THE POWER OF PLACE

TEACHING GEOSCIENCES THROUGH PLACE-BASED EDUCATION

A FINAL REPORT SUBMITTED TO THE DEPARTMENT OF EARTH SCIENCES, UNIVERSITY OF HAWAIʻI AT MĀNOA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN

EARTH AND PLANETARY SCIENCES

BY

TINEILL K. DUDOIT

COMMITTEE:

BARBARA BRUNO (CHAIR)

DANIELA BÖTTJER-WILSON

HENRIETTA DULAI

THE UNIVERSITY OF HAWAIʻI AT MĀNOA

DECEMBER 2020

I certify that I have read this report and that, in my opinion, it is satisfactory in scope and quality as a project for the degree of Master of Science in Earth and Planetary Sciences.

CHAIR

Barbara Bruno
Hawai‘i Institute of Geophysics and Planetology

COMMITTEE MEMBERS

Daniela Böttjer-Wilson
Center for Teaching Excellence & Department of Earth Sciences

Henrietta Dulai
Department of Earth Sciences

DEDICATION

"For I am convinced that neither death nor life, neither angels nor demons, neither the present nor the future, nor any powers, neither height nor depth, nor anything else in all creation, will be able to separate us from the love of God that is in Christ Jesus our Lord."

–Romans 8:38-39

This is dedicated to Jesus, my Lord, Savior, and friend. Thank you for all that do, every opportunity that you have given, and your constant presence in both the hills and valleys of my life. Words cannot express my gratitude for all that you have done and continue to do. To God be the glory!

ACKNOWLEDGEMENTS

I would like to acknowledge Barbara Bruno, Daniela Böttjer-Wilson, and Henrietta Dulai. Your advice, encouragement, and support were vital in the completion of this project. I would also like to thank Anne Wallace, Cherryle Heu, Lindsey Benjamin, Sherry Chou, Deb Eason, Jenny Engels, Lily Shao, and faculty within the School of Ocean and Earth Science and Technology. This work was supported by the University of Hawai‘i Sea Grant College Program and the National Science Foundation (NSF/GEO # 1565950).

ABSTRACT

Place-based education (PBE) is a teaching approach that uses local knowledge and resources to provide students and instructors with a deeper awareness of and connection to their immediate surroundings. The application of this approach has the potential to transform the way students engage with course content and develop critical thinking and practical skills, which can positively impact student achievement. The overarching goal of my research is to promote PBE practices in the School of Ocean and Earth Science and Technology (SOEST) within the University of Hawai‘i at Mānoa. By incorporating PBE into SOEST courses, I hope to contribute to existing efforts within the School that are aimed at increasing recruitment, retention, interest, and engagement of new and current SOEST students. The anticipated long-term impact of my project will be to prepare a local, diverse workforce to meet the geoscience workforce needs within the State of Hawai‘i.

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1. INTRODUCTION

1.1 Project Overview

1.1.1 Goals and Objectives

The overarching goal of this Plan B project is to promote place-based educational (PBE) practices in the School of Ocean and Earth Science and Technology (SOEST) within the University of Hawai‘i at Mānoa. By incorporating PBE into SOEST courses, I hope to contribute to existing efforts within the School that are aimed at

1. increasing recruitment of new SOEST majors from diverse backgrounds (in particular with indigenous roots);
2. increasing retention of existing SOEST majors; and
3. increasing interest and engagement of all students enrolled in SOEST classes – including majors and non-majors – in geoscience content and careers

The anticipated long-term impact of my project will be to prepare a local, diverse workforce to meet the geoscience workforce needs of Hawai‘i. In this paper, I define the word ‘geoscience’ in the broadest possible sense, to include ocean, Earth, environmental, atmospheric, and planetary geoscience.

1.2 Project Components

There are three components of this project. First, I compiled a repository of existing PBE resources that are currently being used in SOEST classes. Second, I expanded this repository to include additional place-based and/or culturally relevant resources that are not currently being used in SOEST but are relevant to geoscience. Third, I created six ESRI Story Maps to showcase some of the resources (existing and newly added), shared them with SOEST faculty, and revised them based on the formative feedback received.

