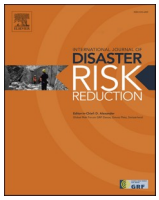
International Journal of Disaster Risk Reduction 42 (2020) 101347

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: http://www.elsevier.com/locate/ijdrr



Bridging the praxis of hazards and development with resilience: A case study of an engineering education program

Santina Contreras [a,*], Skye Niles [b], Shawhin Roudbari [c], Jill Harrison [b], Jessica Kaminsky [d]

[a] City and Regional Planning, Knowlton School of Architecture, The Ohio State University, Columbus, OH, USA
[b] Department of Sociology, University of Colorado, Boulder, CO, USA
[c] Program in Environmental Design, University of Colorado, Boulder, CO, USA
[d] Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, USA

ARTICLE INFO

Keywords:
Hazards
Development
Engineering
Resilience
Boundary work

ABSTRACT

Losses from hazard events disproportionately affect long-term development trajectories and activities of communities in the Global South. For this reason, researchers often discuss the growing intersections in hazards and development work. However, despite longstanding considerations of the interrelated nature of these fields, the integration of hazards and development in application and practice remains a challenge. This is particularly true as it relates to the organization of hazards- and development-related education and training programs. A growing number of 'engineering-for-development' or 'humanitarian engineering' programs aim to depart from the traditional disciplinary canon by providing interdisciplinary training in the engineering, development, and hazards fields. We studied one such program to explore how understandings and practices of hazards work are shaped in a development-focused engineering training program. Through in-depth interviews with program participants and observations of program events, we found that while students working in this area have a broad understanding of the linkages between hazards and development, they identify limitations to the integration of these fields in their educational training and experience in practice. Knowledge gained from students working at the boundaries of the hazards and development fields offers insight into the ongoing frictions of integrating work across these areas. Conceptualizations of 'resilience' offer individuals working at the boundaries of these fields an opportunity to make connections between hazards and development. We argue that an increased focus on connecting development and hazards work through resilience can serve as a useful tool to better train future cohorts of students working in hazards and development.

1. Introduction

There is widespread acceptance of the interrelated nature of hazard and development studies. Increasing occurrences and impacts of disaster events in recent decades have highlighted the need for greater in-depth understanding of these associations. Despite acknowledgment of the interrelated nature of these fields, development and hazards scholars and practitioners continue to be faced with the challenges of exploring root causes, applications, and impacts when undertaking integrated work of this sort [1–6]. This is particularly true when implementing these ideas of integration into the training and practice of students and professionals working at the juncture of both areas. Understanding how students are formulating ideas about the relationships between hazards and development matters because of the future role they can play in improving the success of development- and hazard-related policies and projects. Furthermore, as Andrew Collins [7] discusses in his work exploring the linkages of disaster and development studies, there is a need to extend the focus of field integration to work taking place at educational institutions.

This study explores the relationships between the hazards and development sectors through an in-depth qualitative analysis of the experience of hazards students in an engineering-for-development (EfD) program. In this study, we take an inductive approach to identify (a) how engineering students understand relationships between hazards and development work, and (b) how students bridge these concepts.

* Corresponding author. 275 West Woodruff Avenue, Columbus, OH 43210, USA.
E-mail address: contreras.78@osu.edu (S. Contreras).

https://doi.org/10.1016/j.ijdrr.2019.101347
Received 23 May 2019; Received in revised form 17 September 2019; Accepted 28 September 2019
Available online 30 September 2019

1.1. Hazards and development in research and practice

Studies in sociology, urban planning, engineering, and ecology have frequently examined the intersections between the hazards and development fields [8–13]. Examples of these intersections include development contributing to the creation, exacerbation, and unequal distribution of hazard risks; threats that hazards pose to development gains; and failure to factor in hazard risks leading to a waste of development resources [14]. These interactions tend to highlight a hazard event's ability to influence development not only because of the immediate impact on lives and livelihoods but also because of the effects on current and future development interests. As is noted by Pelling et al. [11], losses from hazard events may set back social investments in development areas by affecting efforts to reduce poverty and hunger, improve employment and income, and provide access to education, health services, housing, water, and sanitation. For these reasons and more, it is often understood that hazard events can "turn back the development clock" [15], potentially setting off backward trajectories that can last months, years, or even decades [13]. To limit hazards' threats to development, scholars and practitioners seek ways to integrate lessons, methods, and practices of both fields.

