

Design Principles for an Educational Intervention into Online Vaccine Misinformation

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Abstract

As part of a design-based research effort into disrupting the spread of COVID-19 misinformation, we are designing, developing, and evaluating a learning intervention intended for public audiences. In this paper we describe the process used and design principles developed to guide our applied research into education on the topic of online misinformation. The six principles guiding our design are: microlearning; equity; relevance and appeal to learners; interventions that do not inadvertently spread misinformation; effective counter messaging; and engagement on an emotional level. These principles are grounded on equitable design, anti-misinformation design, and emotional design as outlined in the literature.

Design Principles for an Educational Intervention into Online Vaccine Misinformation

Since the onset of the COVID-19 pandemic and the flood of online information tied to the disease, addressing the problem of pandemic-related misinformation has become a priority area for governments across the world (Pomeranz & Schwid, 2021). The term misinformation refers to the intentional and/or unintentional spreading of a broad and inclusive category of erroneous information surrounding COVID-19, such as its transmission, treatments, and origins (Brennen et al., 2020). Belief in COVID-19 misinformation has been linked to lower adoption of preventative behaviors like handwashing, social distancing, and wearing personal protective equipment (Hornik et al., 2021), increased vaccine hesitancy (Khan et al., 2020; Loomba et al., 2021), and increased numbers of infections, hospitalizations, and deaths (Islam et al., 2020). The harmful impacts of COVID-19 misinformation have driven the public's demand for more information, reflecting earlier scholarship on emerging infectious disease events that highlights people's tendency to seek out specific forms of information, particularly risk, severity, and symptoms of infection and available treatments, cures, and preventative measures (e.g., Wong & Sam, 2010; Henrich & Holmes, 2011). Such factors all combine to create a complex information environment difficult to navigate and readily exploitable for political and commercial ends (Graham et al., 2020). This environment also provides a fertile ground for instructional design research and practice. Since misinformation is a multi-faceted problem with learning and information processing dimensions, such as deciphering between fact-based and opinion-based information on social media, the design of real-world solutions to this real-world problem is of practical and disciplinary value.

In response to this context, we developed an online learning intervention to address aspects of COVID-19-related misinformation. This intervention uses a narrative structure to

facilitate self-reflection about the role of emotions, such as fear and anger, in the dissemination of misinformation about COVID-19. Our effort is guided by a design-based research (DBR) approach. Traditional research methods have been criticized for failing to yield educational knowledge of societal value (McKenney & Reeves, 2018), and DBR has been proposed as a toolkit to enhance educational research and outcomes. DBR involves the design and investigation of educational interventions in real-world settings, in this case the real-world setting of online social networks impacted by extreme volumes of misinformation. Wang and Hannafin (2006, p.6) summarize DBR as “a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings.” DBR is also an interdisciplinary approach: When developing interventions, design-based researchers draw insights from various disciplines (e.g., sociology, social psychology, instructional design).

In this paper, we report the design principles that we developed to guide our intervention, grounded in the literature on misinformation, vaccine hesitancy, and instructional design. Being explicit about the principles guiding our instructional designs is important, not solely to ensure that our own practical intervention is aligned with theory, but also to make sure that these principles are available to the field-at-large. By sharing the principles, we hope to inform other practitioners of the process we followed such that others could iterate as desired. In the next section, we describe the specific focus of our intervention, including its learning objectives in the context of design research. We then describe the principles guiding our design, along with our rationale for each principle.

The informed exploration stage

Grounded in the understanding put forward by the Design-Based Research Collective (2003, p. 7) that there is no “single design-based research method” and that “design-based research views a successful innovation as a joint product of the designed intervention and the context,” we began our research by exploring the space in which our intervention would occur. In the Integrative Learning Design framework offered by Bannan-Ritland (2003, p. 21-22), this is referred to as the informed exploration stage and it is concerned with “identifying and satisfying the needs of the intended users so that the mature innovation is successfully adopted and used to support its learning goals.”