1.3 University of Hawai‘i Institutional Profile

1.3.1 University of Hawai‘i System

The University of Hawai‘i (UH) is the largest and only provider of public higher education within the State of Hawai‘i. Established in 1907, the UH system has 10 campuses throughout the Hawaiian Islands, including 3 universities and 7 community colleges (University of Hawai‘i, 2020a). The cultural, geographic, and environmental setting of each educational institution provides a unique place of learning that promotes and values the principles of sustainability, preservation, and conservation. Committed to making attendance affordable and accessible, UH has one of the lowest student debt ratios in the country (University of Hawai‘i, 2018). Part of the mission and responsibility of UH is to provide a transformative educational experience that leads to a truly diverse workforce that positively impacts society.

1.3.2 Mānoa Campus

The flagship campus of the UH system, Mānoa, is a land-, sea-, and space-grant institution. Recognized as a doctorate graduating institution with very high research activity (RI) (Carnegie Classification of Institutions of Higher Education, 2020), it provides various opportunities for study and exploration. Accredited by the Senior Commission of the Western Association of Schools and Colleges (University of Hawai‘i, 2020b), Mānoa offers a total of 309 -- 240 degree and 69 certificate -- programs (Table 1.1; University of Hawai‘i, 2020c). Mānoa students come from within and beyond Hawai‘i, comprising a large and diverse campus enrollment (Table 1.2). Many different ethnicities are represented, with Caucasians representing less than a quarter of students. Sixteen percent of students identify as Native Hawaiian or Pacific Islander and 70% list Hawai‘i as their permanent home address (University of Hawai‘i, 2020d).

Table 1.1 Degree Programs and Certificates offered at the University of Hawai‘i at Mānoa (2019 – 2020)

Degree or Certificate	Number of Faculty
Certificate	69
Bachelor	98
Master	85
PhD	53
Professional	4
Total	**309**

Source: Data retrieved from the University of Hawai‘i Degrees and Programs webpage (University of Hawai‘i, 2020c)

Table 1.2 Gender and Ethnicity Demographics at the University of Hawai‘i at Mānoa (Spring 2020)

	Total	Hawaiian or Pacific Islander	Asian	Caucasian	*Other	Mixed	No Data
Men	6,995	1,119	2,930	1,565	241	1,095	45
Women	9,307	1,532	3,646	2,315	366	1,403	45
No Data	381	52	162	82	16	60	9
Total	**16,683**	**2,703**	**6,738**	**3,962**	**623**	**2,558**	**99**
Total (%)	**100 (%)**	**16 (%)**	**40 (%)**	**24 (%)**	**4 (%)**	**15 (%)**	**1 (%)**

*Source: Data retrieved from the University of Hawai‘i Institutional Research and Analysis Office (University of Hawai‘i, 2020d) *Includes Hispanics, African Americans, American Indian and Alaskan*

1.3.3 School of Ocean and Earth Science and Technology (SOEST)

UH Mānoa is home to the School of Ocean and Earth Science and Technology (SOEST). Established in 1988, SOEST is a world-class research and academic institution whose mission is "*to transform the way people live and thrive on Earth"* (University of Hawai‘i, 2020e). With an annual budget of over $100 million in extramural research funding, students and faculty conduct rigorous scientific investigations on topics relating to energy, climate, space, life, Earth, the oceans, and the atmosphere at state-of-the-art research facilities (University of Hawai‘i, 2020f, 2020g).

Facilities consist of nine research units, 16 research centers and 28 research labs. Areas of exceptional strength include the Center for Microbial Oceanography: Research & Education (C-MORE), Hawai'i Institute of Geophysics and Planetology (HIGP), Hawai'i Institute of Marine Biology (HIMB), and the Hawai'i Natural Energy Institute (HNEI) (University of Hawai‘i, 2020f).

