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K-12 trade books' representation of earthquake safety and protective actions: A content analysis

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ABSTRACT

Meaningful learning resources for earthquake safety and survival have become an increasingly important topic among geoscientists, especially educators and researchers. Various members of the public, especially K-12 (ages 5–18) learners, continue to depend on scientific trade books available at their local public and school libraries for information about earthquake concepts. To our knowledge, no research has empirically examined how trade books represent earthquake safety and survival actions. In this research, we combine an iterative qualitative inductive and deductive analysis to explore the representation of earthquake safety and protective actions in 50 trade books. We categorize these actions into time-based practices related to preparedness before an earthquake, protective actions during an earthquake, and recovery after an earthquake. These trade books emphasize preparedness by means of building earthquake-resistant structures and urban planning, and efforts toward community resilience and keeping home supplies. The recommended personal protective action during an earthquake in the United States ("Drop, Cover, and Hold On") is emphasized in the majority of the trade books, as well as other protective actions related to emotional actions and current technological automated actions such as earthquake early warning systems. Finally, the books highlight actions such as damage evaluation and support as ways to recover after an earthquake. Our findings highlight the issues between accepted earthquake safety and survival actions and the limited and/or inaccurate knowledge represented in some trade books. We provide interpretations of how presentation of limited or inaccurate information may increase confusion about appropriate protective actions. The inclusion of accepted and recommended protective actions in future trade books and the use of earthquake drills in public libraries as a supplement for trade book users may improve understanding and implementation of appropriate actions. We further demonstrate the potential of trade book contents in fostering earthquake education through library-community partnerships.

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Introduction

Earthquakes are one of the most important, as well as complex, natural hazards that humanity continues to face. In the United States alone, over 140 million people live in earthquake-prone areas (United States Geological Survey (USGS), 2015). In recent years, integrated responses to mitigate earthquake hazard and risk through technological advances such as earthquake early warning (EEW) systems and protective action literacy/education have become important to the United States. For the West Coast of the United States, the ShakeAlert® EEW system began public alerting to California in 2019 and Oregon and Washington in 2021 (McBride et al., 2022). ShakeAlert®, through its delivery partners, provides alerts *via* mobile phones, so people can take protective actions during an earthquake. The message developed by the ShakeAlert® system includes protective actions, specifically "Drop, Cover, and Hold On" (McBride et al., 2020). Since 2018, ShakeAlert® system data have been used to create applications that launch automated processes, such as slowing down trains to prevent derailment, opening firehouse doors to prevent jamming, and closing valves to safeguard water and gas lines (United States Geological Survey (USGS), 2021). EEW systems may allow people to seek protection before major earthquake shaking arrives.

Science trade books (fiction and nonfiction) are books written and published for the general market to provide scientific knowledge (in the instruction of science) (Ford, 2006). Teaching and learning at the K-12 level (ages 5–18) mostly involve constructivist approaches, i.e., learners construct their own knowledge by connecting new information to prior knowledge (Richardson, 2003). Thus, science educators are more open to the possibility of alternative teaching strategies and resources that extensively feature trade books (Armbruster, 1993; Brunner & Abd-El-Khalick, 2020; Ford, 2006; Watson & Baker, 2021). Trade books have long been

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advocated by educators and researchers for use in science education as a means of integrating science and literacy, as well as for giving kids the chance to think critically, ask questions, and develop a genuine interest in science (Ford, 2004). In fact, the National Science Teaching Association (NSTA) through their recurring articles in "Science & Children" provide several resources for teaching earthquakes through trade books (e.g., Mattox & Zeeff, 2006; Morgan, 2011).

In the United States, teachers and students usually source trade books through their local public or school libraries. Similarly, most of the public depends on K-12 school and public library trade books because they are mostly written to the grade six reading level – the recommended developmental reading assessment (DRA) level for the public (Lexile, 2023). In addition, library trade books offer avenues for equitable and inclusive learning as the books are free to all learners, irrespective of age and socioeconomic status, and also reduce other potential accessibility barriers related to learning resources such as academic journals (Goulding, 2016; Granger, 2017; Hughes, 2017; Scott, 2011). Goulding (2016) and Granger (2017) articulate that the accessibility of trade books from libraries to the housebound, residential homes, jails, and hospitals provide opportunities for lifelong learning in various community languages and diverse forms. Trade books offered by libraries also provide literacy resources to people who may not be able to access the high cost of internet and digital applications at their homes (Hughes, 2017). Unlike other free choice learning settings, such as museums and science centers where there is some form of learning guide or instruction (Sumy et al., 2022a, 2022b), trade books from libraries afford people the opportunity to construct knowledge about concepts independently.

However, to our knowledge, there are no studies that focus on science trade book representations of earthquake preparedness and safety, a situation that this study seeks to remedy. Most of the work (e.g., Ford, 2006; Francek, 2013; Kelly, 2018) that has been done in this area focuses on earthquake concepts yet does not investigate earthquake safety and protective actions.

Earthquake education in the United States

Learning expectations

In the United States, students learn about earthquakes early in their schooling in states that have adopted the Next Generation Science Standards (NGSS) (Willard, 2015; Supplementary Table 1). The understanding of earthquake and related geoscience concepts, such as rock and rock layers, are required learning objectives at the elementary school level, typically Kindergarten (age 5) to 5th grade (age 10), middle school level (6th to 8th grade for ages 11–13), and high school level (9th to 12th grade for ages 14–18) in the United States. For example, from the grade 2–8 level (ages 7–13), students are expected to use earthquake information to provide evidence that Earth events can occur quickly or slowly, describe earthquake patterns, and design and test possible mitigation solutions. This means that students are supposed to know the processes that lead to earthquake formation, where they are most likely to occur, and the Earth forces that drive this phenomenon, in order to produce these mitigation strategies. By the 12th grade, learners are supposed to use these concepts as reference for Earth events and construct ideas about how natural hazards, including earthquakes, impact humans and societies (Willard, 2015). Students use available evidence and data to describe the societal influence and potentially economic impacts of earthquake hazards on neighborhoods, local communities, and individuals.

Earthquake safety and protective practices

Earthquake safety in the United States ranges from structural (e.g., better building codes to reduce damage and protect lives and property) to personal protective actions, such as "Drop, Cover, and Hold On," and to technical or automated actions provided by earthquake early warning systems (Earthquake Country Alliance (ECA), 2021; Minson et al., 2019). Over time, advice has varied from getting into doorways, evacuation of buildings, and, more recently, drop, cover, and hold on; the history of earthquake drills is explored in McBride et al. (2019). The advice regarding standing in doorways came from an earlier earthquake from California, when the only part of a structure from an adobe house still standing was the door frame (Petal, 2009). However, there was a reconsideration after the type of structures being built changed, with many doorways no longer being built to be load bearing, and therefore were not appropriate for life safety (Shoaf et al., 1998). Further, in the review on earthquake injuries in the United States, Peek-Asa et al. (2003) determined that people were more likely to be injured during shaking if they were moving than if they were standing still. This was confirmed in various articles from earthquakes in Aotearoa New Zealand and the United States, as reviewed in McBride et al. (2022). Education in schools for disaster preparedness and earthquakes is reviewed extensively in Johnson et al. (2014). In 2008, there was a concerted effort to use the ShakeOut scenario (Jones et al., 2008) to create an earthquake drill that used "Drop, Cover, and Hold On" (Jones & Benthien, 2011). These drills initially started in the United States, but were rapidly replicated in other nations, and now include more than 50 countries (McBride et al., 2019).

Recently, the ECA (2021) updated the nationally accepted "Seven Steps to Earthquake Safety." The seven steps are further categorized into three linear safety stages including prepare, survive, and recover. The preparation stage involves safety measures to take before an earthquake and includes steps 1–4. Step 1 recommends "securing your space" by identifying hazards and providing safe spaces to keep movable items. Step 2 involves creating emergency plans, such as safe meeting places where family can temporarily stay in case houses are destroyed, and ways of communicating. Steps 3 and 4 recommend organizing disaster supplies such as food, medicine, and water, and ways to minimize financial hardships that will be incurred when an earthquake

strikes, such as keeping important documents in a safe space and getting insurance, respectively. The survival stage involves protective actions related to "Drop, Cover, and Hold On" when the earth shakes (step 5), and safety improvement through evacuation and aiding the injured (step 6). The final step (step 7 on recovery) describes actions to rebuild community, mend damage, and reconnect with others to restore daily life. The United States has advanced in earthquake safety and protection measures, but the key question that we raise here is whether these advancements are present in learning resources such as trade books.