First, we identified an in-situ need or goal (Collins, Joseph, & Bielaczyk, 2004). We oriented our efforts by attending to the broad need expressed by the World Health Organization to “address the proliferation of disinformation and misinformation particularly in the digital sphere” relating to COVID-19 (WHO, 2020). While a range of possible interventions against the spread of misinformation have been proposed, from increasing public trust in scientists (Agle et al., 2020) to encouraging accuracy assessment (Epstein et al., 2021), interventions have overwhelmingly focused on directly countering “bad” information with “good” information via a deficit model of health communication (Mheidly & Fares, 2020; Vraga & Bode, 2021). Deficit models in this context operate from the assumption that people make what are perceived to be less than ideal choices based on inadequate information, so providing accurate information will alter behaviour toward valued outcomes (Bennett et al., 2011; Seethaler et al., 2019). Notably, however, the availability of good information on COVID-19 has not been a problematic issue (Pulido et al., 2020), and fact-checking or myth-busting efforts have had mixed results (Krause et al., 2020; Burel et al., 2020). Instead, it appears that improving *information literacy* is crucial to

protecting people from misinformation (Vraga et al., 2020). To that end, various interventions have been developed to provide people with the tools and competencies to assess source credibility and accuracy of information (Agle et al., 2020). One important aspect of information literacy is helping people reflect on the key role that emotions, like fear and anger, play in how they process and share COVID-19-related information online (Dunwoody, 2020; Martel et al., 2020). Yet while the link between emotions and the spread of misinformation has been well-established in the scholarly literature (as discussed below), few tools or education interventions have been created to specifically develop this aspect of information literacy. As such, we oriented our design-based research towards addressing the issue of emotional competency in the management of COVID-19 misinformation. Our goal therefore was to help people recognize that emotions impact how they respond to information, and that information may be created to intentionally manipulate emotions.

Emotions and misinformation

As we continued our information-gathering process, we also engaged in audience analysis efforts as suggested by Bannan-Ritland (2003) and Dick and Carey (1996). Specifically, we conducted 45 one-to-one, semi-structured interviews in the summer of 2020 to explore how individuals engage with COVID-19 information online. While this research primarily focused on understanding people's online engagement and disengagement habits with COVID-19 information (Houlden et al., 2021) for social and individual reasons, we also examined how people assessed credibility and found that while participants hinted towards many emotions related to COVID-19 information, they seldom expressed or acknowledged their emotions directly as part of their understanding of credibility (Hodson et al. 2021). Nevertheless emotions had a salient impact on their information habits, particularly in the form of how they responded

to information online. For example, our analysis illustrated that negative responses were felt by interviewees when discussing the possibility of changing science that did not align with their previously held views, and that this could impact how they responded to the scientific information. In other words, at times they relied on affect heuristics, which are a type of cognitive shortcut that people use which draw on emotional responses to information to determine validity (Slovic et al., 2007) to assess information. Research into information processing and particularly into the heuristics people use to navigate and make decisions about information (e.g., how they determine if something is true or not) indicates that such processes are indeed often connected to emotions (Metzger, Flanagin & Medders, 2010). For instance, affect heuristics influence credibility assessments based on whether information connects to a good or bad memory (Finucane et al., 2000). While not directly influencing the trajectory of our design research, as we continued exploring our findings in connection to the broader literature, we came to the realization that the relevance of this type of decision-making process should not be under-estimated in the context of an information environment rife with misinformation. This is because the spread of misinformation is well understood to be partially driven by emotions: Misinformation containing negative sentiment has been shown to increase virality of news content (Vosoughi, Roy, & Aral, 2018), while some research has shown that people experiencing negative emotions spread misinformation more often (Wang et al, 2020; Galletta Horner, Galletta, Crawford, & Shirsat, 2021). Similar findings have been found specifically regarding COVID-19 misinformation (Han et al., 2020; Rains et al., 2021). Taken together, this scholarship indicates that an educational intervention to raise competencies in emotional mindfulness online can potentially help reduce the spread of, and increase individual resilience to, COVID-19 misinformation.