SOEST offers 12 degrees through four academic departments: Atmospheric Sciences, Earth Sciences, Ocean and Resource Engineering, and Oceanography (University of Hawai‘i, 2020h). Atmospheric Sciences, Earth Sciences, and Oceanography offer both undergraduate and graduate degrees (Table 1.3). Ocean and Resource Engineering only offers a graduate degree program (University of Hawai‘i, 2020i). Faculty advising is required each semester and allows both undergraduate and graduate students an opportunity to generate an educational plan that is tailored to each students' academic and career goals (Saito & Chong, 2020). In addition,

collaborative research opportunities between students and faculty emphasize the application of skills, development of research experience, and communication of science, which leads to the production of a job ready geoscience workforce.

Table 1.3 Degree Programs and Student Enrollment in SOEST Departments at the University of Hawai‘i at Mānoa (Spring 2020)

	UNDERGRADUATE	GRADUATE	
Department	**Bachelor**	**Master**	**Doctorate**
Earth Sciences	BA (12), BS (29)	MS (30)	PhD (21)
Atmospheric Sciences	BS (11)	MS (17)	PhD (21)
Ocean Resource Engineering	–	MS (9)	PhD (4)
Oceanography	BS (73)	MS (17)	PhD (27)
Total	**125**	**73**	**73**

Source: Data retrieved from the University of Hawai‘i Degrees and Programs Webpage (University of Hawai‘i, 2020c)

Despite having world-class status as a research institution, SOEST has a small student enrollment. Only 271 students (125 undergraduates and 146 graduate students) are enrolled in SOEST majors, which is only 2% of the total student enrollment at UH Mānoa (Table 1.4). Undergraduate enrollment is particularly low in SOEST. Although UH Mānoa has a high percentage (72%) of undergraduates, undergraduates in SOEST make up only 46% of that school’s total enrollment.

Not only does SOEST have a low student undergraduate enrollment, but it is not as diverse as that of UH Mānoa as a whole. In particular, there are very few Native Hawaiian students enrolled in SOEST degree programs. Unlike Mānoa, which has 15% Native Hawaiian student enrollment, only 6% of SOEST students are Native Hawaiian. This suggests that more can be done to increase Native Hawaiian enrollment, perhaps through recruitment and/or retention. If SOEST is to contribute to preparing a local, diverse geoscience workforce in Hawai'i, enrollment needs to both increase and diversify. Finding a way to prioritize engagement, personal learning experiences, and critical thinking that is meaningful to students could boost motivation and persistence in the study of Earth and environmental sciences. Teaching through the power of place (place-based education) is a transdisciplinary educational strategy that can provide a solution (Vander Ark, Liebtag, McClennen, 2020).

Table 1.4 Student Enrollment Demographics for the University of Hawai'i at Mānoa and SOEST (Spring 2020)

	MĀNOA		SOEST	
	Total	**Hawaiian**	**Total**	**Hawaiian**
Undergraduate	11,957 (72%)	1,856 (74%)	125 (46%)	10 (59%)
Graduate	4,614 (28%)	643 (26%)	146 (54%)	7 (41%)
Total	**16,683 (100%)**	**2,499 (15%)**	**271 (2%)**	**17 (6%)**

Source: Data retrieved from the University of Hawai'i Institutional Research and Analysis Office (University of Hawai'i, 2020d)

2. PLACED-BASED EDUCATION

2.1 Introduction to Place-Based Education

Place-based education (PBE) is a teaching approach that promotes a connection to place through the incorporation of local knowledge and resources and serves as the foundation for curriculum development (Smith, 2016). Lessons, topics, and themes are often inquiry based, provide personal learning opportunities, and can promote contributions from a diverse group of community members (Semken et al., 2017). The framework for PBE not only provides students with a deeper awareness of and connection to their immediate surroundings, but also strives to increase relevant opportunities for both student and teacher engagement (Knapp, 2005). Studies suggest that this educational model enriches traditional academic instruction by providing personal and immersive learning experiences. The use of PBE resources and strategies can establish a mastery of knowledge and skills of the subject matter taught, thus improving student outcomes (Gibson & Puniwai, 2006, Semken & Freeman, 2008). Increased interest and participation in courses that employ the PBE method have been well documented (Tan, Barton & Lim, 2010; Sobel, 2004; Goodlad & Leonard, 2018), especially among students from indigenous communities (Cajete 1994; DeFelice 2014). In addition, the emphasis on the interconnectedness of relationships within environments can benefit local systems (Semken, 2005).