Children's views of earthquakes

Educators' and learners' conceptions of earthquakes have received attention from science education researchers. For example, Francek (2013) identified 50 alternative conceptions related to the causes and location of earthquakes among elementary school students and teachers. A common misconception among students and teachers is that earthquakes are limited to warmer climates, that the main driver for earthquakes is heat, and that earthquakes only occur on plate boundaries (Francek, 2013; Leather, 1987). Ross and Shuell (1990) found that elementary school students define earthquakes as an eruptive process and confuse volcanic eruptions with earthquakes. Students have also related the cause of earthquakes in terms of "their religious beliefs such as God's doing or the approaching doomsday," imbalance on the earth's surface, and pressure in the soil at the core (Savasci & Uludüz, 2013). Similarly, Licona et al. (2013) show that elementary and high school students attribute the cause of earthquakes to the movement of land because of push generated by the sea or ocean, and the ground shaking from too much water.

Students have also been found to have alternative conceptions regarding protective actions during an earthquake. Students believe that taking a plane out of the area or standing in a metal doorway are critical protective actions to take during an earthquake (Ross & Shuell, 1993). While students believe that earthquake drills at school and the use of earthquake sensors can promote their safety during earthquake, Savasci and Uludüz (2013) found that about half of students did not know the precautions to take at home when an earthquake strikes. Students shared alternative conceptions such as waiting near their desks, going outside immediately, or jumping out from the windows. In summary, despite the advances in earthquake safety and protective actions, students may still hold incomplete scientific and/or alternative conceptions about actions that they can take before, during, and after an earthquake.

Science trade books in education

The effectiveness of trade books for educators and learners is well established in the extant literature. For example, Brunner and Abd-El-Khalick (2020) identified that both teachers and students gained more in-depth understanding of targeted nature of science (NOS) objectives, and those teachers addressed NOS more frequently and with greater knowledge when they had access to trade books that explicitly supported NOS instruction. Similarly, Farland (2006) demonstrated that the use of historical, nonfiction trade books in a four week intervention lesson helped students to achieve a broader understanding of who conducts science, where it is conducted, and what activities scientists engage in. It has also been found that when children's trade books are used in conjunction with elementary school (e.g., K-5) classroom science activities, learners acquire more conceptual understanding (Lai & Chan, 2020). Both Farland (2006) and Lai and Chan (2020) further share that elementary school preservice teachers (also called teacher candidates) can create and instruct integrated inquiry-based science lessons and continue to utilize them in their teaching with effective training in how to use trade books for scientific inquiry.

Trade books can also be resources for inaccurate information with most science trade books including some inaccurate, erroneous, or limited representations of scientific concepts (Ford, 2006; Watson & Baker, 2021). According to Watson and Baker (2021), around one-third (34%) of the science trade books they examined received a score below four out of five, indicating that their scientific content was insufficiently trustworthy to be recommended for purchase.

Research purpose

Despite the number of people who utilize trade books for earthquake information and the potential benefits of public libraries in earthquake education, no research has yet examined the representation of earthquake concepts related to safety and protective actions in science trade books (fiction and nonfiction) to the best of our knowledge. Delineating alternative conceptions in trade books may support design of effective resources for students' learning. In this paper, we examine a total of 50 trade books in public libraries around the United States to identify how they represent earthquake safety and protective actions. Earthquake safety and protective actions are important concepts within earthquake education and free-choice learning environments (Sumy et al., 2022a). The understanding of these concepts may support preparing for and surviving an earthquake. For example, Johnson et al. (2016) share that the explicit teaching and practice of earthquake safety and preparedness actions based on existing theories improve children's disaster management knowledge. While many protective actions have been taught over the decades around earthquakes, and some are now considered outdated or misinformed, we focus our research on how many trade books include "Drop, Cover, and Hold on," the current recommended protective action in the United States (McBride et al., 2022).

In this study, we focus primarily on personal protective actions identified in K-12 trade books available at public libraries in the United States, which have been used to teach various publics about earthquake safety over the decades. We follow a qualitative content analysis design, as described in Prasad (2008) and Ford (2006), to identify patterns in

K-12 fiction and nonfiction trade books to answer the following research questions on earthquake safety: how do trade books represent (1) preparedness actions, before an earthquake? (2) protective actions during an earthquake? and (3) recovery actions, after an earthquake?

Methods

The methodological approach we used in the study is shown in Figure 1. Input processes refer to the various strategies we used in developing our coding scheme and output processes refer to the product, i.e., coding scheme/codebook we generated from the input processes, and the application of the codebook. In the input stage, we initially sampled a total of 74 books, and reduced this to 50 trade books through our inclusion and exclusion criteria, illustrated in Table 1 and divided by age group and education level in Table 2. We then selected chapters and passages related to earthquake safety and preparedness as our unit of analysis and developed a preliminary codebook using deductive and inductive analytical approaches, as described in Prasad (2008) and Ford (2006). In the output stage, we combined both of these analytical techniques to develop the final coding scheme/codebook. In the final output stage, we applied the final codebook (Table 3) to the 50 books for analysis. We provide detailed descriptions of these processes in the sections that follow.

Context and sampling

The K-12 trade books originated from urban and suburban public libraries in the United States and specifically included fiction and nonfiction books on earthquakes, and a search of books from the National Science Teaching Association (2022) outstanding trade books on earthquake for K-12 students from 1996 to 2021. We included both fiction and nonfiction books because evidence and recommendations from NSTA suggests they are both useful for teaching science content (Royce, 2022). For example, in their trade book typology for science education, May et al. (2020) opine that the use of fictional books (both realistic and science fiction) can be useful tools in teaching scientific inquiry and the nature of science.

In the first stage of the input process, we combined purposive sampling with the review and revision of our initial sampling plan based on the findings from our initial data collection and analysis (Drisko & Maschi, 2015), to identify trade books for our analysis. Purposive sampling is the deliberate choice of samples that represent the elements in our research purpose and questions, i.e., trade books with content on earthquake safety. While purposive sampling assisted in helping us collect the best-fit samples of earthquake trade books pertinent to the study, iterative sampling assisted in fine-tuning the samples to gather data that are comprehensive to the research issue.

During purposive sampling, we focused on books that may be readily available to children at the K-12 level visiting a public library. To obtain the books, the second author searched the Fairfax County (Virginia, United States) Public Library system using terms such as "earthquake" and "earthquakes" to initially identify a suite of books for our study. We additionally sought help from colleagues who reside in metropolitan areas in the ShakeAlert® states (California, Oregon, and Washington) to help identify and collect all children's (K-12) books related to earthquakes from Multnomah (Portland, Oregon), King (metropolitan area outside of Seattle, Washington), Los Angeles (Los Angeles, California), and San Francisco (San Francisco, California) county public libraries, respectively. To select a book, authors read through the book to make sure there was a primary focus on earthquakes with a potential secondary focus on

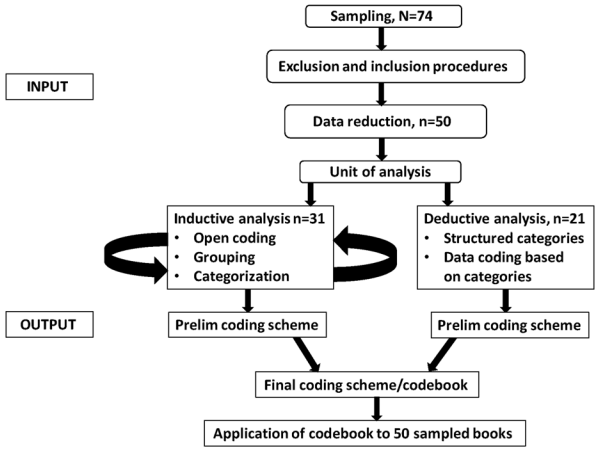

Figure 1. Analytical design employed for creating and evaluating the codebook and analyzing the books. In the input stage, we initially sampled a total of 74 books, and reduced this to 50 trade books through our *inclusion* and *exclusion* criteria (Tables 1 and 2). We then selected chapters and passages related to earthquake safety and preparedness as our *unit of analysis* and developed a preliminary coding scheme using *deductive* and *inductive* analysis. We combined both of these analytical techniques to develop the *final coding scheme/codebook*. In the final output stage, *we applied the final codebook* to each of the 50 sampled books (codebook is available in Table 3).