Vaccine misinformation

There are many aspects of COVID-19 misinformation and information literacy that require attention, ranging from fake cures to conspiracy theories relating to the origins of the virus (Kim et al., 2020). Our review and analysis of the literature led us to the understanding that the issue of vaccine hesitancy ranks as one of the most urgent issues, having sustained urgency throughout the course of the pandemic, and led us to focus our efforts on designing an intervention that centered around vaccines. The circulation of accurate vaccine information as well as the disruption of vaccine misinformation continue to be of paramount importance, especially when one considers the need for large portions of the global population to be immunized. Preliminary calculations estimated that, depending on the efficacy of a vaccine and the reproduction speed of the virus, 75-90% of a country's population would need to be vaccinated to achieve herd immunity (Anderson et al., 2020). Yet recent surveys show that not enough people are intending to receive a COVID-19 vaccine to achieve herd immunity. Sallam (2021) for instance, reports that only 18 out of 30 countries have a COVID-19 vaccine acceptance rate of at least 75%. While vaccine hesitancy is impacted by factors such as age, income, education, ethnicity, and trust in governments and scientists (Dubé et al., 2013), misinformation has been found to be a significant contributing factor to low vaccine uptake during the COVID-19 pandemic. Loomba et al. (2021) found that exposure to COVID-19 misinformation reduced intentions to accept a COVID-19 vaccine by over 6% in the UK and USA. Salali & Uysal (2020) found that the odds of accepting a COVID-19 vaccine was between 26% lower in Turkey and 63% lower in the UK if a person believed in conspiracy theories about viral origins; similar findings have also been reported for Pakistan, Jordan, and Kuwait (Khan et

al., 2020; Sallam et al., 2021). Misinformation about COVID-19 vaccines is therefore of significant importance to global efforts at managing the crisis, and the kind of complex problem that design-based research efforts are well-positioned to address.

In terms of vaccine hesitancy, research into anti-vaccination propaganda demonstrates that the high emotional resonance of anti-vaccine messaging is a primary factor in pushing people from vaccine acceptance to vaccine hesitancy (Bean, 2011; Kata, 2010). While there are interventions developed to address the scientific aspects of misinformation spread (Epstein et al., 2021; Pennycook et al., 2020), we were unable to identify interventions into the emotional aspect of COVID-19 misinformation, even as emotions significantly influence vaccine hesitancy, as noted. To address this gap we oriented our intervention towards the emotional aspects of the issue of vaccine hesitancy.

While conducting analyses of the audience and the topic, we also investigated *health communication practices* specific to vaccines and vaccine hesitancy, which is a rich and substantial area of research (Jarrett et al., 2015). Our intervention is in response to the numerous calls from health communication specialists for vaccine information that specifically addresses and even uses the strategies of anti-vaccine propaganda, which itself heavily relies on emotion generally and narrative or anecdote specifically (Haase et al., 2015). The call for narrative strategies is drawn not just from the understanding that if such a strategy works for anti-vaccine communication it could also work for vaccine-positive communication, but is simultaneously grounded in studies on narrative communication. Narrative is well understood to be effective for engaging people in new or challenging ideas (Murphy et al., 2013; Shen et al., 2015), and is also understood to affect information processing differently than primarily fact-driven communication, in part because of the emotional impact it appears to have on people and

therefore on their responses to ideas (Richter et al., 2019). Significantly, narrative is also an area of interest to our field, as instructional design scholars have described how it could strategically be used to expand the effectiveness, efficiency, and engagement of instructional materials and environments (e.g., Dickey, 2005; Hokanson & Fraher, 2008; Parrish, 2009).

