Resilience to Climate Challenges: Learning Site Selection with Field Investigations

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This paper presents experiential learning in a course on design with climate in an undergraduate environmental design program. This course teaches site analysis through field investigations at high-impact zones of postfire debris flows during the 2013 Colorado historic floods, combining geomorphic knowledge with vernacular experiences. Particularly, this course guides students to discuss the factors causing postfire debris flows and the human responsibilities in such natural hazards. Students in their final papers stated that before taking this class, they were not aware of the potential dangers hidden in the breathtaking scenery. They also thought the postfire debris events happened accidentally and might not happen again. This interdisciplinary course with experiential learning helps students understand the dangerous nature of postfire debris flow and its inevitability in specific landforms during heavy rainstorms. The catastrophes in high-impact zones demonstrate site selection failures. Therefore, avoiding rebuilding in high-impact areas is an effective strategy to enhance mountain community resilience to the extreme climate. The students have presented eagerness and curiosity during field observations. The areas of the field investigations include the debris catchment, the flow track, and the impact area. This first-hand knowledge helps students understand that the larger-scale considerations in site selection are significant to avoid future failures. Field investigation is an efficient way for students to learn site selection to enhance resilience to climate challenges. In undergraduate education, training students' critical thinking by going to the real world, finding problems, and making solutions, is a crucial educational approach besides teaching skills applied in a digital-virtual world.

Keywords: *Experiential learning, Field investigation, Interdisciplinary, Resilience, Postfire debris flow*

1. Introduction

The high temperatures and dry climate in the western United States have made for frequent wildfire threats [1]. While wildfires themselves can cause extensive destruction, the landscapes that they desolate are left vulnerable to additional hazards, such as postfire debris flows. Erosions in fire-scar areas effectively accelerate and amplify the debris flow process. Recently, vast fire scar zones have covered various and complex landforms. Many postfire debris flow events occur within areas that are not currently observed or mitigated by the government or scientific organizations. Evidently, many people unknowingly reside in disaster-prone zones.

Debris flows are regarded as one of the most dangerous natural hazards [2] and are often referred to by the media as "mudslides," "mudflows," or "flash floods." Debris flows begin with a dense combination of mud and stone, which increase in solidity, concentration, and size when proceeding downstream and finally develop into a fast-moving debris flow [8]. During intense and heavy rain, a debris flow can gain great power, especially when originating at higher elevations. Debris flows can reach speeds of up to 100 mph, and the initial debris walls can be up to 30 feet tall, quickly destroying homes and taking lives [4]. There can be major and minor debris flow events. Major debris flows have often been recognized and mitigated by scientists and local governments [5]. The minor debris flows typically occur within local hills and can go unnoticed. All types of debris flows have the potential to be deadly.

Debris flows following wildfires are common. According to Wells, the surface soil on a burned slope is loosely compacted and easily wet-able. This water-repellent layer is formed by burned organic molecules, which coat the soil particles and create a barrier for water to filter into the regolith. When it rains, this layer accelerates the erosion process, affecting and strengthening debris flows [11].

From September 9th - 15th, 2013, the Colorado Front Range experienced a week of heavy rain, which caused historic floods. The violent power of the floods destroyed homes and infrastructure, wiped out small towns, rerouted water channels, and took several lives. The most highly impacted areas experienced debris flows that damned water channels and caused additional flooding. The homes demolished within debris flow impact zones exemplify the site selection failure. A lack of knowledge of postfire debris flow exposes the architectural education weakness, in which scientific knowledge on natural hazards has only been introduced superficially.

As a resident living in the foothills of Boulder for thirty years, a professor of Environmental Design, and a *feng-shui* consultant, the author has experienced three evacuations from fires and the 2013 Colorado historic floods. Her community's tragedy in the 2013 historic floods inspired her research on fire and post-fire debris flow. Integrating the author's current research, this paper presents experiential learning in a course on design with climate in an undergraduate environmental design program. This course teaches site analysis through field investigations at high-impact zones of postfire debris flows during the 2013 Colorado historic floods, combining geomorphic knowledge with vernacular experiences.

With considering undergraduate student learning behaviors, the course methods include the following components: 1) Lectures and literature study of geomorphic research on debris flows and post-fire debris flows, combined with a vernacular method of *feng-shui. Feng-shui* is ancient Chinese practice used to harmonize people with their environment. 2) field investigations in the high-impact areas of the 2013 Colorado debris flows and investigated the recovery and rebuilding in the highly impacted areas. Field lectures and observations provide first-hand knowledge to examine theories. 3) Class discussions on human responsibilities to fire and postfire debris flows. 4) Final presentation with an essay to conclude their learning on site selection to adapt to climate challenges.

2. Experiential learning – with field investigations in impacted areas

High-intensity rainstorms are a known trigger for debris flows, but their spatial distribution also appears to follow a pattern. This distribution pattern has not been well studied [6]. Using *feng-shui* as a clue, this class guided students to learn landform patterns of areas prone to debris flow with evaluations of mountains, hills, water, site and orientations [16]. Based on geomorphic studies, landforms of three areas, where a debris flow initiates, develops, and ends, include the debris catchment, the debris flow track, and the debris flow fan/impact area [9]. By combining scientific knowledge with *feng-shui* criteria, this class learns the landforms of high impacted area of the 2013 debris flows.

