



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 have iteratively designed, developed, and evaluated a learning intervention intended for public audiences. In this paper we describe the design principles we created 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.

Keywords Narrative intervention · Microlearning · COVID-19 misinformation · Design based research · Vaccine education

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 that is difficult to navigate and readily exploitable for political and commercial ends (Graham et al., 2020). This environment 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 significant 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 learner 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

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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 (2005, 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).

This study is part of a much larger project in which we sought to identify, understand, and respond to COVID-19 misinformation. The broader project tracked COVID-19 misinformation, investigated the ways in which people engage with COVID-19 information, explored the ways in which people assess the credibility of COVID-19 related information, and designed, developed, and iteratively evaluated educational interventions to mitigate the spread of COVID-19 misinformation. In this paper, we describe design principles that we developed to guide our initial interventions, 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 on them. 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 et al., 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 is expected to alter human 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). 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 & 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. This research primarily focused on understanding the reasons that people

engage with or disengage from COVID-19 online information (Houlden et al., 2021). It also examined how people assessed credibility and found that while participants hinted towards experiencing many emotions when they encountered COVID-19 information online, they seldom expressed or acknowledged their emotions in relation to assessing the credibility of information they encountered (Hodson et al., 2021). Nevertheless, emotions seem to have had a salient impact on their information habits, particularly in the form of how they responded to information online. This finding is congruent with broader literature that highlights the relationships between emotions, design, memory, information processing, and learning (e.g., Mayer & Estrella 2014; Norman, 2004; Parrish, 2005; Plass & Kalyuga, 2019). For example, our analysis illustrated that interviewees responded negatively when discussing the possibility of changes in science that did not align with their previously held views, and that these emotions could impact how they responded to scientific information. In other words, interviewees oftentimes relied on *affect heuristics*, which is a mental construct that allows people to react quickly using their emotions rather than relevant information (Slovic et al., 2007). 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 et al., 2010). For instance, affect heuristics influence credibility assessments based on whether information connects to a good or bad memory (Finucane et al., 2000). As we continued exploring our findings in connection to the broader literature, we arrived at the realization that the relationships between emotions, information-processing, decision-making, and credibility, should not be underestimated 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 et al., 2018), while some research has shown that people experiencing negative emotions spread misinformation more often (Wang et al., 2020; Galletta Horner et al., 2021). Similar findings have been reported specifically around COVID-19 misinformation (Han et al., 2020; Rains et al., 2021). Taken together, our research, supported by this broader scholarship, indicates that instructional efforts 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 DBR 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, 2012). 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 (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 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) to educate the public about COVID-19 vaccines. 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 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 near-immediate reactions 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. We developed these principles as guides, via discussing, interrogating, and exploring the emerging findings of the broader research project as described above, informed by our understanding and interpretation of the literature, as well as by our interdisciplinary expertise. The principles focus on three areas: equitable design, anti-misinformation design, and emotional design (see Table 1).

Equitable Design

The first principle that guides our work is to create an equitable learning intervention as a means to efficiently and effectively reach a specific audience. The audience for this effort was mothers. We focused on mothers because they are potentially vulnerable to vaccine misinformation online, they are disproportionately the household health decision makers, and are commonly active online (Houlden et al., 2022). For this audience, we approached equitable 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. This is significant because researchers have noted that many people, and especially 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 min 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 to reduce the cognitive effort required

Table 1 Design principles

Principle	Definition	Implementation	Goal
Equitable design			
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 (e.g., 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, 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. Design must also include attention to representation of people from a variety of cultures, races, and education levels, for example.	Will be specific to the intervention but may include things like attention to font, colour contrast, potential for audio translation, alt text etc. Interventions should be functional on multiple devices with minimal internet connectivity and minimal systems requirements needed Diverse representation in any visuals, including race, ethnicity, disability etc.	Increase effectiveness in achieving learning outcome, equity, and accessibility
Relevance and appeal to learners	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.	Appropriate aesthetics for chosen audience which 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. 2021)	Improve engagement
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 to not be as much of a concern as initially perceived (Walter and Tukachinsky, 2019)	Increase efficiency for overall design objective (i.e., the problem of misinformation)
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			

Table 1 (continued)

Principle	Definition	Implementation	Goal
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