Narrative at the intersection of vaccine misinformation and emotions

Consequent to our reviews and analysis of existing literature, we sought to develop a narrative intervention that relied on the conventions of story (e.g., character, action, conflict, resolution) in order to educate the public about the COVID-19 vaccine. As the findings of our interview data became clearer, and the influence of emotion on information processing in the context of the pandemic emerged, this strategy seemed increasingly fruitful. By working iteratively between literature reviews, practitioner consultations, and public engagement as suggested by Bannan-Ritland (2003), we developed an educational design to address COVID-19 misinformation that uses narrative (as explained above) to teach people to become aware of their emotions when exposed to COVID-19 information as a means to slow the spread of vaccine misinformation. Furthermore, grounded in the understanding that much of this misinformation occurs online, and that the central aim of the informed exploration phase is to identify user needs so as to ensure success, we considered how we might best intervene online. Much of misinformation around COVID-19 exists in social media settings, and thus constrains the kinds of interventions that can be offered. For instance, instructor-led, weekly-based, or module-based interventions may be inappropriate in a social media context driven by speed and brevity. Based on this understanding, we noted the need for interventions to be short, and thus landed on the framework of microlearning. Microlearning is an approach to education that uses short, simple, and engaging activities to convey one or two specific and self-contained learning outcomes.

Typically no more than a couple minutes, microlearning efforts are designed to be accessible and flexible (McLoughlin & Lee, 2011) and to introduce or reinforce a bite-sized learning objective that does not require external material to deliver, while relying upon active engagement to trigger a learning response (Defelice & Kapp, 2019; Zhang & West, 2019).

Design principles for vaccine misinformation interventions

Next, we discuss the general principles or areas of focus we developed to guide our design, with specific practical recommendations given within each of these principles. These design principles guide our intervention and address three areas: equitable design, anti-misinformation design, and emotional design (see Table 1).

Table 1. Design Principles

Design Principles

Principle	Definition	Implementation	Goal
<u>Equitable design</u>			
Microlearning	The underlying design of any intervention must account for the fact that in the context of the COVID-19 pandemic, as well as the broader digital environment, attention and time will be limited and therefore interventions must be short and concise.	Few learning outcomes per interventions (1-2) Interventions take no longer than five minutes to complete on average. Content is clear and shareable (eg., share buttons); avoids jargon	Increase effectiveness in achieving learning outcome
Equity	People have different ways of accessing content online due to disability and technological access,	Will be specific to the intervention but may include things like attention to font, colour contrast, potential for	Increase effectiveness in achieving learning

	and to make our content available to as many people as possible, we need to use accessible design that accounts for varied needs and realities.	audio translation, alt text etc.	outcome, equity, and accessibility
	Design must also include attention to representation of people from a variety of cultures, races, and education levels, for example.	Interventions should be functional on multiple devices with minimal internet connectivity and minimal systems requirements needed	
	For the intervention to resonate it will need to appeal to a particular market or cohort in a way that is responsive to their tastes, histories, and motivations.	Diverse representation in any visuals, including race, ethnicity, disability etc.	
Relevance and appeal to learners		Appropriate aesthetics for chosen audience which	Improve engagement
		Narrative and framing that features familiar character-types and problems	
		Initial interaction with content should be appealing; have a “hook”	
		Prosocial communication strategy (Jordan et al. 2020; Heffner et al. 2020)	

Anti-misinformation design

Design interventions that do not inadvertently spread misinformation	The intervention should help learners achieve the learning outcome without amplifying misinformation messages.	Avoid repetition of misinformation in intervention if possible, or clarify its status as misinformation before intervention is over. (However, it’s notable that the boomerang effect appears	Increase efficiency for overall design objective (i.e., the problem of misinformation)
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		to not be as much of a concern as initially perceived (Walter et al. 2020)	
Use effective counter messaging	The intervention should draw on the latest evidence-based understanding of how to address and correct misinformation	Provide facts from trusted sources Note scientific consensus Highlight gaps in logic in any misinformation under analysis Make the correction the memorable part of the message Pro-social orientations (Caulfield et al., 2020)	Increase efficiency for overall design objective (i.e., the problem of misinformation)

Emotional design

Develop an intervention that engages people on an emotional level	To teach how vaccine misinformation is grounded in emotional manipulation, demonstrate the effects of emotion on susceptibility to misinformation	Apply a narrative structure as a shortcut to emotion Connect learner to the experience of emotion in misinformation via metacognition/self-awareness skills development (e.g., affect labelling) Attend to specific emotional predispositions of moms (Chou & Bedenz, 2020)	Increase effectiveness in achieving learning outcome
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Equitable design

