IReNE: AN ENVIRONMENTALLY IMPACTED INFRASTRUCTURE CASE STUDY REPOSITORY FOR EDUCATION ON RESILIENT AND SUSTAINABLE PRACTICES

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Maintaining information that documents damages that natural disasters cause to infrastructure and documenting the efforts to rebuild it, is essential for future infrastructure mitigation and reconstruction actions. To address this, we have developed the Interdisciplinary Research Network Extension (IReNE) aimed to keep record and centralize data relevant to cases in Puerto Rico. IReNE has been conceptualized following the case study methodology and it has been designed to fit and scaffold the Resilient Infrastructure and Sustainability Education – Undergraduate Program (RISE-UP), following the four stages defined by the Depth of Knowledge (DOK) model and a Project Based Learning approach. This paper presents the development of IReNE and presents case study examples of its current use for supporting the RISE-UP teaching model. IReNE was designed as an open-source platform that will be timely available to researchers, academics, and practitioners. We also expect their conceptual and applied developments to be replicated in other academic contexts, and therefore contributing on documenting, systematizing, and disseminating the impact of natural events on infrastructure.

Keywords: Resiliency, Sustainability, Case study database, Natural disaster.

1 INTRODUCTION

Maintaining information that documents damages that natural disasters cause to infrastructure and documenting the efforts to rebuild it, is essential for future infrastructure mitigation and reconstruction actions. As the often-repeated aphorism by Santayana reminds us of the course of forgetting: "those who cannot remember the past are condemned to repeat it" (Santayana 1905). As Zulfadrim *et al.* (2018) points out, there is an enormous value on local wisdom, both formally documented as well as oral stories, that might be helpful to augment by providing relevant information that can help on community preparedness when facing natural disasters, establishing policies, defining procedures, and selecting technologies.

Hurricanes Irma and Maria hit both Puerto Rico in September 2017, triggering the awareness for the need of documenting the damages caused by natural disasters on infrastructure. It also made apparent how relevant is for a post-disaster situation, the need for stakeholders such as professionals, government organizations and the community to collaborate in order to ensure the resiliency and sustainability of the rebuilding of the impacted infrastructure.

To address these concerns, we initiated in 2019 the academic project entitled Resilient Infrastructure and Sustainability Education – Undergraduate Program (RISE-UP). This program aims to use real scenarios related to infrastructure, to conduct research via case study that helps students to both develop awareness about the situations in study, but also act as the grounding for the development of both in-class and field experiences aimed to develop their interdisciplinary skills for infrastructure related problem solving and design.

RISE-UP is a collaboration involving three campuses at the University of Puerto Rico. The project encompasses three ensuing broader impacts connected tightly to the preservation and understanding of the historical impact of extreme environmental stresses on the infrastructure: a) to benefit society by increasing infrastructure capacity through in-depth training engineers, surveyors, and environmental designers on resilient infrastructure; b) to work on issues related to resiliency and sustainability; and c) to create a repository of case studies that will preserve the memories/local wisdom associated the impact of the events, and make it available to conduct research and modeling to academics and other prospective users.

In this context, we have developed the Interdisciplinary Research Network Extension (IReNE) to maintain a record and an archive of data relevant to cases in Puerto Rico. IReNE has been conceptualized following the case study methodology and it has been designed to fit and scaffold the RISE-UP program, following the four stages defined by the Depth of Knowledge (DOK) model that works as learning model for the development of the RISE-UP curriculum.