Despite well-established work exploring the interrelated nature of hazards and development, the integration of the fields in application and practice remains a challenge. Much work has been undertaken to investigate which gaps and obstacles impede the integration of the two areas [1–7]. However, the often-fuzzy linkages between hazards and development theory and practice, and associated conceptual and policy dilemmas, continue to create challenges for the integration of the two paradigms into a single framework [3]. Scholars frequently examine how the fields exist as separate areas of practice and inquiry [10], the continued gaps in the practical implementation of the fields at a large scale [7], and the lack of regular and effective interactions among policymakers and scholarly communities of practice [5]. As a result, studies of hazards and development either become conflated in problematic ways that ignore key differences in their practices and theories, or they remain separated and unable to offer key lessons across disciplinary boundaries.

1.2. Hazards and development in education and training

One area in which these continued divisions between the hazards and development fields can be seen is in the organization of hazards- and development-related education and training programs. Explorations into the education and training of future generations of *hazards* professionals continues to be of great importance, with a growing number of studies focusing on disaster and emergency management training [16–20], disaster medical training [21–23], disciplinary-specific hazards training [24–26], hazards-related service learning and community engagement training [27–29], and a focus on disaster risk and resilience in planning programs [30]. However, these hazards education studies focus minimally on development-related topics and concerns. Consequently, hazards education programs are lacking in terms of training of the histories, theories, and practices of development. As a result, emerging hazards professionals are not well trained in connecting hazards work to the critical and political processes of international development.

By contrast, studies in the *development* planning literature frequently highlight the curriculum and training of students preparing to work in international development, including a focus on development education [31–34]; international fieldwork, service learning and volunteering [35–38]; and the role of engineers in development [39–45]. Similar to the gaps in hazards education research, these development education studies have tended to place minimal focus on hazards-related topics. Thus, the integration of these fields is often lacking since the education and training is frequently occurring in isolation from one another.

These limitations in training are not surprising. Work in development and hazards continues to be undertaken by two different communities: hazard or disaster risk reduction practitioners and development planners [11]. Furthermore, the breadth of the hazards and development terrain and the range of people with an interest in it make it difficult for a single position to claim overall control of the field and work [10]. Differences in language, methods, and political relevance can contribute to intellectual divides [5]. Thus, with studies suggesting that the complexity of the disaster-development nexus could benefit from increased integration by multiple disciplines [10], individuals training at the intersections of these diverse fields can provide valuable insights into the challenges facing such integration.

1.3. Boundary work

Boundary work is a potentially useful organizing concept for understanding the themes of interest in this study. A boundary object is an analytic tool used to describe things, ideas, or objects that inhabit several intersecting social worlds while satisfying the informational requirements of each. Boundary objects are often plastic enough to adapt to the needs and constraints of the several parties employing them, yet robust enough to maintain a collective identity across sites [46]. Therefore, boundary objects are mechanisms that enable coordination between different groups [47].

We use the idea of boundary work to better understand students working at the intersections of the hazards and development fields. Studies frequently draw on the concept of boundary objects to describe how collective and individual actors with different ideas, statuses, or practices form interstitial spaces to engage one another in meaningful collaboration and exchange [48]. In addition, scholars note that holding a position in a network that bridges fields often lessens institutional embeddedness because actors are exposed to incompatibilities in understandings and have an increased awareness of alternative explanations [49]. Thus, individuals existing at the boundaries of hazards and development may hold valuable perspectives and insights based on their experiences getting training and experience at the intersections of the two fields.

1.4. Engineering for development and hazards training

Our study focusses on EfD students who hold unique positions in regards to their relationships with the engineering, development, and hazards fields. A growing number of university programs provide engineering students with training in development. These programs vary in structure and level, but they typically aim to bridge engineering education with broader training in community development, humanitarianism, international development, and service learning [50]. Despite the additional training provided to EfD students beyond traditional engineering curriculums, questions remain on the details of their development preparation, particularly as it relates to their knowledge of the broader forces that directly or indirectly affect development interventions [51]. In addition, there has been limited exploration into the involvement of EfD students in hazards-related work.