The first principle that guides our work is to create an equitable learning intervention as a means to efficiently and effectively reach an audience potentially vulnerable to vaccine misinformation online, namely mothers. We selected this group to orient our work to as mothers are disproportionately the household health decision makers and are commonly active online (Houlden et al., 2022). For this group, equitable design is approached through several key factors: timeliness, accessibility, and cultural relevance. In terms of timeliness, short and concise learning interventions are important during the COVID-19 pandemic. Researchers have noted that people, including mothers, are stretched thin in terms of time (Bhumika, 2020). Moreover, as such interventions are meant to take place in an online environment (such as social media), they compete with a variety of other rich and persuasive media that aim to capture online users' attention. Therefore, they need to be designed to capture attention in particular ways, namely through immediate and rapid stimulation, rather than in ways that enable individuals to engage with more intensive forms of learning that require increased and effortful attention. To respond to this context effectively we decided to use microlearning strategies. In practice, this entails having few learning objectives (e.g., 1-2 per intervention), shortening the design's completion time (e.g., no longer than 2-3 minutes to engage or complete), and developing content that is clear and easy-to-share. The timeliness design principle also calls for the intervention to be efficiently comprehensible in order to reduce the cognitive effort required to engage with it. By incorporating visual communications techniques such as the Gestalt principles of visual perception (O'Connor, 2015), our goal was to make our intervention as quick and easy to

comprehend as it is to complete. Finally, timeliness requires any intervention be conceptually enticing enough to attract participation away from other content competing for people's time.

Accessibility principles emphasize the reality that people have different ways of accessing content online and have various barriers both in terms of disability and technology. While not specific necessarily to mothers as a general category, mothers, like all people, have differing access needs. Drawing upon principles of universal design for learning (UDL), which hold that there is no "normal" way to engage with learning materials so that materials should present multiple means of engagement (Hall et al., 2012), numerous scholars have increasingly pointed to the need to make digital materials more inclusive given their reliance on visuals (e.g., De Marsico et al., 2006; Rodriguez-Ascaso et al., 2018). There are simple design considerations that can be used to significantly increase the accessibility of some online content. For example, for text-based content, attention to font type and size, colour contrast, and alt-text in the case of images is important for people with visual impairments (Association of Registered Graphic Designers, 2019). More technical designs require attention to system requirements such that users can use a wide variety of devices to access the intervention, and this becomes especially true if interventions are meant for areas that may lack affordable access to broadband (Garcia & Lee, 2020), such as remote and rural communities.

As for cultural relevance, any intervention should be designed with content and framing relevant to the groups for whom it is meant (Houlden et al., 2022), with particular attention being paid to representation from people of different races and cultures so that people targeted by the intervention see themselves within it. For example, if an intervention is meant to primarily engage members of Black or Indigenous communities, representations within any intervention must speak to them and reach the networks in which they operate. In the case of our intervention

this also meant that we needed to understand the histories of both vaccine and medical intervention within those communities, given that particular representations (e.g., White male doctors) may signal distrust rather than trusted authority where histories of racist medical abuse have occurred, as has been the case in many racialized communities (Nuriddin, Mooney & White, 2020). As such, the focus on our design was not about counteracting specific health or vaccine misinformation, or aiming to create trust in authority, but rather focused on empowering users with information literacy in the context of online environments rife with vaccine misinformation.