2.1.1 Place-based Education in Geoscience

Place-based education can be beneficial in any subject area; however, some subjects (for example math and physics) are more conceptual/theoretical and can be more challenging to frame in a PBE context. For example, it can be difficult to envision how a professor could teach calculus, differential equations, and/or nuclear physics through place. Long lasting and applicable knowledge should be well integrated, and any difficulty in integration can result in a disconnect with the knowledge being presented (Kastens & Manduca, 2012). On the other hand, PBE is a natural fit for geoscience, because geoscience utilizes branches of knowledge (transdisciplinary approach) that often connect Earth processes, features, and issues related to a local geographic location (Semken & Freeman, 2008). Informed knowledge of places can provide a comprehensive understanding of observations and systems within a location.

Studies on PBE in geoscience have been shown this strategy to be effective. In particular, PBE in geoscience can improve students' understanding of scientific concepts (Semken et al., 2017), increase student scientific self-efficacy (Chinn, 2006), and inspire the study of Earth and environmental sciences (Reano & Ridgway, 2015). The combination of PBE strategies and resources gives students and educators the opportunity to participate in relevant research, enhance their understanding of complex concepts, and study site-specific topics, so that they can develope a deeper understanding of key issues. Throughout the process, students gain hands-on, real-world experience by utilizing class content, context, data gathering, and problem application skills. Ultimately, these tools and skills will help equip and enable students to make contributions and decisions critical to environmental management practices, protection, and stewardship of resources within a community. In addition, PBE can recognize and promote alternative ways of understanding in geoscience, which may help retain, recruit, and inspire students, especially those with an indigenous worldview (Reano & Ridgway, 2015).

Local environmental knowledge of indigenous people is relevant to geoscience. The intergenerational transfer of indigenous knowledge obtained through observations and application are fundamental to the native perspective and can provide valuable information concerning local systems. The combination of this traditional knowledge with Western science has been well recognized and documented by educators (Cook, 2020). Examples of such PBE literature include curricula based on natural processes and cultural themes (Palmer et al., 2009;

McCoy et al., 2011), sampling and monitoring programs (Dalbotten et al., 2014), ecosystem restoration (Kaneshiro et al., 2005; Chinn, 2006; Kuwahara, 2013; Chinn, 2015), and geotechnical applications (Gibson & Puniwai, 2006). Positive student impacts reported include increased sense of place, gains in conceptual knowledge, improved engagement, and increased confidence in science and communication (Semken et al. 2017). In addition to documenting positive impacts on students, these studies showcase the exploration of natural landscapes, local environments, and communities through science and culture.

2.1.2 Place-based Education in SOEST

The prioritization of student knowledge and interaction with place makes PBE an effective teaching method in geoscience (Kuwahara, 2013). However, to gauge its significance and effectiveness in SOEST, an inquiry was necessary. Starting with questions such as: Do students and faculty value PBE resources and practices? How prevalent is PBE in SOEST? Is PBE widely used by professors? If not, why not? If so, does it improve students' learning experience?

To answer these questions, Böttjer-Wilson and Bruno (2019) conducted a survey of PBE in SOEST. In Spring 2018, two online surveys (one for faculty and one for students) were designed to gain information relating to PBE in SOEST courses. The various question types that were utilized for each survey included Likert scale, open-ended, and multiple-choice questions. The Likert scale used in the survey was a five-point scale that ranged from 1 (very uncomfortable), 2 (uncomfortable), 3 (neutral), 4 (comfortable), to 5 (very comfortable). The student survey included 14 questions, and the faculty survey included 13 questions. Courses that the respondents reported on ranged from entry level (100) to graduate level courses (600+), and included both lecture and lab styles.