How current cohorts of engineering students frame and bound their understandings of hazards work carries particular significance for the future of the field. As designers, planners, and builders of physical infrastructure, engineers frequently have a clear stake and growing interest in this sector. In traditional engineering design, much attention is devoted to mitigating the impacts of hazardous extreme events. For example, structural engineers may work on the construction of earthquake-resistant buildings, and civil engineers often engage in flood hazard modeling and post-disaster scenario planning. This training can be interpreted as a way for engineers to stake their role in the hazards sector.

EfD programs play an essential role in providing hazards training for graduating cohorts of engineers. How students and the programs they enroll in understand the intersections between hazards and development

work can have implications for the future of the field. Hazards experts that consider their work in broader historical trajectories of development work may be more likely to draw on important critiques of development. In contrast, hazards experts that consider their work to be a humanitarian effort that is distinct from longer-term development trajectories may be more inclined to engage communities in shorter-term disaster-assistance frames of practice. Thus, how current cohorts of students' frame and bound their understandings of hazards work and its relationship to development carries particular significance for the future of both of these fields.

2. Research methods

This study investigates the challenges students face in integrating hazards and development training. To do so, it uses a case study of a development-focused engineering training program that strives to integrate training in development and hazards. Data collection involved in-depth, semi-structured, and open-ended interviews with students and observations of program courses, events, and meetings. We identified students' interpretations of key concepts relating to development and hazards, how students bridge these concepts, the forces students believe mitigate against integrating training in development and hazards fields, and the implications of those tensions for future engineering practice of hazards-related work in developing countries.

2.1. Case study

The study was conducted as a component of a project investigating university-based EfD programs. Findings presented here focus on data collected at a graduate-level EfD degree program (Masters and Ph.D.) at a large, public research institution where both Masters and Ph.D. students take classes as part of their studies. The program showcased in this article focuses specifically on the hazards work within developing contexts. We selected this case in part because of the growing interest in hazards within the program, as evidenced by newly hired hazards-focused faculty, the addition of hazards courses, and the increasing number of students working in hazards-related research and practice. While not formally linked towards any particular outside agency or accreditation board, the program content frequently references guidelines on development and hazards from major international organizations such as the World Bank, USAID, and the United Nations. The primary course content focuses on engineering in developing contexts in the Global South. Students from the program have gone on to either form or work at international development organizations after graduating, as well as have become faculty at other EfD programs. Therefore, this case study is significant because the training taking place in this program both reflects the perspectives of dominant hazards and development institutions and also has the potential to shape the future of hazards and development fields. Furthermore, as a program explicitly striving to integrate training on hazards and development practice, this study casts into sharp relief factors that will likely thwart the integration of these fields in other contexts as well. Thus, this case study provides a compelling example of the kinds of challenges that other educational programs may potentially face in attempting to integrate hazards and development work more fully.

2.2. Interviews

Our primary data source are face-to-face, open-ended, semi-structured interviews with students in the EfD program. The semi-structured nature of the interviews allowed us to explore specific themes of interest while also permitting the participants to narrate and interpret their experiences and allow for the expression of unanticipated ideas. Following guidance on the use of key informants [52], we conducted interviews with individuals occupying critical locations at the intersection of hazards, development, and engineering. Due to the interest in understanding the role of hazards training specifically in the EfD program, we used purposive and snowball sampling to recruit students identified as being *hazards students*: those with experience working on a hazards-related thesis or dissertation project, involved with EfD hazards-related internships, or enrolled in a non-required (i.e., elective) EfD hazards course. We targeted our data collection to focus on students within the EfD program because they are best situated to provide insights into the integration of the fields of hazards and development engineering. Thus, we did not interview non-EfD students in this study. Future research could explore whether and how the knowledge and experience of students who are not in an EfD program varies from those that are within the EfD programs.

We conducted 20 in-depth interviews with Masters and Ph.D. level students in the EfD program. We completed 12 of these interviews with students whose training and research focus on the relationships between development and hazards. We conducted an additional 8 interviews with students studying engineering for development generally, without a specific focus on hazards.