2 RISE-UP AND CASE STUDIES

The University of Puerto Rico (UPR) is a system of eleven campuses each of them offering clusters of different academic disciplines. In example, the School of Architecture is housed in the UPR-Rio Piedras campus, a campus located in the San Juan metropolitan area, while the College of Engineering is housed at the UPR- Mayaguez Campus, located in the West side of the island. Additionally, a two-year associate and articulated degrees in Engineering and Construction are housed in the UPR-Ponce campus, a campus located in the South part of the island. Prior to the implementation of this initiative, the Architecture/ Engineering/ Construction (AEC) curriculum had students developing in silos, without the required interaction and learning experience of work with other infrastructure-related disciplines (Lopez del Puerto *et al.* 2019). The academic preparation of students in areas related to infrastructure is often offered in not integrated professional fields, following a scenario consistent with the one described for the UPR (Schön 1987, Martin *et al.* 2007), and thus seldomly addressing problem-solving in an interdisciplinary manner, nor emphasized in understanding the results and lessons learned of past natural disasters. To address this situation and to provide a solution, the RISE-UP program has conceived. RISE-UP is a platform that collaboratively allows Faculty from the three participating institutions to offer a curriculum that is integrated and resulted in a Minor degree. Through this initiative, students pursuing degrees in Architecture/ Engineering/ Construction (AEC) collaborate and experience learning that promotes cooperation as professionals and allows them to contribute in interdisciplinary groups who are integrated and share common goals.

The approach that we follow in RISE-UP is a combination of modeling the courses on a Project Based Learning (PBL) based on case studies and framed in the context of Norman Webb's Depth of Knowledge (DOK) model (Webb 1997). Our expectation is that by learning though their own experiences, students in the program using PBL will encounter and address real life scenarios. The exposure to these situations is reported via Case Studies, in which each case study is "an intense study of a single unit with the purpose of a larger class of (similar) units" (Gerring 2004). This method of approaching the reporting of experiences and local wisdom has been used considerably

to conduct research and for teaching in academia. As Breslin and Buchanan point out, in design "case studies have a rich history for exploring the space between the world of theory and the experience of practice" (Breslin and Buchanan 2008). To support our project-based learning strategy, we advocate for the use of evidence as a tool to support making decisions and generate knowledge. Previous case studies related to the impact of natural events to Puerto Rico´s infrastructure will be used as evidence and for teaching. As defined by Gerring, and with the pedagogical purposes' cases have been used in academia following the methods originally pioneered by Christopher Langdell in which cases are used as instances to understand situations that later students can use to understand and solve novel situations (Howard and Randazzo 2017). We consider this approach as a useful mechanism to both create knowledge and to support making decisions.

In RISE-UP, case studies are selected keeping as a goal that ultimately, the case studies will be indexed and encapsulated as experiential wisdom that students can use as lessons learned to acquire experiences and avoid pitfalls. This will contribute to the development of actions that they might be implemented in future projects that will be presented in RISE-UP. And then as part of the database and once it will be publicly available, as sources of wisdom to the wider community of practice and multiple stakeholders associated with decision making in infrastructure design and operation. With this goal in mind, students are asked to report their cases following a structure of variables coming from the environment under study and therefore preparing the content to be researched/mined in the future.

3 THE INTERDISCIPLINARY RESEARCH NETWORK EXTENSION (IReNE) AND THE DOK

Together with the interdisciplinary/collaborative development of the case studies, students in RISE-UP follow a learning model that has been structure following the Norman Webb's Depth of Knowledge (DOK) model (Webb 1997). This model conceptualizes the learning model in four levels of activities, that go from recalling and reproduction of knowledge, to the basic applications of skills and concepts, to the development of strategic thinking, and finally reaching the level in which learners can extend what has been learnt to the evaluation of scenarios of impact to their decision making.
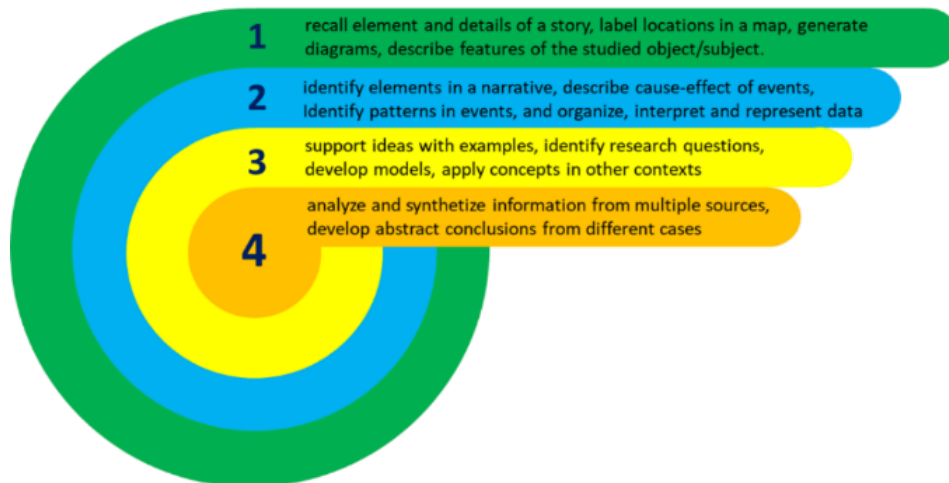