Table 1. Exclusion and inclusion criteria used for data reduction.

Inclusion Criteria	Exclusion Criteria
Listed as a trade book	Listed as a textbook, edited volume, magazine.
Catalogued by a library as part of their collections	Not listed as part of a library collection
Listed as a children's book (K-12)	Listed for general audience or adults, beyond the scope of K-12
Published between 1990 and 2021	Contains content on earthquakes, but is written before 1990
Content specifically related to earthquakes	Content contains concepts related to earthquakes (e.g., volcanoes, tsunami), but not on earthquakes
Written in English	Written in languages other than English

Table 2. Distribution of books across content categories in study sample. Books that target multiple grade levels are counted as such.

Book Genre	Total Number of Books ($N=50$)	Range of Publication Year	Target Grade Level			
			Pre-K	K-5	6–8	9–12
Nonfiction Scientific	28 (56%)	1990–2021	5	22	11	2
Nonfiction Historic	4 (8%)	1992–2017	0	4	2	0
Fiction Scientific	4 (8%)	2006–2013	1	2	1	1
Fiction Historical	14 (28%)	1993–2020	0	12	5	1

Table 3. Description of earthquake survival and protective action categories and examples of coded texts.

Category	Code	Example	Corresponding Step to Seven Steps to Earthquake Safety (ECA, 2021) https://www.earthquakecountry.org/sevensteps
1. Preparedness Describe safety measures to take before an earthquake to minimize impact.	1A. Structural Preparedness – architectural and constructional designs that can withstand earthquakes.	Reinforce buildings with steel, concrete, logs, and rubber pads; install latches and cabinet doors and bolt/strap tall drawers and cases.	Step 1: Secure your space. Step 4: Identify your home's potential weaknesses.
	1B. Urban and Home Planning – planning and design of cities and towns to protect social infrastructure when an earthquake occurs.	Keep gas, water, and electricity pipelines from fault lines; build where the ground is solid from shaking due to seismic waves.	Step 1: Secure your space.
	1C. Create community connections – plans to keep people in contact/together when an earthquake happens. Includes training community members about safety protocols and how to use safety equipment.	Create connections with family, friends, and neighbors; training in extinguishing fire and first aid.	Step 2: Plan to be safe.
	1D. Create household supply plans – plans to store home supplies, such as an 'emergency backpack', extra water and food.	Sturdy and easy containers to carry at least a three-day supply of water and nonperishable food; keep an extra pair of accommodations like eyeglasses, extra canes, battery operated television and batteries, wheelchair, flashlight, whistle, etc.	Step 3: Organize emergency supplies.
2. Protective Action Describe protective action measures to take during an earthquake. Human and automated actions that can be done to seek physical and emotional protection during earthquakes.	2A. Personal protective actions – physical protective actions that can be taken by people to seek protection when an earthquake strikes. Indoors e.g., house, classroom, theater Outdoors e.g., parks, gardens, streets Moving objects e.g., Wheelchair, vehicle, elevator	Drop, Cover, and Hold On; hide under a table or similar shelter; stand in a doorway; if you are already in the elevator, stay in and use telephone or intercoms to communicate that you are trapped.	Step 5: Drop, Cover, and Hold On or other recommended actions.
	2B. Automated protective actions – activities put in place to trigger physical automated response during earthquakes, e.g., automated earthquake alerts, doorways, and utilities.	ShakeAlert information to communities; automatic shutdown of gas pipelines, doorways, electricity, etc.	Not included, but mostly aligns with Step 5: Drop, Cover, and Hold On or other recommended actions.
	2C. Affective/Emotional actions – emotional capabilities for protection during earthquakes.	Do not panic or be afraid; there is nothing you can do during an earthquake (fatalism)	Not included, yet aligns with Step 5: Drop, Cover, and Hold On or other recommended actions.
3. Recovery Describe activities that can be done after an earthquake to return to normal.	3A. Damage control and evaluation – actions to help prevent further injuries/damages after an earthquake and take stock of damages and injuries.	Check yourself and take care of yourself and check on those around you; do not go exploring because there may be aftershocks.	Step 6: Improve safety.
	3B. Support – community efforts to provide emotional, medical and economic support after an earthquake.	Repair, make connections and protect against looters/thieves; make evacuation plans.	Not included, yet aligns with Step 7: Reconnect and Restore.

their attendant phenomena (e.g., tsunamis and volcanoes). Through this effort, we collected 74 trade books distributed across fiction and nonfiction categories (Figure 1). We scanned the relevant pages in each of the books and stored our data in an online, password-protected cloud service provided by the second author's institution (the Incorporated Research Institutions for Seismology (IRIS), now the EarthScope Consortium).

The first and second authors then engaged in iterative sampling by reading through the relevant pages of the 74 books to get a sense of the context and information provided. Through this process, we created an inclusion criterion (Table 1) to remove books that did not fit into the appropriate standards. For inclusion in the final sample, the book must have been cataloged by a library as part of their collections to ensure that all the books selected are those that have been accepted by United States public libraries – this check was done through WorldCat (2023) (Figure 2a). Second, the book must be listed as a children's book by the Lexile framework for reading (Lexile, 2023) to ensure that we are capturing samples purposefully written for the K-12 audience. The Lexile framework uses tools which provide information on book categories (whether fiction or nonfiction), year of publication, and the targeted grade level. We combined information from Lexile (White & Clement, 2001), WorldCat (Turner, 2010), and online marketplaces where necessary (Sadq et al., 2018) to identify age or grade level information (Figure 2b). Third, we selected sample books published between 1990 and 2021 that have specific content related to earthquakes. We focused on 1990 onward because our initial analysis during iterative sampling revealed that most of the books published before this year do not talk about protective actions or earthquake survival and are difficult to track down through public libraries (Figure 2c). Although earthquake safety and protective measures have changed in the past decade, books from the 1990s feature strongly in libraries.

Through these sampling techniques, we selected 50 books (32 nonfiction and 18 fiction) that serve as the study sample for analyses (Table 2 and Supplementary Table 2). Because

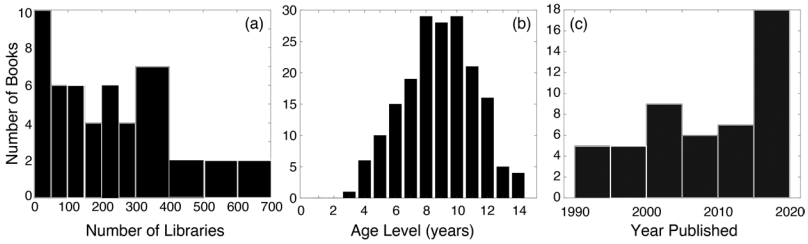

Figure 2. Graphical representation of information about the trade books analyzed. (a) The number of books with how many libraries in the United States they were found in according to WorldCat (2023). Note that the bin size is non-linear. (b) The number of books with intended age level, ranging from 3 to 14 years old (note: no data existed for older age ranges 15–18 years old). Each book was counted per year, so if the age range was 3–5, the book appears in the 3-, 4-, and 5-year-old categories. (c) The number of books with year published in five-year bins.

the books specifically contained only scientific or historical information, we further categorized them into fiction or nonfiction scientific and fiction or nonfiction historical books. We operationalize (define) scientific books as those that follow the principles of science and historical books as those that provide accounts of the past with realistic detail.