There were no formal programmatic differences between the students with and without a hazards focus, as all students had the same course and degree requirements. The only differences between the students were that they had chosen to receive additional hazard-related training either by taking a non-required hazards course or by participating in a hazard-related thesis, dissertation, or internship. Analytically, we used our interviews with non-hazards students and observations at general (non-hazards specific) EfD events in order to develop a broad, contextual understanding of the EfD program, while we used our interviews and observations with hazards students and hazards-specific events in order to garner an in-depth understanding of how students who are more immersed in hazards topics understand the relationship between these fields. This allowed us to gain a wide variety of students' perspectives about engineering for development programs, as well as to specifically learn about students' experiences integrating training in hazards with their training in development. While non-hazards students were able to provide insights into EfD generally, hazards students were able to speak to the intersections of the hazards and development fields. Although we did not collect full demographic data from students during the interview process, data on respondents' gender, graduate level, and program focus are shown in Table 1.

Students were invited via email to participate in the study. Interviews were conducted with students individually at locations convenient to participants. Interviews took place from March 2017 to September 2017 and ranged from 45 min to 3 h in length. Once respondents gave informed consent, interviews were audio recorded for

Table 1
Demographic and programmatic profile of participants.

	Gender	Program Level	Hazards Focus
Student 1	Woman	PhD	Hazards
Student 2	Woman	PhD	Hazards
Student 3	Man	PhD	Hazards
Student 4	Woman	PhD	Hazards
Student 5	Man	PhD	Hazards
Student 6	Man	PhD	Hazards
Student 7	Man	Masters	Hazards
Student 8	Woman	Masters	Hazards
Student 9	Man	Masters	Hazards
Student 10	Man	Masters	Hazards
Student 11	Woman	Masters	Hazards
Student 12	Woman	Masters	Hazards
Student 13	Man	Masters	Non-Hazards
Student 14	Man	PhD	Non-Hazards
Student 15	Man	Masters	Non-Hazards
Student 16	Woman	PhD	Non-Hazards
Student 17	Woman	PhD	Non-Hazards
Student 18	Woman	Masters	Non-Hazards
Student 19	Man	PhD	Non-Hazards
Student 20	Man	Masters	Non-Hazards

subsequent transcription. Detailed field notes were written following the interview. We asked students to describe how they understand hazards and development work to be related, what distinctions they see between the fields, and where they were learning about the relationships between these fields—for example, through mentorship groups, fieldwork, peer groups, and classes. We also asked contextual questions about how students developed an interest in hazards and development work, as well as their future work goals. By using the semi-structured interview format, we were able to maintain consistency of thematic inquiry across our interviews, while at the same time the flexibility of the interview structure allowed us to probe and ask follow-up questions in order to learn more about specific areas of interest as they emerged in our conversations.

2.3. Observations

We also observed EfD-related events to identify how EfD students cultivated shared understandings of what EfD work entails [53,54]. These events included student group social gatherings, student-organized conferences, student field practicum pre-and post--sessions, student-sponsored activities for faculty searches, presentations of student research and practicum work, program-wide meetings, relevant EfD courses, EfD program-sponsored lectures and seminars, and related external events promoted by the EfD program and attended by EfD students. All classroom observations were conducted with the prior consent of the course instructor. Information on observation events was obtained from university and EfD student weekly bulletins, or by invitation from EfD students, faculty, and administrative staff. Observations took place from September 2016 to March 2018 and ranged from 1 to 8 h in length. In total, we observed 49 EfD-sponsored or -promoted events, with a subset of 24 of the events being advertised as being hazards-focused, for a total of approximately 80 h of observations.

During the observations, we took detailed hand-written notes and subsequently developed them into fieldnotes that documented the ways in which hazards and development work were discussed; whether and how they were linked; what kinds of questions and debates took place regarding the topics; the sources of information used to teach students; and the amount of attention given to different issues by students, faculty, and staff. Conducting repeated observations over time allowed us to make note of particular themes and patterns that transcended different contexts, as well as instances in which they varied. Through the contemporaneous combination of interviews and observations, we were able to identify patterns consistent in interview and observation data, consider interview participants' claims in light of our observational data, ask follow-up questions during our interviews about issues of interest that emerged during our observations, and identify which issues were publicly debated (and how) and which others were confined to more private conversations. Thus, the combination of methods both generated and resolved questions and allowed for a more in-depth approach than any one method on its own would have allowed.