Anti-misinformation design

There has been a growth in misinformation studies in recent years, many of which examine how and why misinformation spreads, as well as how best to intervene. For instance, some recommendations put forward have been fact-checking programs (Nieminen & Rapeli, 2019), information literacy development (Hameleers, 2020), and “pre-bunking” strategies (Cook et al., 2017). A major challenge faced by anti-misinformation interventions is how to correct misinformation without inadvertently reinforcing it. For example, some researchers have shown that fact-checking and debunking misinformation can have a “backfire” or “boomerang” effect, as at times fact-checking may render the original misinformation more familiar or because it may lead to a biased interpretation of the fact-check (Lewandowsky et al., 2012). Notably, however, this concern has been lessened as more recent research has suggested that the backfire effect is relatively rare (Swire-Thompson, DeGutis & Lazer, 2020; Wood & Porter, 2019). So while the backfire effect may be less of a threat with respect to compounding the problem of misinformation, understanding the better anti-misinformation practices is key. Research into this topic also extensive, and with several guidelines being established to create effective anti-

misinformation interventions: demonstrating that facts are from trusted sources, noting scientific consensus, highlighting gaps in logic, and making the correction or intervention the memorable part of the message itself (Cook et al., 2015; Walter & Tukachinsky, 2019). As such, an important design principle that guides our work is to create interventions using these established guidelines to effectively counter misinformation and prevent inadvertently exacerbating the problem. Rather than focus on counteracting or debunking specific examples of misinformation, with changing understanding of how misinformation operates, we focused our design on information literacy. Importantly, as the field of digital misinformation studies grows rapidly, continuing being informed about research on this topic is key for designing effective instructional interventions addressing vaccine misinformation.

Emotional design

As already established, emotion is a major factor in the spread of misinformation (Weeks, 2015). While there are a variety of theories as to why this is the case, it is fairly well understood that vaccine misinformation relies on emotion to great effect both in terms of furthering its spread and in terms of its persuasiveness (Shelby & Ernst, 2013). As such, drawing on emotion marks the final design principle that we adopted, tied directly to the problem of vaccine misinformation. To draw on emotion, we relied on narrative techniques as a way to illustrate the impact of emotionally-charged online information. A substantial body of literature demonstrates the relationship between narrative and emotion, which enables audiences to rely on their own experience for understanding an issue (Moore and Green, 2020), with particular emphasis placed on creating the transportation effect in a story, which is when an individual is deeply absorbed in a story (Sestir, Moore & Green). While this is not easily achieved in a story the length required by microlearning interventions, relying on familiarity can help. For instance, there is evidence in

the literature to suggest that transportation and immersion can be facilitated through placing familiar characters in familiar settings and conflicts (i.e., telling culturally relevant stories, which is also key for equitable design) (Green & Brock, 2002).

Furthermore, many researchers note that when scientific and health information is presented in a narrative format it is more accessible, relatable, and influential than the same information presented as stated facts or data (Fagerlin et al., 2005; Ratcliff & Sun, 2020). Narrativized data (i.e., stories) can convey implicit knowledge: emotional and experiential knowledge that unconsciously becomes imprinted to everyday actions (Richter et al., 2019). This is because narratives have the power to contextualize abstract data within storylines that can be reasonably envisioned and translated into people's own lives (Shen et al., 2015). Narratives also have the ability to immerse and transport people into other worlds (Green, 2004), which has been shown to result in deep emotional connections (Escalas, 2006). By incorporating emotional design as a principle, we created a narrative to help people contextualize the abstract influence of emotions on the spread of misinformation into relatable storylines that they can apply to their own lives. By telling our narrative through realistic characters learning to interact mindfully with emotional misinformation in relatable, real-world situations, we can transport readers into our educational environment.

Translating theory into practice

The principles described above came together in our research in an education design iteratively shaped around teaching people about the relationship between emotions and misinformation, which we subsequently evaluated in Veletsianos (2022a and b). In this section, we describe the final design in detail (figure 1) to demonstrate how the principles described above are reflected in the design artifact (i.e. how we applied theory to practice). The design

itself took shape in a six-panel, one-page comic that read from top to bottom. It first introduces the relationship between misinformation and emotions (i.e., that strong emotions can drive the spread of misinformation), and that pausing before sharing or engaging with content can help slow the spread of misinformation. The content is delivered by a talking cartoon cat in the role of a narrator-educator. The brief story then tells the experience of Jenny, a Black mother, as she scrolls through her Instagram feed while her child naps. When Jenny comes across a post that suggests police will be prioritized over teachers for vaccines, she becomes very upset and wants to forward the post's information to her mother and her sister, who is a teacher. At this point, the cartoon cat jumps in with a reminder to pause and notice the feelings arising from the post. Jenny does so and decides to put her tablet down and read a book instead.