Development of coding scheme

In the final stage of our input process (Figure 1), we used a qualitative content analysis design to explore K-12 trade book representations of earthquake preparedness, protective actions, and post-earthquake recovery and to identify patterns of accurate conceptions and potential alternative conceptions that may exist. Qualitative content analysis is the systematic analysis of texts to identify their content, themes, and core ideas (e.g., Drisko & Maschi, 2015; Kyngäs, 2020; Schreier, 2012). We employ qualitative content analysis because we seek to explore both the themes and central concepts present in the books' primary material as well as the manifest content regarding earthquake safety and protective measures (Mayring, 2021). Thus, we use a combined inductive and deductive approach as the analytical framework for this study (Figure 1). Inductive analysis helped us explore in-depth both the manifest and latent meaning of the representations, while deductive analysis helped augment this exploration with extant literature (e.g., Creswell & Poth, 2018; Drisko & Maschi, 2015; Kyngäs, 2020; Miles et al., 2018). Bingham and Witkowsky (2021) opine that qualitative research that is more rigorous, systematic, and analytically sound benefits from data analysis that employs both inductive and deductive techniques.

The first step in creating a coding scheme was through inductive analysis (Figure 1). Our inductive process mainly utilized open coding (e.g., Corbin & Strauss, 2015), where we relied upon ideas that best capture the meaning of the inscriptions found in the books. We must emphasize that unlike in grounded theory, where open coding is restricted to the development of concepts and theories (Corbin & Strauss, 2015), the open coding process in our content analysis follows descriptions of categories and codes in our data. The first and second authors read 31 books (62% of the total sample) in their entirety and made memos (note: bibliographic information is available in Supplementary Table 2). We then identified and highlighted passages that explicitly mention earthquake safety and survival actions, such as preparation or planning for an earthquake, what one can do in times of an earthquake, and what to do after an earthquake has happened. Following Ford (2006), if the book does not explicitly mention earthquake survival and protective actions, we considered the book to be implicit about the actions and highlight descriptive passages relating to earthquake safety and survival.

After highlighting the passages, we entered all 31 books into NVivo 21 (Bazeley & Jackson, 2013) and engaged in inductive spiral qualitative content analysis (e.g., Drisko & Maschi, 2015; Miles et al., 2018) to develop a coding scheme. The first author read through the highlighted passages in the 31 books and created codes based on the conceptual and contextual meanings from the book. The second author also selected seven (7) books and independently generated initial codes. After developing the codes, the first and second author read through the highlighted passages to discuss the initial codes and categorized the codes to develop a preliminary coding scheme. We then applied the preliminary coding scheme to the remaining 19 books. Through this iterative process, new codes were developed and integrated into the existing coding scheme until we reached saturation, i.e., the point where information from our sample became repetitive and we were not gaining any new information (e.g., Hennink et al., 2019). We then engaged in two more rounds of discussion to create an initial codebook. The final codebook is available in Table 3.

We then engaged in deductive coding (Braun & Clarke, 2013) of 21 books by comparing our initial inductive codebook to accepted best practices of earthquake protection – the ECA (2021) "Seven Steps to Earthquake Safety." However, the categories and steps described in the conceptual framework were similar to our generated codes, so we modified our initial coding scheme by collaboratively building categories and codes. Based on our research questions and using the "Seven Steps to Earthquake Safety" as our conceptual framework, we assigned inductive codes into segments of the deductive codes to build a single coding scheme. However, three of the codes captured during inductive analysis (automated protective actions, affective actions, and support) were not explicitly stated in the "Seven Steps to Earthquake Safety" but were included in the coding scheme. We discussed and finalized the codebook after several rounds of discussions. We then

presented our coding scheme during a one-hour webinar with an international group of 13 education researchers focused on earthquake early warning education for expert feedback and communal validation on whether the coding scheme itself or the development process generated potential warnings or errors, fit into the project, and if the categorization and definitions makes sense. Once validated, we created a final coding scheme by refining the categories and codes (Table 3).

The final coding scheme (codebook) is made up of three categories of earthquake survival and protective actions and nine total codes (Table 3). The three categories are inherently time-based actions to save lives and protect property through preparedness actions before, protective actions during, and recovery actions after an earthquake (Table 3). Codes describe the meaning of specific narratives of each theme identified in the trade books. Examples demonstrate narratives that explain each code and contain both accurate and inaccurate conceptions. We determined a statement to be accurate or inaccurate (misconception) depending on the accepted recommendations described by authoritative bodies such as the USGS (n.d.) and ECA (2021).

Validity and reliability

We use the definition of intercoder validity described by Drisko and Maschi (2015) and Schreier (2012) as the extent to which our categories and codes adequately represent the concepts under study. To ensure the validity of our data, the first and second authors independently generated codes and captured both manifest and latent content in the books that describe earthquake safety and protective actions to capture both explicit and implicit information. Again, throughout the sampling of books to data analysis, we kept annotations and memos (indexation) that helped us track questions we might have and with areas that needed further clarification. This enabled discussions throughout the analysis to establish agreement on all the applied codes. Finally, we presented and shared our coding scheme in a virtual webinar with a large education group made up of qualitative and education research experts and seismologists. The feedback obtained through individual suggestions and group discussions was to make sure our coding scheme is authentic, credible, and thoroughly captures accurate conceptions, defined as a communal test of validity by Bernstein (1983).

Also, we treated reliability as the consistency of our coding scheme to yield data that are free from error (e.g., Drisko & Maschi, 2015; Mayring, 2000). We ensured that our data are reliable by engaging in intercoder agreement – if different persons assign the same text to the same category (Stemler, 2000). The first and second authors independently applied the coding scheme to the same set of six books (12% of the total books) and we calculated intercoder reliability (measured by the number of agreements divided by the total number of coded passages). We achieved an average intercoder value of 85.5% between the first and second authors. This value is higher than Miles and Huberman (1994) recommended value of 80%.

Analysis of 50 books

In the final output stage (Figure 1), the first author applied the final coding scheme (Table 3) to all 50 trade books in NVivo 21.0 (Bazeley & Jackson, 2013). We compiled codes that represented earthquake safety and protective actions, and generated interpretations that explain earthquake safety and protective actions as represented in the sampled books. In this paper, we use passage quotes from the books that represent our findings and provide numerical values of some of our qualitative information (e.g., Maxwell, 2010). All book numbers used in this paper were assigned by the first author to specific texts provided in Supplementary Table 2. The citation is provided as EB##, where EB stands for "earthquake book" followed by a number. Trade books are published for the general market, thus the association of which number to which book is kept confidential to avoid the appearance of promotion, endorsement, and/or marketing of a book that is available for purchase (e.g., Ford, 2004).

Researchers' positionality

In qualitative research, the perspective of researchers (i.e., their roles, backgrounds, and biases) has the potential to influence data generation, analysis, and interpretation (Feig, 2011). Positionality acknowledges that research on social processes cannot be done without inclusion of the perspective of the researcher, as they too are part of the social world (Holmes, 2020). The first author is a geoscience education researcher interested in how people construct knowledge and how knowledge is represented in learning resources. The second author is a seismologist with several years of experience researching earthquake protective actions. She is passionate about earthquake survival and thinks positively about protective actions during an earthquake. The third author did not participate in the data analysis but has conducted content analysis on earthquake preparedness booklets and brochures previously and is well versed in the protective actions and earthquake preparedness literature. Discussing the findings and interpretations with research associates and experts reduced our degree of subjectivity, but also was informed by insider perspectives of the researchers (all researchers are geoscience and earthquake preparedness education enthusiasts and frequent trade book users) (Dwyer & Buckle, 2009). Again, only the first and second authors had a role in data analysis and interpretation of findings. Each process taken and information collected was shared and discussed with the coauthors and research associates which ensured multiple perspectives to the analysis and interpretations.

Findings

Although the sampled books include conceptual and factual earthquake content, the books explicitly and implicitly mention safety and protective actions with varying depth of explanations, from simple mentions to detailed descriptions. We note here that in the fiction books, the safety and protective actions are not presented as scenarios that people

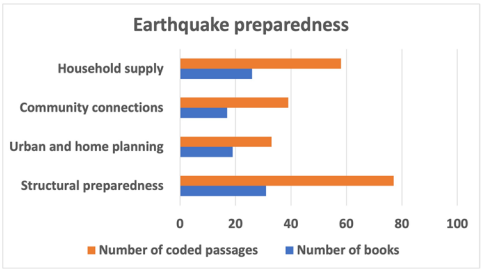

Figure 3. Breakdown of books by coded passages that mentioned earthquake preparedness.

should follow but rather peoples' experiences (stories), and only two of these books provided accurate safety and protective information as appendices.