2.4. Data analysis

We coded all collected data to generate thematic categories related to hazards and development work. Interview transcriptions and all fieldnotes were imported into the ATLAS.ti qualitative software package (ATLAS.ti v.8). Our analytical approach involved coding for themes from the literature as well as for themes that emerged unexpectedly in the processes of data collection and analysis [55,56]. We performed a first round of coding to identify and classify the interview transcripts and fieldnotes into themes relevant to our research questions, such as definitions of and relationships between hazards and development work, engineers' roles in hazards and development work, and areas conflicts between hazards and development work. As analysis progressed, similar codes were grouped into themes to identify overarching relationships and patterns. This process was used to uncover associations experienced and defined by respondents through the language they use [57]. Throughout the analytical process, a coding dictionary was iteratively created to operationalize each of the codes. As this codebook was developed and finalized, the researchers re-coded the data set to ensure the codes were consistently applied across coders and throughout the dataset. Following Saldaña [55], our analysis was a reflective rather than a linear process, in which we continually revisited and refined our codes and themes. We also wrote analytic memos throughout the process of coding and analysis to establish and explore patterns in our data. We used this iterative analysis of the data to identify key themes in our data, including those that we present below.

3. Results and discussion

The results of the qualitative analysis revealed key themes related to student perspectives of hazards and development intersections based on their experiences training and working at the boundaries of the two fields. Each of the following themes is explored in more depth in the proceeding sections: humanitarian terminology in hazards discussions; integration of engineers in hazards and development; student perspectives of structural constraints; and resilience as a tool for hazards/development integration. Collectively, these themes demonstrate some of the limits to integrating hazards and development work, as well as suggest a pathway towards improved links between these two fields. The details shared below offer examples of discourse and framings that are emerging in pre-professional hazards training.

3.1. Humanitarian terminology in hazards discussions

Students' conversations of hazards and development work illustrated a solid understanding of the integrated nature of the two fields. However, study data highlighted interesting patterns related to the terminology used by students to describe the hazards and development fields, particularly related to framings of *humanitarian* work. When asking hazards-related questions, we used the term "hazards" in all question prompts, yet students predominantly responded using terms and ideas connected to humanitarianism. For example, when asked how they see hazards work fitting into their courses and program, one student responded, "I think they're directly related. There's a fine line, if there even is a line between humanitarian aid and development." Furthermore, when describing their work and activities, students would mention things that would frequently be considered hazards-related, such as post-disaster response, relief, and recovery activities, but would describe them under the umbrella terms of humanitarian and humanitarianism.

This is significant because, despite there being commonalities, there are important distinctions that can be made between humanitarian and hazards-related work. The use of the term humanitarianism often refers to the transnational concern of helping persons in exceptional distress [58]. While this discourse is frequently applied to the delivery of aid or assistance, in the wake of hazard events, conflicts, and development crises, scholars note that the language of humanitarianism often carries outdated notions of charity, protectionism, and neocolonial paternalism [59,60]. Work in the hazards field may include examinations of humanitarian-related activities, particularly as it relates to response and relief efforts immediately following a disaster event.

However, this is only one aspect and approach within the hazard field, which covers a much broader area of efforts. For example, as is frequently noted by hazards researchers, work in the hazards field also includes actions such as pre-disaster preparedness and mitigation, as well as post-disaster recovery planning [20,61–63]. When students frame hazards work only in terms of humanitarian relief efforts, this limits the inclusion of broader issues in the development field that relate to long-term recovery and future hazard mitigation. This issue was explained by a student who reflected on the other students by noting:

> I get a little frustrated I think sometimes when people talk about like disaster recovery and then humanitarian response as the same thing. I think there's an overlap between those two, but the mandates are much different. If you look at ethically what is the mandate of humanitarians, it's really just to provide immediate life-saving assistance. They're not concerned with these long-term political issues.

In part, this conflation of terminology may arise because most hazards-focused students that we interviewed work in humanitarian-related activities, such as post-disaster reconstruction efforts, versus longer-term recovery or mitigation work. As one student described, "my experience in hazards has kind of only been in humanitarian response."

Also, the courses and informal conversations on hazards primarily focused on humanitarian-related topics and training. For example, we observed a course on humanitarian response and disaster management. At the time of data collection, this was the first, and only hazards-related course offered within the program and was developed as an elective in response to frequent student requests for the expansion of their hazards-related curriculum and training. However, despite being the only hazards-related course offering, the course centered on humanitarian-related topics and training. Thus, the overwhelming emphasis on humanitarianism in courses, practicums, and other training tools, appeared to be contributing to student assumptions that humanitarian and hazards work are more or less indistinguishable. This framework contributes to an understanding of "hazards work" as short-term relief efforts, limiting students' engagement with how hazards work also relates to longer-term development processes.