Following approval from the UH Institutional Review Board (Protocol#2018-00399), surveys were distributed within the departments of Atmospheric Sciences, Earth Sciences, Oceanography, and Ocean Resource Engineering. Surveys were emailed to SOEST teaching faculty (n = 120) and students (n = 276) at the beginning of the Fall 2018 semester. The survey was designed to take no more than 10 minutes to complete and responses were tallied after approximately three weeks. Data were collected and analyzed using Survey Monkey software.

Survey questions presented in Böttjer-Wilson & Bruno (2019) are provided in Table 2.1. A total of 81 student (43% undergraduate and 53% graduate) and 59 faculty survey responses were

analyzed. The survey results indicated that the survey respondents felt that PBE is important. Most participants -- 78% of students and 83% of educators -- found PBE to be an effective teaching and learning method. Positive impacts reported by students included enhancement of student learning (81% agreed/strongly agreed) and increased interest in geoscience content (75% agreed/strongly agreed). There was also an agreement among students (100%) that more should be done to incorporate and perpetuate PBE into current and future courses. Almost all (91%) of SOEST faculty respondents reported that they incorporate PBE. The most commonly utilized PBE strategies were local/regional data sets (79%), local/regional experts as guest speakers (59%), and geoscience-related field trips (53%). These PBE activities fall into Layer 1 of Figure 2.1. This level of PBE requires the least cultural competency to implement.

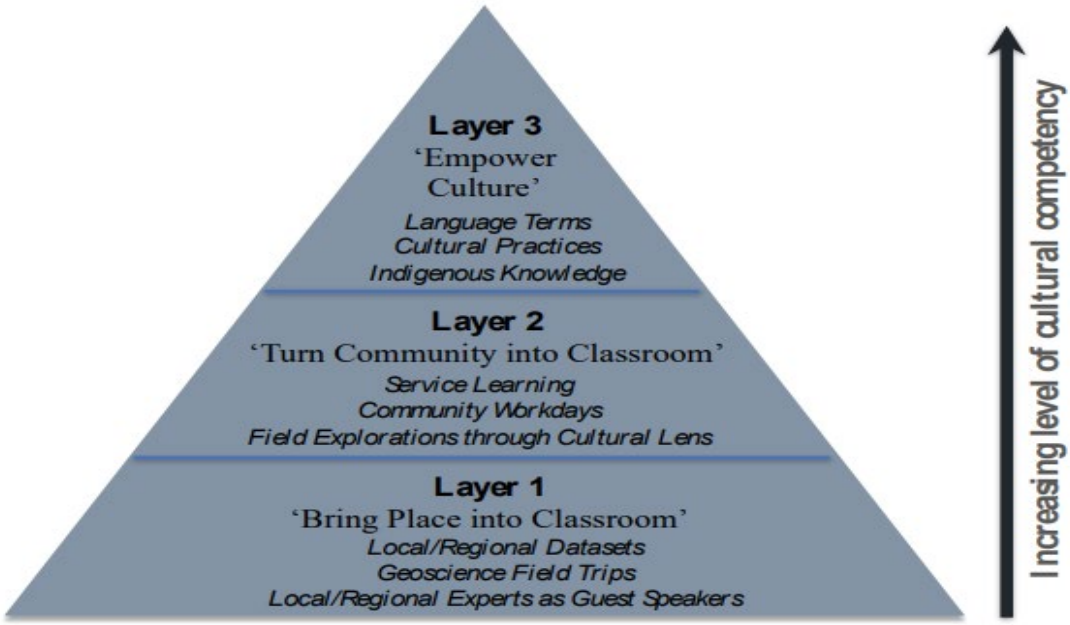

Figure 2.1 Three-layered pyramid framework for introducing place-based teaching practices into the classroom (Böttjer-Wilson & Bruno, 2019)