Earthquake preparedness

We interpreted that, irrespective of the degree of explanation, safety measures or plans to take before an earthquake to minimize impact are within the structural preparedness, urban planning, creating community connections, and making plans for household supplies codes (Figure 3). Out of the 50 books, 40 mention earthquake preparedness with a range of different descriptions on how to use these preparedness strategies. From the list of 40 books that mention preparedness, 31 describe structural measures to reduce or avoid possible impacts of earthquakes. Also, 19 books mention urban planning that can direct the development of cities and towns to withstand the possible hazards associated with earthquakes. Regarding human preparedness, 26 books emphasized creating a collection of household supply items, and 17 mentioned creating community connections in anticipation of earthquakes. In the following subsections, we present the results of the explicit and implicit passage coding of earthquake preparedness.

Structural preparedness

We define structural preparedness as architectural and constructional design suggestions that would be able to help built structures (e.g., houses, bridges, and other buildings) to withstand earthquakes, consistent with Paulay and Priestley (1992) and Krüger et al. (2015). The primary intent of the trade books conveyed to readers the role of structural strengthening in earthquake preparedness. For example, they mostly cite the process of upgrading structures using steel and/or rubber reinforcements to improve performance during the shaking of the Earth.

> Buildings in Earthquake zones should be built to withstand the shaking of an earthquake. Layers of rubber and steel between the buildings and their foundations absorb shock waves. Steel beams strengthen walls and reduce the amount of shaking. Upper floors that can sway a little help to stop buildings collapsing by changing some of the earthquake's energy into movement. EB 018

In the nonfiction books, information related to structural preparedness was presented as factual and established knowledge based on scientific information. Although most of the books convey the importance of having strong structures to withstand earthquakes, many do not provide information on how to design or build strong structures. Statements such as: "concrete reinforced with steel rods will support the building" (EB 020); "earthquake resistant buildings and bridges should have extra beams and supports" (EB 027); and "buildings made of brick crumble when they shake. Builders make stronger buildings by using steel" (EB 019) were the main representations of structural preparedness associated with earthquake safety.

The fiction books were implicit in their representations and mostly presented structural preparedness as nonscientific suggestions based on extant knowledge and practices. The books mostly cited information on the role of structural preparedness in previous earthquake events and design strategies that have been used – things mostly absent from the nonfiction books. Examples included:

> He showed me how the new addition was bolted to the foundation with heavy threaded steel. He took me inside the addition and pointed out some heavy metal anchors bolted to the corners of the wooden frame. "Hold downs," he called them. Those plus the plywood walls kept the addition from shaking apart. The old part of the house had been built without hold downs or plywood. EB 012.

> In Iran, reinforced brick structures are replacing flat-roofed, mud homes, and in Tashkent in Uzbekistan concrete buildings have replaced the brick and mud structures. The 830-ft-high Transamerica building in San Francisco is a monument to the success of earthquake architecture. Its triangular framework is supported by concrete-clad steel columns that should withstand even the most severe earthquake. EB 004.

In summary, the books that mentioned structural preparedness did not contain any identified alternative conceptions relating to earthquake safety. However, we found that the books merely made mention of structural preparations without fully delving into the processes of designing and developing earthquake-resistant buildings, likely for the purposes of simplification.

Urban and home planning

Geological and topographical information is frequently included in written information for various publications about earthquakes, to explain these physical processes (McBride, 2017). Coded passages within this category provided preparedness information relating to the geologic landscape in urban planning. All 33 of the passages came from nonfiction books and mostly related to the geographical and topographical features and rock/soil composition of the land. Example statements include "building on steep hillsides or on loose soil is dangerous" (EB 020) and "hotels and other public buildings should be away from dangerous faults" (EB 038). Passages also mentioned preparedness related to the interior and exterior design of infrastructure. For example, "place beds away from windows and heavy pictures and check for objects that could fall on you during a quake" (EB 002); "gas and water pipes, and electricity cables should be well protected" (EB 035).

The few fiction books that mentioned urban planning did not contain explicit passages. For example, EB 002 implicitly states that "the great ShakeOut is tomorrow, so I am making sure the bookcase is securely attached to the wall." The passages primarily related to previous (historic) earthquakes and mostly focused on how people were able to survive as a result of urban planning for earthquakes.

> A building should not be built on weak mushy soil or on soil permeated with water… We should not build on the side of a hill unless it has been carefully checked by an engineer to avoid the house being found on weak soils and possibly tumbling down the hill in an earthquake, as happened in Alaska in 1964. EB 013.

As compared to the planning strategies recommended by the USGS and ECA, urban and home planning related alternative conceptions were rare in both the sampled fiction and nonfiction books.

Community connections

Earthquakes occur with little warning and family/community members may be in different locations. Communication methods are vital to ensure that people are connected and capable of survival if an earthquake occurs (Aldrich & Meyer, 2015). We identified two variances of community connections from the 39 passages in the 17 books with this type of information. First, the majority of passages emphasized preparedness to bring people together during and after an earthquake. While the nonfiction books (14) were explicit about these plans, the fiction books (3) mostly presented these as practices from previous earthquake events. The nonfiction book EB 028 instructs readers to "create an emergency plan to know where to reunite with family and friends in case you get separated." Similarly, in EB 035: "there should be a pre-arranged meeting spot that is chosen in the event that any family members are separated during an earthquake." EB 029 also shares with readers to

> Select two relatives or friends who do not live in your area – one to be the primary contact and one to be the alternate contact. Make sure that all family members know the contacts' phone numbers. In the event of an earthquake, everyone can contact that person so that all family members' whereabouts are known.

In the fiction book EB 008, it stated "at our family meetings, we'd sit around the dining table and review where to go when an earthquake happens." Similarly, EB 016 mentioned

> On a billboard at the edge of Golden Gate Park, people started to post messages. They wrote their names and where they were staying. That way, families and friends could find one another.

The second variance relating to community connections centered on training community members about safety protocols and how to use safety equipment. This was found only in nonfiction books, and they mostly emphasized earthquake survival drills and emergency plans, and the use of equipment such as fire extinguishers. For example, EB 034 share with readers to "rehearse with your family the emergency plan you choose to enact in the event of an earthquake." Some of the books go further to explain where these trainings can be obtained. EB 022 instructed readers to:

> Make sure that every adult member knows how to use a fire extinguisher. Training can be obtained from the local fire department. Get training in first aid. Check with your local American Red Cross chapter to see if it offers first-aid classes.

An interesting finding under this variance of creating community connections for earthquake preparedness is the emphasis on schools in the training process. About six of the books mentioned this explicitly. EB 028: "in Japan, every school holds earthquake drills." Similarly, EB 027 mentioned they had earthquake training both in school and at home:

> I thought of all the boring earthquake drills we'd had at school. Over and over we'd been told what to do. At home we made earthquake plans, too.

Within the books, we noted an emphasis is placed on community connections because they are often an important source of social connection and a sense of belonging after a catastrophic event, such as an earthquake. Because first responders may not be immediately available when an earthquake strikes, training on the use of safety equipment and drills, especially in schools, is also emphasized (e.g., Adams et al., 2022).

Household supplies

During and after an earthquake, the supply of food, water, power and access to roads may be difficult, as has been noted in previous earthquakes (Akbari et al., 2004; Daoud et al., 2016; Du Plessis et al., 2015). Hence, stocking household supplies to keep people safe and healthy is considered an important part of preparedness (Kapucu, 2008; Levac et al., 2012). Out of the 26 books that mention household supplies, 23 were nonfiction books and three were fiction books. The fiction books' representations were mostly based on evidence from past earthquakes such as "many households had prepared earthquake survival kits and kept emergency supplies in hand" EB 006.

> Father handed me a laundry basket. I collected some extra clothes and food for you EB 003.

> "people poured out of the buildings carrying bundles of clothing, cartons. One man rushed by with a birdcage" EB 045.

The majority of nonfiction book passages (17) provided explicit instructions on what items to stock and in some cases created an itemized list of things. For example, EB 041 mentioned:

> People who live in places where there have been earthquakes should always keep a supply of plastic bottles of drinking water. They should also have a supply of canned food, a flashlight, a fire extinguisher, and a battery-powered radio.

