overview presentation of our project. We did not try to help one another become experts in our various fields, but instead, we taught one another about our individual disciplines, encouraged questions, and when co-authoring, every member took turns writing and editing until we achieved a collective product that was clearer than what a single author could have produced.

By partnering we were able to do something that we could not have done alone, a goal of convergent-like projects (Peek et al. 2020). We provided cutting edge social media monitoring, while also being responsive to needs of emergency practitioners and the needs of the people that were labeling the messages. This project creates a pathway for similar AI initiatives, and serves as a proof-of-concept for our human-computer workflow. We hope to expand this workflow for use in other communities and for other types of disaster events in the future.

Best Practices for Practice/Research Collaborations

We examined one successful case study in this paper. While the success of the study could be based on circumstances unique to the case (e.g., the COVID-19 study context, the relationships and interests of the researchers and practitioners), we nonetheless feel there are lessons that can inform the more general case. We offer eight best practices for building and sustaining practice/research collaborations:

1. ***Early relationship building:*** Establish relationships before a disaster occurs, so that your partnership is ready to work together when the next opportunity arises.
2. ***Workflow continuity:*** Include multiple researchers and multiple practitioners as team members so that if any one researcher or practitioner is overly busy others can sustain the collaboration.
3. ***Recognition:*** Share recognition and credit for the project across both practice and research disciplines.
4. ***Continual team communications:*** Communicate regularly and establish recurring meetings.
5. ***Team-building activities:*** Celebrate both individual and team successes. Create tokens (e.g., coins, t-shirts, hats, etc.) that symbolize shared experiences and involvement in the project team.
6. ***Public communications:*** Coauthor publications and presentations to peers in both practitioner and researcher communities and venues.
7. ***Real-time feedback:*** Find ways to make research results and insights available during the disaster event of study, so improvements can be made to practitioner processes and tools in real-time.
8. ***Share insights.*** Help each other understand and appreciate the different perspectives that team members bring to the collaboration and teach one another about your expertise.

CONCLUSION

Forming partnerships between researchers and practitioners promises many benefits. In this paper, we discussed several ways of creating and improving these partnerships, such as establishing teams long before a disaster event of study occurs, communicating regularly, sharing insights and successes amongst the team, and finding ways to bring research findings into real-time emergency management efforts.

Despite challenges we believe all research/practice collaborations can be done in a way that brings benefit to both parties. The results of this study and our list of best practices can help to this end. We hope this paper can be useful for practitioners and researchers who are seeking ways to work together and we hope to see more practitioner and researcher partnerships in the ISCRAM community.

ACKNOWLEDGMENTS

We thank all the volunteers who participated in this research. This work has been supported by grants from the

National Science Foundation [award # 2029692, 2029698, 2029719, & 2043522].

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