JENNY'S MISADVENTURES WITH MISINFORMATION

DID YOU KNOW THAT COVID-19 MISINFORMATION IS A SERIOUS GLOBAL CONCERN? AND THAT MISINFORMATION IS DRIVEN BY EMOTIONS LIKE FEAR & ANGER?



While her kid naps, Jenny scrolls through Instagram.

"Ooh, that's a cute picture of Sara's baby...
Wow, that's an ugly bathing suit, no thanks.
OMG, what's this?"



CLICK!

WHAT?! Teachers not a priority for vaccines? Jenny is furious. She wants to send this to her mom and her sister, who is a teacher.



WAIT! IT'S TIME TO PAUSE

FEAR AND ANGER DRIVE MISINFORMATION.
IF YOU NOTICE THOSE FEELINGS WHEN SEEING SOMETHING ONLINE, TAKE A SECOND BEFORE REACTING.



Instead of letting her anger get the best of her, Jenny puts her tablet down and decides to read a book instead.

By not reacting to the post, she has helped reduce the spread of misinformation.



Figure 1: The short learning intervention in the form of an educational comic developed using the design principles.

Based on our first overarching design principle of using equitable design, the comic we created was short in order to meet the requirements of microlearning: the narrative was uncomplicated, brief, and used plain language, explaining concepts where appropriate, such as when describing the nature of misinformation. The comic was also minimal in its technical requirements for use on different devices, including mobile, and did not require any specialized applications to run. The font colour and size vary, to draw attention to various significant aspects of the topic. Equitable design is also about cultural relevance, and to make it culturally relevant to mothers we created a context for the narrative that is familiar to many Western mothers with children at home. This decision also addressed the principle of emotional design, as a familiar scenario is more likely to elicit an emotional response in a learner.

In terms of anti-misinformation design, the intervention focuses on information literacy using the techniques of highlighting and repeating the key elements connected to the learning outcomes, namely that the spread of misinformation can be driven by strong emotions, and that checking in with emotions before reacting is a useful strategy for slowing the spread of misinformation. Both ideas were repeated at the beginning and end of the comic in order to leave a lasting impression and with the aim of improving the success of the learning outcomes. We also needed to pay special attention to the fake piece of information we created for the comic. The information needed to be relevant to current events, and at the time there were ongoing conversation in the public sphere around the audiences that should be prioritized regarding access to vaccines. Our design sought to be relevant to this conversation, while seeking to reduce the risk of a learner misapprehending misinformation in the comic as true in a way that could be harmful. In other words, we felt that even in the unlikely situation in which learners

misapprehended the information presented, the topic of *prioritization* of vaccines was potentially much less harmful than, say, dealing with vaccine *effectiveness*.

Finally, emotional design was incorporated into the intervention through narrative that relied on familiarity, as noted above. While short, we strove to incorporate as many realistic details about the experience of being a mother at home with her child. What's more, we specifically chose an example of misinformation that would believably elicit a strong emotion in a mother and a sister of a teacher who would be potentially negatively impacted by delayed vaccine distribution, with the idea being that such a person would care about teachers and family.

Conclusion

Effective vaccine communication strategies and education, especially during the COVID-19 pandemic, are centrally important to public health outcomes as a variety of COVID-19 vaccines rollout around the world. Delineating design principles to guide design-based research educational efforts in real-world contexts are essential because they enable analysis and iterative evaluation and improvement. In the case of our intervention, which is meant to facilitate the mitigation and disruption of vaccine misinformation online, our initial design principles focus upon (1) microlearning, (2) equity, (3) relevance and appeal, (4) caution around misinformation content, (5) effective counter messaging, and (6) engagement at an emotional level. Future work involves the translation of these principles into a learning experience, formative evaluations in real-world contexts, and iterative design, development, and evaluation of this effort.

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