3.2. Integration of engineers in specific phases of hazards work

When having conversations with students regarding the integration of engineers in hazards and development, students conceptualized connections between hazards and development as being stronger or weaker depending on the phase of hazards work. Despite the dominant humanitarian focus in their curriculum and training, many students felt as though development-related engineering work generally did not fit well with the activities taking place immediately following a hazard event, thus increasing the disconnect between hazard and development work. As was noted in one interview, "I think … of … how does hazards fit in with development and with [EfD] and I think there are definitely parts that maybe don't … there are different phases of time post-hazard event or post-disaster … the first one the immediate response … I think it's 48 or 72 [hours] right after. I don't think that's [EfD]."[1] Another student said, "I feel like natural hazards are almost in a different realm because there's this immediate response to them … and we are not in that space." These student's statements represent how hazards and development are conceptualized differently in terms of their temporal scale as well as temporal orientation, leading students to indicate that hazards work is outside of the scope of work of development engineers. Hazards is dominantly conceptualized as short-term response work oriented towards a past event, and development is understood as long-term planning oriented towards future goals. These different time-periods and orientations towards either the past or the future create difficulties for integrating the two fields, as their purpose and duration are understood to be distinct.

Despite feeling a lack of integration of the fields immediately following a hazard event, students tended to agree that as time progresses, there were much more opportunities for engineers to be involved in the integration of hazards and development work. One student described how "the recovery space is where those [hazards and development] start to meld together … You don't need an engineer to put up a tent city 12 h after a disaster. But certainly [you do] for recovery and making those decisions." When connecting this data back to our understandings of hazards-related work, there appear to be gaps in students understanding and training in terms of making connections between their development-related work and the various phases of hazards planning. For example, there was no direct mention by students of their role in other stages of the disaster planning cycle, such as the mitigation phase. Scholars note the important position engineers play in the mitigation of hazard impacts [64,65]. Thus, engineering students not fully understanding the critical role and potential opportunities for them in these other areas of hazards work may lead to missed opportunities for applying their skills and training in the hazards field. This finding highlights the potential need for improving how we educate engineers of the various ways they can use their engineering and development training in the hazards field. This finding highlights the potential need for improving how we educate engineers of the various ways they can use their engineering and development training in the hazards field.

3.3. Student perspectives of structural constraints

In addition, many students shared their perspectives and experiences on the structural issues they believe hinder the integration of hazards and development fields. Specifically, students noted a lack of alignment of fields when it comes to the specificity of activities, practice, and implementation on the ground. This indicates that, even as students strengthen their understanding of connections between hazards and development within their professional and educational training, they still are mindful of the barriers towards integration that continue to exist within the broader institutional context of hazards and development. This sentiment was captured by one student who explained, "I thought the two [fields] were much more aligned when I started and as I got into the work …. I realized how disconnected the two fields actually are."

Furthermore, students frequently discussed the role that logistical barriers, such as funding, play in keeping the hazards and development fields disconnected in practice. For example, students described the divisions between hazards- and development-related funding streams. Students noted that these divisions in what each field is willing to fund often create what one student described as an "empty space …. in that everyone owns it, [but at the same time] nobody does." Another student explained her thoughts on this division when she explained:

> [Organizations and governments] often fund temporary shelters, which is fine because people need it, but temporary shelters often turn into permanent shelters …. If a country wants to build concrete homes for their people instead … development streams don't want to pay for that because you're building those [temporary shelters] because it's post-disaster.

This finding is in alignment with observations made by other scholars who note that institutional separation of funding structures continues to be one of the most critical issues inhibiting the incorporation of disaster risk reduction into long-term development planning [5,6,66].

Similar to these funding issues, students also considered how timing-related problems, such as disaster events occurring for extended periods, affects field integration and effectiveness. For example, some students expressed that because short-term humanitarian initiatives such as temporary shelters often are used long beyond the originally intended time after a disaster, it regularly contributes to deepening gaps and misunderstandings between the hazards and development fields. Importantly, these gaps between the fields often have significant negative consequences for people in the Global South who are affected by a disaster, as lack of coordination between hazards and development fields can stymie each fields' effectiveness.