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 et al., 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 et al., 2020; Wood & Porter, 2019). Therefore, while the backfire effect may be less of a threat with respect to compounding the problem of misinformation, understanding better anti-misinformation practices is key. Research into this topic is extensive and offers several guidelines 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 (Han et al. 2020). While there are a variety of theories as to why this is the case, it is 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 and diverse body

of literature demonstrates the relationship between narrative and emotion (e.g., Bilandzic et al., 2020; Davies et al., 2019; Fogg, 1998; Moore & Green 2020; Morris et al., 2019). Emphasis in this literature is placed on creating the transportation effect in a story, which is when an individual is deeply absorbed in a story (Sestir et al., 2020). 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 can also immerse and transport people into other worlds (Green, 2004), which has been shown to result in deep emotional connections (Escalas, 2007). 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 interacting mindfully with emotional misinformation in relatable, real-world situations, we can transport learners into our educational environment.

Translating Theory Into Practice

The principles described above guided our design decisions. Those designs were iteratively shaped around teaching people about the relationship between emotions and misinformation and were iteratively evaluated in Veletsianos et al. (2022a and b). In this section, we describe the initial design that arose from these principles (Fig. 1) to demonstrate how the principles came to be reflected in the design artifact (i.e., how we applied theory to practice). In Table 2, we describe how specific elements in the design map to each principle. It is important to state here that the worked design presented is only one possibility amongst an endless possibility of designs that could be generated using these same guiding principles.

The design itself took shape in a six-panel, one-page comic that read from top to bottom. It first introduces the



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

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 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.

Based on our first overarching design principle of using equitable design, the comic we created was short 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 conversations 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*.

Table 2 Design principles mapped to design elements

Principle	Application
Equitable design	
Microlearning	Two learning outcomes Brief, one-page comic Comic contains no jargon and is a single shareable image
Equity	Narrative was uncomplicated Comic font size and type selected for readability Comic was a single image requiring no additional software to access Comic character was a Black mother
Relevance and appeal to learners	Narrative for comic developed in consultation with three mothers with experience using social media Hook designed by reliance on familiarity with the experience of being a mother scrolling on social media
Anti-misinformation design	
Design interventions that do not inadvertently spread misinformation	Stated misinformation was corrected in comic, and not left unaddressed
Use effective counter messaging	Comic emphasized a pro-social technique: the strategy of self-awareness of emotions as key to disrupting misinformation
Emotional design	
Develop an intervention that engages people on an emotional level	Comic used a narrative which would be familiar to mothers who use social media (i.e., framed through a familiar experience) Purposeful selection of social media post containing misinformation because it was anticipated that it would elicit fear response in character, and would be familiar to learners Cat used because cats are an integral part of Internet culture (Thibault & Marino, 2018) Cute cartoon cat selected to facilitate affective engagement (Lien & Wu, 2021)

Finally, the element of emotional design was primarily incorporated into the intervention through narrative that relied on familiarity. While short, we strove to incorporate as many realistic details about the experience of being a mother at home with her child. Further, 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. Emotional design was further incorporated through the use of a cute cartoon cat, as social media research highlights the significance of cats in Internet culture (Thibault & Marino, 2018), and recent research has shown that cute images coupled with text yield strong affective responses in viewers (Lien & Wu, 2021).

Conclusions

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. Design principles that guide our worked designs are also important to share, as we do in this paper, because doing so enables other

designers to understand the design decisions and thinking that guides our designs. One of the challenges we faced in doing this work was the dearth of design principles available in literature pertaining to misinformation and information literacy. While we were able to identify design principles used in other design-based research efforts and investigate their relevance to our own scholarship (e.g., Vesper et al., 2015), we were unable to identify design principles specifically tied to anti-misinformation designs. We hope that by sharing the principles that guided our own design, we can provide a foundation, or at least a starting point, for other designers and researchers studying ways to address misinformation. Future research in this area can expand upon these principles, interrogate them, or share alternative designs that arise from them. In the case of our specific 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. Our own future work involves the translation of these principles into a learning experience, formative evaluations in real-world contexts, and iterative design, development, and evaluations this effort.

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Declarations

Conflict of Interest The authors have no relevant financial or non-financial interests to disclose.

Ethics This research was reviewed and approved by the Royal Roads University Research Ethics Board.

Informed Consent This study did not involve human participants.

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