1 recall element and details of a story, label locations in a map, generate diagrams, describe features of the studied object/subject.

2 identify elements in a narrative, describe cause-effect of events, Identify patterns in events, and organize, interpret and represent data

3 support ideas with examples, identify research questions, develop models, apply concepts in other contexts

4 analyze and synthetize information from multiple sources, develop abstract conclusions from different cases

Figure 1. The four levels of Webb's DOK model (Webb 1997).

In RISE-UP we have structured the curriculum to address these levels, to progressively educate students to develop the different thinking skills associated to each one of the levels defined by Webb (see Figure 1).

We used these DOK levels also as a guideline to conceptually delineate the database we have developed as a repository for the cases, and that we have called the Interdisciplinary Research Network Extension (IReNE). This database has three major components (Figure 1) that we have called: TellSpace, SearchSpace, TraceSpace. Conceptually, each of these spaces in IReNE allows users of the repository to perform tasks that relate to Webb's model:

- TellSpace: This is the section where the information is gathered in the repository and where cases are introduced. Its use is connected to activities that are consistent with the two first levels of Webb's model.
- SearchSpace: This is the section where the data is turned into information that is structured to address specific new problematic situations. The interface allows users of the repository to access visualizations, allows filtering, searches and activities related to identifying and creating relationships among the cases reported. This fosters the creation of explanatory models and allows us to explore the commonalities among the stories and develop narratives that are based on the data that was initially submitted in TellSpace. This level relates to the third level of activities in Webb's model.
- TraceSpace: This is the level in which users of the repository can work in the formulation of new problems and get together in the resolution of those problems, using for that the tools provided also by Tell and Search spaces. This environment will provide the tools for students, professionals, and stakeholders to meet through collaborative interfaces to combine, synthesize and apply the information contained in IReNE, to illuminate new problems and situations. This space is consistent with Webb's fourth level in the model.

Currently, the TellSpace and SearchSpace of IReNE are fully operational for students and Faculty of RISE-UP to use, as can be seen in Figures 2 and 3.
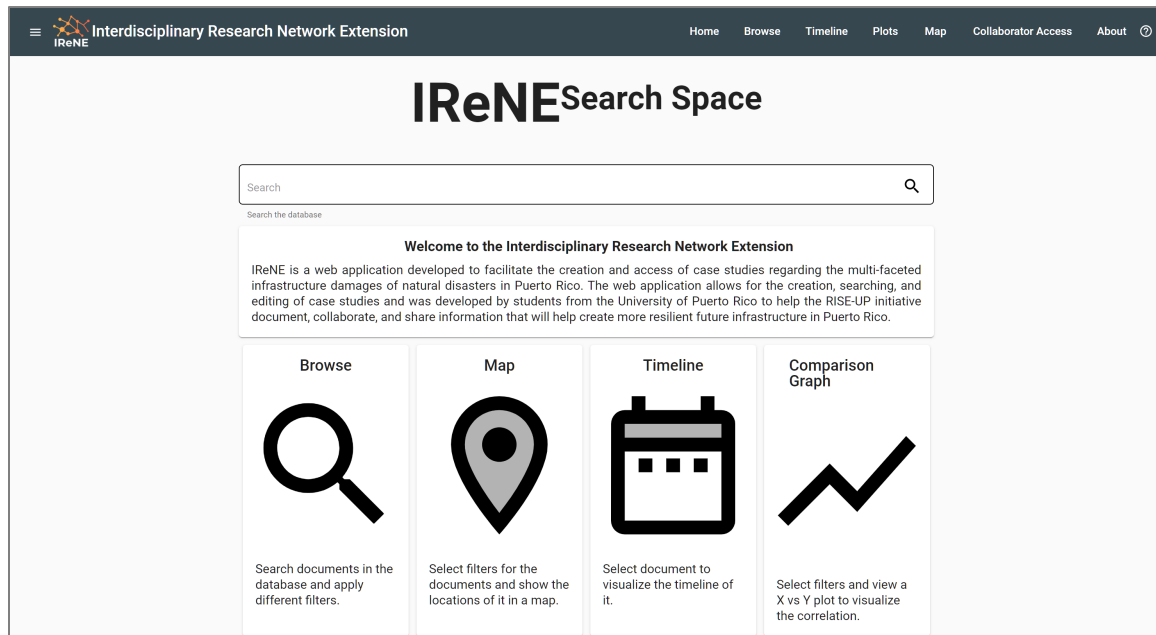