For instance, when we observed the hazards course, students spent much time deliberating the frequent occurrence of "protracted crises"

[1] To maintain the confidentiality of our study site, we insert the name EfD when participants refer to their home institutions.

where countries exist in states of continual and repeated crisis due to underlying vulnerabilities. Much of the discussion around risk in protracted crises centered around underlying political and economic instabilities, although climate change was also brought up in other classes throughout the semester as another factor that increased hazard risk. Students noted how, in these protracted crisis situations, the lines between hazards and development are often blurred, which frequently leads to confusion surrounding roles and responsibilities for providing assistance. One example that students discussed was that there may be conflicts between aid workers and agencies whose primary goals and resources are directed towards saving lives, and those who are interested in longer-term development goals. These disagreements can have adverse effects on the effectiveness of both hazards and development initiatives. However, one student also pointed out that resiliency planning can aid both in development and also in disaster recovery—indicating how resiliency can be the bridge that links these two fields, a finding that we explore in more detail in the subsequent section of this paper.

Additionally, students explained how factors surrounding timing and funding often work together to complicate field integration further. For instance, students debated how funding decisions surrounding putting money and resources towards immediate response may affect long-term development and underlying economic issues. An example of this was highlighted during a course conversation focused on the role of organizations and the distribution of free aid services after a disaster event. In this dialogue, students weighed concerns of providing immediate resources and assistance against the potential unintended consequences of damaging the local economy and affecting a countries ability to develop their economic capacities. For example, organizations providing humanitarian services may undermine the viability of local businesses who are undercut by the influx of free goods and services. Short-term relief may result in long-term damage to the economy, representing another potential conflict between hazards and development work. Thus, these findings indicate that even though educational programs play a significant role in shaping hazards and development work, students continue to be aware of the many logistical barriers and institutional forces that continue to limit the integration of these two fields.

3.4. Resilience as a tool for hazards/development integration

One specific way that students appeared to see connections between hazards and development was through discussions of *resilience*. Despite many students detailing the differences that continue to persist between hazards and development, and the difficulties they face in attempting to link those fields, many students noted that the concept of resilience provides a bridge between the two areas. For example, the student who stated that he felt like the first 72 h after a disaster didn't fit in the roles and responsibilities of development engineers work, noted that "building resiliency, building capacity, that sort of phase, and planning for the next hazard, I think that fits under EfD."

Other students pointed out that conversations surrounding resilience were the only ways they successfully experienced hazards/development integration. As one student described, "pretty much the only time we discussed humanitarian stuff [in the program] is when we talked about resilience." Similarly, students expressed plans to study resilience in thesis/dissertation projects because they are seen as the predominant way to connect the hazards/humanitarian and development fields. Some students went so far as feeling as though resilience created opportunities for engineers and engineers alone. As was explained by a Ph.D. student:

> We need to make sure that they [communities] are resistant and resilient to hazards because [when] a wave comes, [or] a storm comes and knocks down the wastewater, water, electrical, roads, infrastructure for a city, even if the houses are standing, the city is destroyed … If we can keep reminding ourselves about the importance of resiliency integrating into recovery—No one else is really thinking about that, right? That's our job. Not the sociologists, urban planners, geographers. That is our unique [job], that's where we can be.

Although there are potential issues with the claim of engineers being the only ones thinking about these resilience-related concerns, the point presents a critical takeaway. From the viewpoint of students training to work in this intersecting area, resilience-related efforts provide an opportunity for them to actively take part and even take on a feeling of ownership in the integration of the hazards and development fields.

As was previously reviewed, a boundary object is an analytic tool that can be useful in understanding how ideas or individuals exist within intersecting fields while satisfying the informational requirements of each [46]. Scholars have noted the use of resilience as a boundary object between the natural and social sciences [46,47,67,68]. In addition, research across a wide array of fields have established resiliency's ability to serve as a bridging concept in stimulating interdisciplinary dialogues and collaborations across areas.

The concept of resilience has become increasingly popular across a wide range of fields. This is particularly true as it relates to discourses around the management of uncertainty and risk [69] and in the development field among international development and humanitarian NGOs, multilateral and bilateral agencies, and development reports and policies [70–72]. However, despite overwhelming interest in the idea of resilience across multiple fields of research and practice, what has been less explored is its use as a training tool for teaching about relationships between hazards and development. Many have made the case that resilience should be used to bridge the fields. Findings from this study show that engineering students do indeed use the concept of resilience in this way. These findings support the potential use of resilience as a training tool for bridging the gaps in integration that continue to be faced by individuals working at the bounds of the hazards and development fields.