Similarly, EB 032 instructs readers to "store emergency supplies of food and other essentials." Three of the nonfiction books also described creating emergency supplies for animals and pets. For example, EB 038 mentioned

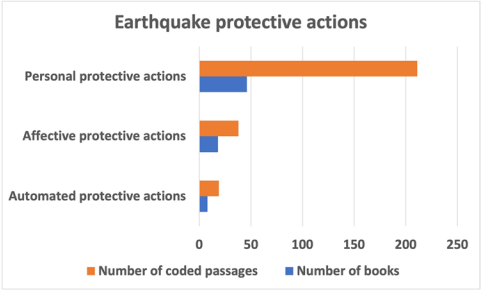

Figure 4. Breakdown of books by coded passages that mentioned earthquake protective actions.

> Have a portable carrier available to transport cats and small, or medium sized dogs. Put large dogs on a leash. Bring pet food, bottled water, and bowls for food and water. Bring litter and a litter box for cats.

However, only four of the books included tips for people with disabilities.

> People with special needs have to safeguard their home, create a disaster plan, and assemble a disaster kit also. EB 021

Similar to all the earthquake preparedness strategies mentioned above, we found that the books in this category did not contain any alternative conceptions about household preparation before an earthquake. Irrespective of the genre of the book, much emphasis is placed on basic supplies such as food, lighting, shelter, and other household items that will make life comfortable when an earthquake strikes.

Earthquake protective actions

Protective action refers to immediate lifesaving actions that can be taken during an earthquake (e.g., Champlin, 2001; McBride et al., 2022). The passages in the books represented three main protective actions (Figure 4): personal (physical) protective action(s), affective protective action(s), and automated protective action(s).

Personal protective actions

Personal protective actions refer to the physical actions that people take to seek protection when an earthquake occurs (McBride et al., 2019). Overall, we identified 211 passages in 46 books (31 nonfiction and 15 fiction) related to personal protective actions that can be taken indoors, outdoors, and/or in moving equipment (e.g., cars, elevators, etc.) when an earthquake occurs. The fiction books portrayed personal protective actions in the form of descriptive historical experiences, yet the information was not different from the nonfiction books which predominantly portrayed these actions as scientific and accepted procedures.

Out of the 211 passages related to personal protective actions, 124 described indoor protective actions. Consistent across all books, the main personal or physical protective action to take when trapped in a building or any structure during an earthquake is protection from falling objects. The most common physical action identified in 44 of the books related to the accepted standard of "Drop, Cover, and Hold On" (e.g., McBride et al., 2022). This means that during an earthquake, people are instructed to drop onto their hands and knees where they are, then cover their head and neck with one arm and hand and hold on until the shaking stops. However, most of the books made simple mentions of the procedure without detailed descriptions of how to perform each of these movements. For example, EB 017 instructs leaders to "take cover! Get under the table. Crouch next to a sturdy object." EB 022 shares with readers that if there exists no sturdy object, "sit on the floor against an inside wall away from windows, bookcases, or furniture that could fall on you. Do not go to another room." Some of the books go further to provide detailed descriptions of the "drop, cover, and hold on" procedure.

> If you are indoors, drop, cover, and hold on. Get under a sturdy piece of furniture or stay by an interior wall and protect your head and neck with your arms. Don't go outside until you are sure the earthquake is over. EB 014.

Similarly, the fiction book EB 011 described the procedure used by two siblings during the 1906 San Francisco earthquake:

> Put your hands over your head. Stay where you are. Although there was no roof to cave in on him, [name redacted] put his arms over his head as he fell. We have to get under shelter. Try to crawl with me.

Other indoor protective actions included shutting off flammable sources such as electricity and gas. EB 047 instructs readers to "…next, shut off the gas and the electricity." Similarly, EB 013 shared "those who remained in their homes tried to prepare for fire. They filled containers with water to put the fire off."

> If you are in the kitchen, make sure to move away from the stove, the refrigerator, and any object that can start a fire. EB 001

Some passages also mention avoiding moving objects such as elevators and bus/trains when in public buildings or bus/train stops. For example, EB 030 shares that "do not get in an elevator during or just after the quake."

However, we found several alternative conceptions in the representations provided by the books. These were mostly conflated with accurate representations. Most of the books contained one or more alternative conceptions about indoor protective actions. Major alternative conceptions included standing in doorways or under door frames ($n = 21$ books, nonfiction = 14, fiction = 7), and holding on to sturdy structures without cover ($n = 26$ books, nonfiction = 17, fiction = 9). Other alternative conceptions related to running into other rooms or outside ($n = 9$ books, nonfiction = 1, fiction = 8), and crawling under a table ($n = 5$, all fiction books). For example, EB 028 simply mentioned "inside, go to a safe spot in a doorway." EB 012 instructs that it is fine to flee outside if things begin to fall: "when the back wall next to her bed fell down. She scooped up her children and fled outside." Similarly, "she crawled to the open window and pulled herself up to look outside and staggered back to her bed and clung to the headboard" EB 007. It is prudent to state here that three books explicitly debunked some of

these alternative conceptions. For example, EB 018 mentioned "contrary to advice given in previous years, it is better not to stand under a doorway during a quake." EB 023 also shared "wait until shaking stops, and you can safely move outside."

Sixty-three of the passages related to personal protective actions in outdoor environments with 41 explicit mentions appearing in 23 nonfiction books and 22 implicit mentions in nine fiction books. The passages mostly describe going to open spaces such as ball fields, parking lots, and emergency assembly points that are away from buildings, power lines, and streets. EB 035 mentioned "if you are outdoors, move away from powerlines and tall buildings." EB 014 shared that getting on higher ground when at the beach, and avoiding sidewalks, overpasses, and bridges are helpful, as these structures can collapse during an earthquake:

> If you're caught outside, get to an open area. Avoid sidewalks or areas near tall buildings. Avoid bridges and overpasses because they might collapse. If you're near the ocean, try to find higher ground after the initial shaking stops. Earthquakes can trigger huge waves called tsunamis.

Similarly, EB 047 mentioned "outside our house is the best place to be (sic). Outside, where nothing can fall on you." Other passages describe dropping down and keeping away from structures and things that have the potential to fall. "If you are outside, drop to the ground. Keep away from buildings, trees, or anything that might fall" EB 024. Only one book implicitly shared the misconception that running into a building from outside is a good option. "As he felt the ground rumble again, [name redacted] knew the shaking was about to get worse. He ran back to the building (sic)" EB 004.

Trade books are crucial tools for K-12 learners to use as they study how to prepare and protect themselves during earthquakes, yet our analysis reveals that the books were generally non-inclusive for people with disabilities. Based on our findings, we found the books are largely silent on alternative strategies for people who need special accommodation. For example, out of the 50 sampled books, less than 10% contained information for people with disabilities. Notably, lack of support and information is consistent with experiences for people with disabilities during earthquakes, as explored in Phibbs et al. (2014), Kelman and Stough (2015) and Adhikari et al. (2017). This information was mostly related to preparedness with no information on protective action during an earthquake. So, we ask the question: how does a disabled person drop, cover, and hold on? DCHO is the only personal protective action for earthquakes that has advice for those with disabilities, as discussed in McBride et al. (2019).

Lastly, there were 23 passages that described protective actions to take when in moving equipment (e.g., a car or elevator) during an earthquake. All passages were identified in nonfiction books, and most of the passages prescribe bringing the equipment to a halt in open space, free from objects that can fall or collapse. For example,

> If you are in a car pull over or tell the driver to pull over and stop in a safe place. Stay inside the car until the quaking is over. The car should offer some protection from falling objects. EB 039.