The most effective way to learn site selection is to conduct field investigations. As a *Feng-shui* master stated, to learn *feng-shui*, people must hike for thousands of miles along with studying thousands of books [14]. Field investigations are the highlight of this course. The students have presented eagerness and curiosity during field observations. The class has investigated the high-impacted site at Chapel on the Rock, Allenspark, CO. This debris flow originated from Mt. Meeker five miles away. Mt. Meeker can be classified as a "sick dragon" with a concave basin. This first-hand knowledge enhances students' understanding of larger-scale considerations crucial in site selection to avoid natural hazards.

A narrow canyon with a steep slope or creeks can trigger debris flow [9]. Especially, a dry wash pointing straight towards a house is called by *feng-shui* a "hidden arrow," a debris flow track, which could cause vast destruction [15]. The field investigations demonstrated that the heaviest impact areas of the 2013 Colorado floods all involved attacks of a "hidden arrow" from debris flow or engulfing flood. The confluence area could have high flood impacts, particularly the area outside of a curve flow [15]. A site with even level grading could prompt flooding.

The field investigations indicate that the high-impact areas correspond to the negative *feng-shui* criteria while the surviving areas correspond to the favorable criteria. Thus, *feng-shui* can provide a clue to identify landscape patterns of areas susceptible to debris flow, emphasizing spatial characteristics and relationships among landscape elements [12]. Insight into *feng-shui* practice with the comparison of scientific knowledge helps students understand the vernacular method's values in site selections, particularly *feng-shui* analysis from mountain ranges to a home site. This large-scale consideration is crucial to avoid future failure [10]. *Feng-shui*, with its rustic terms and practical method, is easy for undergraduate students to absorb and practice.

The class visited several high-impact areas affected by the 2013 post-fire debris flows. Eight years after the hazard event, Boulder has recovered and is as beautiful as ever. The recovered environment presents the desire to rebuild homes, an effort supported by state and federal government funds. Surprisingly, several cases show that new buildings were built upon the same spots where debris flows destroyed the original buildings. This common situation inspires students to think critically. What is the best way to enhance the mountain community's resilience to climate challenges?

3. Class discussions on Human's responsibilities

Students participated with great interest in the class discussions guided by the professor. They stated that people often think fire and postfire debris flow strikes are not preventable and blame nature. They attempt to believe that the hazard experienced has never happened before and will not occur again in their lifetime. These mountain hazards are likely to occur more often with recent extreme weather patterns. Should humans take responsibility for their role in these disasters?

Fire strikes are often called "wildfires." However, over sixty percent of Colorado "wildfires" are caused by human ignition [13], particularly by campfires. Some people asserted their freedom and independence, regardless of the risks associated with hazard-prone zones. These wildfire hazards can swiftly destroy hundreds of thousands of acres of forest, taking homes and lives. Even after the initial disaster, vast landscapes are left vulnerable to the deadly threat of postfire debris flows. Some reside by lakes or at a confluence of two rivers, where there are often debris flow-prone zones. In addition, more people are moving into these susceptible, hazardous zones, which aggravates the impacts of hazards further.

Moreover, some mountain residents often lack knowledge of postfire debris flows. During the debris flows, most fatalities were residents sleeping when the disaster struck, while some were swept away when they attempted to venture outside. Some residents located within the mandatory evacuation area ignored the evacuation notice. Students realized that some people exercise their freedom yet fail to consider the dangerous hazard consequences. People should recognize human responsibilities to causing or enlarging the impacts of natural hazards and learn from their mistakes.

4. Conclusion

Mountain hazards are likely to occur more frequently with the onset of extreme weather patterns. It is more troubling that the increasing population is moving into these susceptible zones, which exacerbates the impacts of these hazards. Fire and postfire debris flows are natural processes. They have happened consistently throughout history and will continue to occur in the future. Once people move into the debris flow-prone zone, they are in danger. Considering the risk and recurrence of debris flows, paired with the expense of mitigating infrastructure, the most effective strategy for dealing with the hazard is to avoid building and rebuilding homes in areas prone to debris flow to enhance community resilience to climate challenges.

Homes destroyed in high-impact zones illustrate the failure of site selection, which demonstrates the educational weakness. Ian McHarg indicates that modern architecture and landscape architecture education follow the dogma invented by famous architects without any effort to elicit the response of inhabitants to the existing environment. Indeed, science was resolutely excluded [7]. In addition, vernacular practices providing significant experiences to design with climate are also rarely included in architectural courses. To overcome the weakness in architecture education, we should require scientific knowledge and vernacular practices in current curriculums. An interdisciplinary approach would contribute to seeking better solutions for the future of education.

Moreover, increasing field investigations would benefit teaching theory courses because students can use first-hand experience while examining a theory. Many undergraduate students love field trips as most are energetic hikers, nature lovers, and quick learners through keen observation. Experiential learning demonstrates great value in undergraduate education. Training students' critical thinking by going to the real world, finding problems, and making solutions, is a crucial educational approach beyond teaching skills applied in a digital-virtual world.

Educating undergraduate students to recognize human responsibilities to natural hazards will enhance their social responsibility. In our society, any independence is relevant to interdependence. Identifying human mistakes in causing hazard impacts would inspire students to seek solutions to reduce hazard damages in the future. Natural hazards are often beyond human control. However, disaster impacts reflect a significant design mistake in the initial site selection. Rebuilding houses within the same high-impact areas will repeat the failure because the landforms of these areas are prone to post-fire debris flows. To hope a debris flow never happens again is to wish the heavy rainstorm never comes; this is not the reality. Fisher states that we designed our way into disasters, but we can design the way out of them by understanding the nature of our errors. We cannot simply repeat these mistakes as we have done repeatedly in recent decades [3]. Facing climate challenges, we must find divergent paths towards a future that enhances the resilience of mountain communities.

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