It is relevant to note that this study does not explore the specifics of the student's definitions of resilience. Scholars have shown that vague definitions of boundary objects – including resilience – have led to issues such as the legitimization of activities of groups with very different interests and hide conflicts connected to different meanings being prescribed by different groups [67,73]. This remains an important point and may be particularly relevant as it pertains to individuals working at the boundaries of multiple fields, as well as to avoid the previously noted issues of loose terminology surrounding hazards and humanitarian work. While this concern deserves further research, our findings nevertheless illustrate the concept's practical use as a bridging or boundary concept, in alignment with Walsh-Dilley and Wolford's [74] examination of "what resilience as a motivating discourse does" [74].

4. Conclusion

This study explored the relationships between the hazards and development sectors through an in-depth qualitative analysis of the experience of hazards students in an engineering-for-development (EfD) program. In this work, we find that while students working in this area have a broad understanding of the linkages between hazards and development, they identify continued limitations to the integration of these fields in their educational training and experience in practice. Factors such as the predominance of humanitarianism, contrasts between the immediacy of humanitarian assistance versus the emphasis in engineering on longer-term recovery and mitigation, as well as how broader structural constraints such as funding streams and timing constraints affect how students understand field integration. At the same time, we find that resilience can function as a bridging concept that helps to resolve some of these conflicts and improve integration between hazards and development fields. Past research has not explored student perspectives of these relationships; however, this is an area of key importance. Since disasters disproportionately affect people in the

Global South, understanding how professionals are developing ideas about the relationships between hazards and development matters for improving the success of both development and disaster risk reduction policies and projects.

The specific focus on the training of engineering students is critical for several reasons. As the number of disaster events taking place worldwide continues to increase, it has placed more importance in understanding how an emerging class of experts is trained to deal with these frequent events. There exists a need for integrating hazard reduction measures into all phases of the design, construction, and operation processes, as opposed to merely adding them on as an afterthought [75]. Engineers often play a significant role in achieving this goal. They are frequently involved in the various phases of a hazard event, including the mitigation and ultimate recovery of impacted communities. However, engineers can also contribute to the creation rather than the alleviation of hazardous conditions through ill-conceived development practices. An example offered by Freudenburg, Gramling, Laska, & Erikson [76] highlights efforts by engineers to build levees and canals requiring the removal of wetlands and river deltas, which upon failure may unintentionally cause increased flooding and other disaster impacts on communities. For these reasons, it is essential to understand how engineers are being trained to deal with hazard-related issues, especially as it relates to the context of the Global South. Thus, in broadening our knowledge of engineering perspectives of the hazards and development fields, we aim to make contributions to improving the work undertaken by engineers in this area that can ultimately help reduce disaster losses, including the loss of life, as well as improve development processes.

Our study establishes that one solution towards dealing with the ambiguities between hazards and development is the concept of resilience. Findings from interviews and observation data suggest that 'resilience' can help define boundaries, bridge divisions, and often serve as a boundary object for students in understanding intersections between the hazards and development worlds. Teaching about resilience in educational programs can address some of the challenges of integrating hazards and development work by expanding an understanding of hazards beyond humanitarian response phases and into longer-term development planning and hazards mitigation, as well as recovery strategies. However, despite the potential usefulness of resilience as a bridging concept, it is also necessary to be mindful of the potential issues and conflicts that may arise in the use of resilience as a boundary object. For example, scholars note that even when using common terminology, bridging terms such as resilience can work to hide the details of divergent intentions, power interests, and policy choices [66,72,77]. For this reason, with time, students will need to be pushed towards more critical understandings of resilience, in order to maintain its potential usefulness as a bridging tool. With students noting continued feelings of siloing between the hazards and development fields, conceptualizations of resilience may provide opportunities for engineers to work beyond the traditional bounds of their discipline. Therefore, as we bring more attention and emphasis to conversations surrounding resilience, we could carefully leverage resilience as a useful tool to better train new cohorts of engineers in the intersections of hazards and development.

Acknowledgments

This research was supported by funding from the National Science Foundation [Grant Number 1636349/1636383]. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The authors thank the students, faculty, and program administration participants for their involvement in the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2019.101347.

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