Affective protective actions

Earthquakes can be very dangerous physically but also cause a variety of emotional and mental responses, with reported increases of mental disorders related to damaging earthquakes; hence, providing emotional and moral support can help people cope in the face of danger (Marlowe, 2015; Mooney et al., 2021; Zuñiga & Villoria, 2020). Affective protective actions emphasize providing/having emotional capabilities for protection during earthquakes. There were 18 books and 38 passages that described emotional support as a form of protective action during an earthquake. Almost all the passages describe being calm to maintain composure and refrain from taking any actions that can endanger you or others. This consisted of simple mentions such as "stay calm" EB 028; "easy now, fellas, easy" EB 009; to detailed instructions such as:

> The most important thing to remember during an earthquake is to stay calm. Panic is one of the leading causes of injury during and after an earthquake. Panic can cause you to forget the things for which you are prepared. People who lose control may try to run away or leave a building instead of finding a safe place to drop, cover, and hold on. When adults and teenagers panic, small children are also more likely to be frightened. EB 030

Other passages also mention providing what we interpret to be comforting words:

> I wanted to comfort [name redacted] but did not know how. She exchanged stories with the others, asking opinions, listening. She seemed lighthearted, but when she mentioned her father, she burst into tears. I started to cry, too, seeing her distress. While our new friends consoled us, I counted my sorrows. We exchanged looks of relief, touching each other for reassurance as we stood. EB 015

Performing activities that may take the mind off what is happening such as playing and singing were mentioned: For example, EB 043 "when the earth shook again, I was afraid and sometimes I cried. But in my mind, I played" and

> If it is a little longer, take a deep breath and start singing your favorite song. Breathe and sing, breathe and sing until the shaking stops. It may feel like a long time, but remember no matter how long the shaking lasts, earthquakes always end. EB 001.

A major misconception identified under this category is the impression that "there is nothing or little one can do during an earthquake." Most of the books begin to mention protective actions by stating this misconception before going on to describe the actual protective actions. For example, EB 036 before getting into earthquake protective actions mentioned "in some dangerous earthquakes, there is little that people can do to protect themselves."

Automated protective actions

This refers to activities put in place to trigger an automated response during earthquakes. We identified 19 passages in eight books related to automated earthquake alerts from buildings, equipment, and mobile devices that provide people with direct forms of protection or personal protective information during an earthquake. The most significant examples included the use of sensors that help buildings get

into stable positions during vibration and automatic shutdown of flammable equipment, such as the ShakeAlert® earthquake early warning system for the West Coast of the United States. For example, EB 039 described:

> When special motion sensors show that a building is beginning to vibrate, a computer system calculates how much the weight must shift to balance the vibrations and then moves it into position.

Similarly, EB 30 mentioned "expect fire alarms and sprinklers to activate" and EB 038 shared:

> In some earthquake-prone areas in the United States, electricity generators automatically shut down in the event of an earthquake, and gas pipes are closed by automatic valves.

The ShakeAlert® system appeared in three nonfiction books. For example, EB 029 mentioned:

> It'll [ShakeAlert® signal] arrive at a field seismometer first. Once it does, that seismometer relays information about the wave to a central computer. It, in turn, can issue a warning that is pushed out to cell phones and other devices before the ground shaking begins.

Similarly, EB 034 shared:

> The warning may come a few seconds or half a minute before the shaking starts. The amount of time depends on how far people's homes are from the epicenter of the quake. But even a few seconds can help. It gives people time to take cover.

Earthquake recovery actions

This category describes efforts that can help people resume their daily activities and operations following an earthquake. There were two types of recovery actions described in the books: damage control and evaluation; and support (Figure 5).

Damage control and evaluation

This refers to steps taken to safeguard lives and property and to reduce secondary earthquake threats soon after an earthquake (e.g., earthquake-induced fires and hazardous material spills). There were 88 passages in 25 books (14 nonfiction and 11 fiction) that described damage control and evaluation. The most significant passages related to awareness about aftershocks soon after an earthquake. For example, EB 019 reiterates the need to be prepared for aftershocks: "wherever you are, remember there may be smaller shocks after the main quake. These aftershocks could cause more damage." Similarly, EB 024 shares the need to be vigilant around damaged objects and materials that have the potential to fall or collapse: "be careful around earthquake damage. It can be unstable. Sometimes more earthquakes can hit, too." and EB 014 describe the danger of other disasters (e.g., tsunami) setting in:

> We need you to evacuate, she says. The town isn't safe. We're at risk for aftershocks and it's likely that we'll get a tsunami within a few minutes. This is a very dangerous situation.

Other significant passages related to caring for oneself and identifying people who have been injured or checking for damages that may cause fire.

> After the earth stops shaking, the first thing you need to do is make sure that you are alright. Check yourself for cuts, bruises, and other injuries…. After taking care of yourself, check those around you. Look for injuries or other earthquake-related problems, such as someone who might be trapped under debris. EB 030

Similarly, EB 005 mentions "They looked around through the dust-filled air. They then helped her stand and asked, "are you hurt." EB 018 describes the need to check for broken electricity and gas pipelines:

> Have an adult check for broken water or gas lines. If you smell gas, first open windows and then get out of the building as quickly as possible. Call the gas company from a safe location. Using the telephone in a building with a gas leak might trigger a small spark, which would cause an explosion. Don't use any matches or turn on electrical switches until you're sure there are no leaks.

Although the majority of passages cautioned about aftershocks, some of the passages on checking out for the injured and damages encouraged the misconception that people can begin looking out for injured people and damages immediately without referring to aftershocks. For example, EB 016 mentions that "soon after, I carefully walked through the debris to look out the window and take stock of damages and injuries." However, damaging aftershocks can occur immediately following an earthquake (Hough & Jones, 1997).

Support

In terms of the support category, efforts to provide emotional, medical and economic support are emphasized by 21 books because of the short-and-long-term damaging effects of an earthquake (e.g., Becker et al., 2022; Doocy et al., 2013; Potter et al., 2015). About 90% of the 62 passages under support related to providing medical and economic support such as medication, food, and shelter. The most significant examples are "as well as medical attention, the survivors' first needs are shelter, water, and food" EB 022. This is because buildings can be damaged or destroyed (Mangalathu et al., 2020; Okada & Takai, 2000), while water can be contaminated due to utility failure (Porter et al., 2017; Toland & Wein, 2021). EB 013 describes the importance of trained support staff during this period: "the Red Cross started community kitchens. They provided hot meals for people who still had no homes."

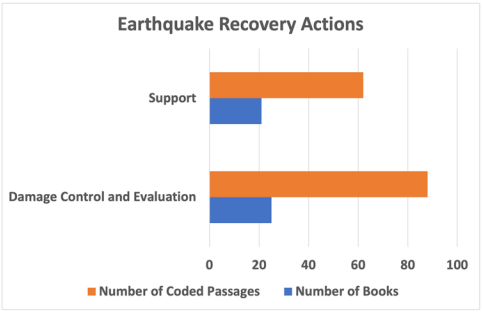

Figure 5. Breakdown of books by coded passages that mentioned earthquake recovery actions.

Other passages reported the importance of emotional support during the recovery process. EB 041 describes the benefits of having the support of families, friends, and counselors to help people heal emotionally:

> Earthquake survivors don't just have physical needs. They also have emotional needs. Disaster victims often need talk, tears, and time to heal from the shock and stress of their experience. Talking to friends, family members, and counselors can help people make sense of what has happened.

EB 034 describes the need to make emotions known to people and helping others as a form of therapy:

> Don't keep your emotions inside. Tell people how you feel and don't be afraid to ask questions. Helping others is another way of coping. And remember that things will get better.

Discussion

We have identified that trade books for K-12 students provide important suggestions for earthquake safety and protection that consider preparedness, protective actions, and recovery. However, most of the books are not explicit on the time-based efforts for preparation, protection, and recovery which may generate some level of confusion about what to do at particular times. For example, we found that it is not clear what immediate actions one should take with the knowledge that an area is earthquake-prone or during an earthquake because these ideas are conflated. This finding is in contrast with the accepted time-based, stepwise "Seven Steps to Earthquake Safety" procedures provided by the Earthquake Country Alliance (ECA, 2021). These safety procedures outline that we first prepare our families and properties *before* the next big earthquake; offer/seek protection *during* the next big earthquake and restore our quality of life *after* the immediate threat of the earthquake has passed (Han et al., 2012; Nguyen et al., 2006). We argue that time-based representation of earthquake safety and protection processes in books that follows the suggestions of the ECA facilitates explicit understanding by the public on when to use preparation strategies, protective actions, and recovery procedures.