These results could suggest that SOEST faculty lack confidence in using PBE practices that require higher levels of cultural competency. In fact, a fair number of faculty expressed the desire to include indigenous knowledge or ways of knowing (29%), service learning (29%), and cultural practices (26%) into future SOEST courses (Table 2.2). However, when asked about their comfort level in implementing these approaches into their curriculum, SOEST faculty respondents reported a low level of comfort (2.9, 3.5, and 2.8, respectively) (Table 2.2). Overall,

the study indicates that more can be done to address the lack of resources and faculty confidence in generating culturally relevant teaching materials.

Table 2.1 Faculty and student questionnaires (Böttjer-Wilson & Bruno, 2019)

A) Faculty Survey Questions (13 total)

1. Place-Based Teaching (PBT) is a pedagogical approach that can be defined as using place and its resources (*e.g.*, linguistic, cultural, historical, spiritual, environmental, or physical) as a foundation for learning across disciplines. Is there anything that you would like to add or change to this definition of PBT? (OE)
2. PBT in Hawai‘i is an important and effective strategy to reach: (MC)
3. Which instructors should use PBT when teaching in SOEST? (MC)
4. Which PBT approaches do you currently use in your teaching, if we define “place” as Mānoa, O‘ahu, Hawai‘i or the Pacific region? (MC-all)
5. Which PBT strategies do you <u>not</u> currently use in your teaching but would like to in the future? (MC-all)
6. On a scale of 1 to 5, with 5 being very comfortable and 1 being very uncomfortable, how would you rate your level of comfort in incorporating the following PBT strategies into your teaching: (L5)
7. Have you participated in any professional development training with regard to PBT practices and strategies?
8. What SOEST lab and lecture classes have you taught in the past 3 years? (MC-all)
9. What level are these SOEST lab and lecture classes? (MC- all)
10. Where are you from (born and/or raised)? (MC)
11. What best describes your gender? (MC)
12. What is your ethnic origin? (MC- all)
13. Is there anything else that you would like to add about place-based teaching? (OE)

B) Student Survey Questions (14 total)

1. What is your current status in SOEST? (MC)

2.-3. Same as Faculty Question 2-3

4. What % of your SOEST lab and lecture classes have incorporated strong ties to place in the curriculum, if we define “place” as Mānoa, O‘ahu, Hawai‘i or the Pacific region? (MC)
5. In what SOEST disciplines were these place-based lab and lecture classes? (MC-all)
6. What level were these SOEST lab and lecture classes? (MC-all)
7. What aspects of PBT were included in these SOEST place-based lab and lecture classes? (MC- all)
8. Please select the answer that best indicates your agreement or disagreement with the following statement: *"SOEST lab and lecture classes with strong ties to place (Mānoa, O‘ahu, Hawai‘i or the Pacific region) have greatly improved my learning experience"* (L5)
9. Please select the answer that best indicates your agreement or disagreement with the following statement: *"SOEST lab and lecture classes and courses with strong ties to place (Mānoa, O‘ahu, Hawai‘i or the Pacific region) have significantly increased my interest in pursuing a major and/or career in the Earth, Ocean, and Environmental Sciences"* (L5)
10. What aspects of PBT would you like to see included in your SOEST lab and lecture classes in future semesters? (MC- all)

11.-14. Same as Faculty Questions 10-13

Codes: (OE) = open-ended; (L5) = 5-point Likert-scale; (MC) = Multiple Choice – single response required; (MC-all) = Multiple Choice – check all that apply.