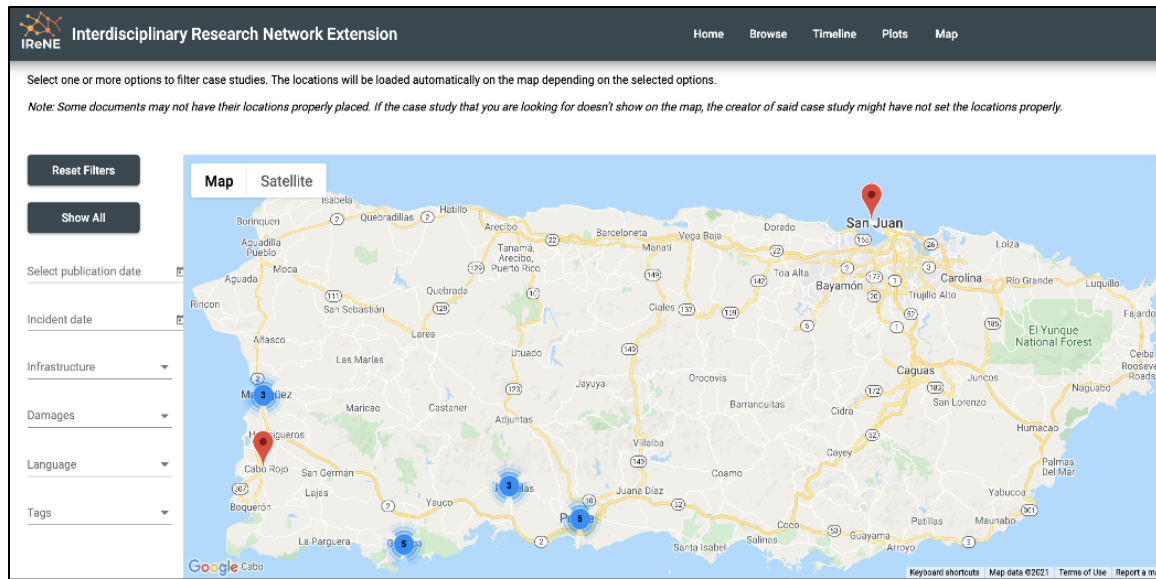Figure 2. Initial screen of IReNE's SearchSpace.

Figure 3. Above, examples of the "Map" search screen of IReNE's SearchSpace. This screen shows the case studies available based on the filters selected on the left side of the figure.

4 CONCLUSIONS

The case study repository can be used to answer hypothesis for users through the results of case studies searches in TellSpace. The outcome of the development of the repository is a platform that can be used for to conduct research and to teach. Researchers, academics and practitioners in the US and other countries who need to record and systematize information after catastrophes, can replicate the repository.

Although still in its initial phases of development, we expect IReNE to become be an open-source platform that in the future will be available to researchers, academics, and practitioners. We also expect that the platform´s conceptual and applied developments will to be replicated in other academic contexts to locations beyond Puerto Rico, which and therefore will contributing to on documenting maintaining a record, systematizing, and disseminating the impact of natural events to on the infrastructure.

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