Notably, 61% of the books we analyzed contained one or more inaccurate pieces of information on protective actions. Our findings suggest that alternative conceptions were primarily identified in fiction books, which is to be expected since most of these books described historical protective actions (e.g., what to do during the 1906 San Francisco earthquake). The most common alternative conceptions in these books were to "stand in the doorway" and "hold(ing) on without cover." Protective action strategies are those that directly reduce mortality and injuries during earthquakes and that any form of misconception related to these strategies can have serious consequences (e.g., Arlikatti et al., 2019; McBride et al., 2022). Whereas most of the information in the nonfiction books is commonly accurate knowledge, a lack of in-depth explanations may make the information ambiguous for readers to grasp. For example, just stating that people should hold on to sturdy structures without including "drop, cover, and hold on" may make the endeavor a dangerous one, as these structures may not provide the support assumed by people taking action. Similarly, in the fiction books, the authors mostly used inaccurate protective actions in the fictional earthquake scenario and it is unlikely that readers would understand the nuance of these experiences. Also, the misconception relating to there being nothing a person can do during an earthquake is an idea that can lead to fatalism. As suggested by McClure et al. (2001), communications emphasizing the uniqueness of earthquake protective actions would be more successful than the "scare" alerts, such as there is nothing one can do.

These findings are consistent with Ford (2006) and Yılmaz et al. (2020) who identified alternative conceptions about scientific concepts that are presented in K-12 trade books. People are likely to be influenced by wrong information, depending on who is providing such information and through which medium (e.g., Arlikatti et al., 2019). The majority of students obtain their scientific information through these trade books (May et al., 2020). Hence, we argue that including detailed information relating to protective actions in trade books may reduce alternative conceptions and ambiguity. Fiction books could include a note at the end of their book noting where people can get the latest protective actions advice or include it within the text the book. As argued by Arlikatti et al. (2019), people will embrace information related to earthquake safety and protection if it is simple to understand, frequently cited by numerous sources, and simple to access.

We also identified automated earthquake early warning systems, like the U.S. Geological Survey's ShakeAlert® system, which may help people prepare and plan for an earthquake, are mostly missing from these trade books. We identified three books with information on ShakeAlert®, which is understandable considering that the majority of books were written before the system started providing public alerts in California in 2019 (McBride et al., 2022). However, we argue that presenting such systems in future trade books as EEW systems are able to detect earthquakes quickly and alerts can reach some areas before strong shaking arrives (USGS, 2021) may increase correct reactions to earthquakes. We also provide implications for such systems in the next section.

We identified recommendations that foster elements of community collaborations in preparing for, surviving, and recovering from earthquakes. Having a community in times of disaster can be very useful in providing support and an important way to enhance social and emotional connections (Kenney & Phibbs, 2015; Shaffril et al., 2021). Our findings are consistent with McBride et al. (2022) and McBride et al. (2019) who share that though taking preventative measures is sometimes portrayed as an individual task, the actual learning, comprehending, and acting are communal in nature, and that through social modeling, and training opportunities that reaffirm expectations and attitudes, people learn about catastrophe preparedness and response (Adams et al., 2017). In the majority of fiction books we analyzed, as opposed to nonfiction books, social collaborations were the main source through which preparedness, protective actions, and recovery manifested before, during, and after an earthquake.

Limitations and future work

We acknowledge that the use of content analysis is a limitation to our data collection, analysis, and synthesis. In our final analysis, we concentrated on earthquake safety and survival passages or phrases in isolation, ignoring other conceptual learning elements and ideas such as what causes an earthquake, description of magnitude and intensity, and the complexities in seismological data. The lack of consideration given to these concepts can be reductive and limit our interpretations to some degree of subjectivity. Exploration of the intersectional links between the conceptualization and operationalization of earthquake preparedness, protective actions, and recovery in relation to concepts like earthquake causes, magnitude, and intensity could support the educational advancement of EEW as a human-centered system. In this study, we reduced this limitation by fully reading all the books to get a sense of context before the final analysis.

We chose these books because they were accessible to most K-12 learners and educators *via* public libraries, and also because these are largely still in print. This means some trade books may have been overlooked due to lack of accessibility. We also did not analyze trade books in other languages or those produced in other nations (except for two books available primarily in Aotearoa New Zealand). Our methods could be used to expand on this work by making it more inclusive of other experiences, including of those with different physical abilities, or protective actions advice in trade books or text resources from other countries, and online sources such as social media sites or feeds. Finally, we acknowledge limitations to this study include difficulty to ascertain the sources of information used by the authors of the books reviewed, as most of these books do not include reference lists. Research that explores how authors search and decide on appropriate sources for the safety and protective actions information that they include in books could assist in developing better guidance for authors in future.

Implications for earthquake education

Our work, combined with Sumy et al. (2022a), suggests there is much to be done in books, libraries, museums, and other free-choice learning environments, to educate learners and educators about contemporary personal protective actions around earthquakes. Our studies, when combined, paint a cautiously optimistic picture of currently available public education materials, displays, campaigns, and trade books that accurately portray DCHO and EEW systems. However, Jenkins et al. (2022) explores more inclusive and accessible public education campaigns for both topics.

Our work suggests that affective actions that tell people "what to do" before, during, and after an earthquake may be more applicable and purposeful than telling people "how to feel." We argue that learning resources which encourage calmness can be problematic. Feelings about earthquakes post shaking are varied, ranging from excitement to anxiety (Becker et al., 2012, Ceyhan & Ceyhan, 2007; Freeman et al., 2015; Kowalski & Kalayjian, 2001). Further, affective action processes mostly involve higher working memory (e.g., cognitive strategies that store and process small amounts of information at a time; Sweller, 2011), something that is difficult for a lot of people to do in the face of disasters (e.g., Dacey, 2021; Whittle et al., 2012). As emphasized by Dacey (2021), in addition to the earthquake itself, human interactions also influence behavior during earthquakes. Thus, we encourage trade book writers to provide earthquake protective action information that emphasizes direct instruction on what to do rather than how to feel.

We echo McBride et al. (2020) and encourage drills and books that focus on EEW strategies and systems as effective ways to promote protective actions. The broadening of EEW information could include preparedness and recovery information in addition to the unique information about shaking, DCHO, and the automated actions it provides in preventing train derailment and shutdown of gas and water systems. Collaboration between libraries and EEW systems could provide education focused on creating earthquake-resistant communities. For example, libraries could work together with USGS to educate communities on the role of ShakeAlert® in helping communities recognize disasters, understand what to do to avoid harm and reduce it, take steps to improve their readiness, and participate in planning for community resilience (Federal Emergency Management Agency, 2018).

As described by Mutch (2015), teachers are the immediate first responders in schools when a disaster strikes. Formal training in classroom drills that enable teachers and school resource officers (e.g., security) to be more effective in guiding students during an earthquake (considering that thousands of pupils may be in teachers' care at any given moment throughout a school day) may support more earthquake informed and prepared students and even their parents or guardians through at-home discussions. We also echo Izadkhah and Heshmati (2007) that regular earthquake simulations conducted for children to evaluate their reactions in simulated situations may reinforce effective behavior during an earthquake. Furthermore, teachers can use trade books' accounts of the history of geologic hazards as a tool to teach about the nature of science (Brunner & Abd-El-Khalick, 2020; Lai & Chan, 2020). We identified from most of the books (both fiction and nonfiction) that the 1906 San Francisco earthquake can be a rich geologic history on which to teach students about the role of geohazards within communities.

Conclusion

Our research explores how trade books depict, describe, and educate K-12 learners about earthquake preparedness, protective actions, and early earthquake warning technologies. Our analysis included an initial review of more than 70 trade books, with an in-depth analysis of 50 of these publications. We found that 31 of the 50 books contained limited knowledge or alternative conceptions about protective actions for earthquakes, indicating the potential usefulness of better and more accessible messaging for authors and publishers for correct protective actions such as "drop, cover, and hold on" (DCHO). These books are largely silent on protective actions for those with physical disabilities, leaving little

information for people who require this information. Our analysis further revealed that there is little information about the value of infrastructural strengthening, like better building codes. We also identified that most of the trade books emphasize effective communities as important in creating earthquake-resistant societies. A community that provides social and emotional support before, during, and after earthquakes can be instrumental for earthquake safety and survival. However, emotional support that emphasizes feelings rather than what to do may not be useful.

In summary, trade books can be important resources for learning about earthquake safety and protective measures, but constructing knowledge from these books may be constrained by the information they contain if that information is not time-based and contains alternative or inaccurate conceptions.

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