Table 2.2 Summary of survey responses regarding place-based teaching (PBT) in SOEST, and faculty comfort level in using these practices (Böttjer-Wilson & Bruno, 2019)

	Student Survey Responses		Faculty Survey Responses		
Answer Choices (check all that apply)	**Q7** What aspects of PBT were included in these SOEST place-based lab and lecture classes?[1]	**Q10** What aspects of PBT would you like to see included in your SOEST lab and lecture classes in future semesters?[1]	**Q4** Which PBT approaches do you currently use in your teaching, if we define "place" as Mānoa, O'ahu, Hawai'i or the Pacific region?[1]	**Q6** How would you rate your level of comfort in incorporating the following PBT strategies into your teaching?[2]	**Q5** Which PBT strategies do you not currently use in your teaching but would like to in the future?[1]
Local/regional data sets	91%	70%	79%	4.6	9%
Local/regional experts as guest speakers	43%	69%	59%	4.5	16%
Field trips	76%	82%	53%	4.3	17%
Service learning	19%	51%	19%	3.5	29%
Community workdays	19%	46%	10%	3.3	26%
Hawaiian language terms	44%	64%	47%	3.2	22%
Cultural practices	25%	59%	24%	2.8	26%
Indigenous knowledge, or ways of knowing	43%	69%	33%	2.9	29%
None of the above	0%	0%	9%	--	28%
Other	4%	9%	21%	--	14%

1Percentage of respondents who selected this choice. 2 Likert scale, ranging from 1 (very uncomfortable) to 5 (very comfortable).

2.1.2.1 Addressing the Lack of PBE in SOEST

Expansion, promotion, and further integration of PBE resources and practices, especially those with cultural context, can help improve teaching and learning. Going beyond the current level (Level 1) of PBE strategies (Figure 2.1) to incorporate higher levels of cultural competency could lead to a more holistic approach and thus SOEST could take advantage of all of the benefits PBE has to offer. Such benefits could include generating interest in Earth science topics, recruiting and retaining students, and increasing diversity in geoscience. As a result, the number of local experts in the community who can meet current and future professional needs could increase. My approach is to help SOEST faculty introduce higher-level PBE practices into their classrooms by creating an online resource repository. This repository would allow faculty to easily access resources that incorporate place and culture.

3. PROJECT COMPONENTS

There are three components of this project. First, I met with 16 SOEST faculty within the four academic departments (Table 3.1) and asked them to share the PBE resources that they are currently using in their classes. These included field guides, PowerPoint presentations, literature (books and journal articles), lessons, datasets, and models that are rooted in place and/or Hawaiian culture. With their permission, I created an online repository (google drive) of these resources and summarized them in an Excel sheet (Appendix 1).

Table 3.1 SOEST Departments and Number of Participating Faculty Members in PBE Meetings

Department	Number of Meetings
Atmospheric Sciences	4
Earth Sciences	5
Oceanography	5
Ocean and Resources Engineering	2
Total	**16**

Second, I expanded this repository to include additional place-based and/or culturally relevant resources that are not currently being used in SOEST but are relevant to geoscience. Appendix 2 summarizes the new resources that I added.

Third, I created six Environmental Systems Research Institute (ESRI) Story Maps to showcase some of the place-based resources (existing and newly added) on the google drive. Table 3.2

summarizes these story maps. The first two story maps, "Exploring Hawai'i and the Pacific through Hawaiian language, legends, and belief systems" and "Exploring Hawai'i and the Pacific through traditions, land-use practices, and geoscience", highlight selected resources, such as books, journal articles, and newspaper articles. They are intended to give SOEST faculty a small taste of the many resources available on the google drive, and to encourage faculty to explore this repository more fully. Categorized as resource-specific story maps, each page corresponds to an individual resource on the google drive (Figure 3.1).

Table 3.2 Summary of ESRI Story Maps*

TITLE	PAGES	RESOURCES
Exploring Hawai'i and the Pacific through Hawaiian Language, Legends, and Belief Systems	19	19
Exploring Hawai'i and the Pacific through Traditions, Land-Use Practices, and Geoscience	28	28
State of Hawai'i	11	29
Field Guide of Maui	7	35
Field Guide of O'ahu	9	48
Field Guide of Hawai'i Island	8	63

**These storymaps are available at https://storymaps-classic.arcgis.com/en/my-stories/. Contact tineill@hawaii.edu or barb@hawaii.edu for login credentials*

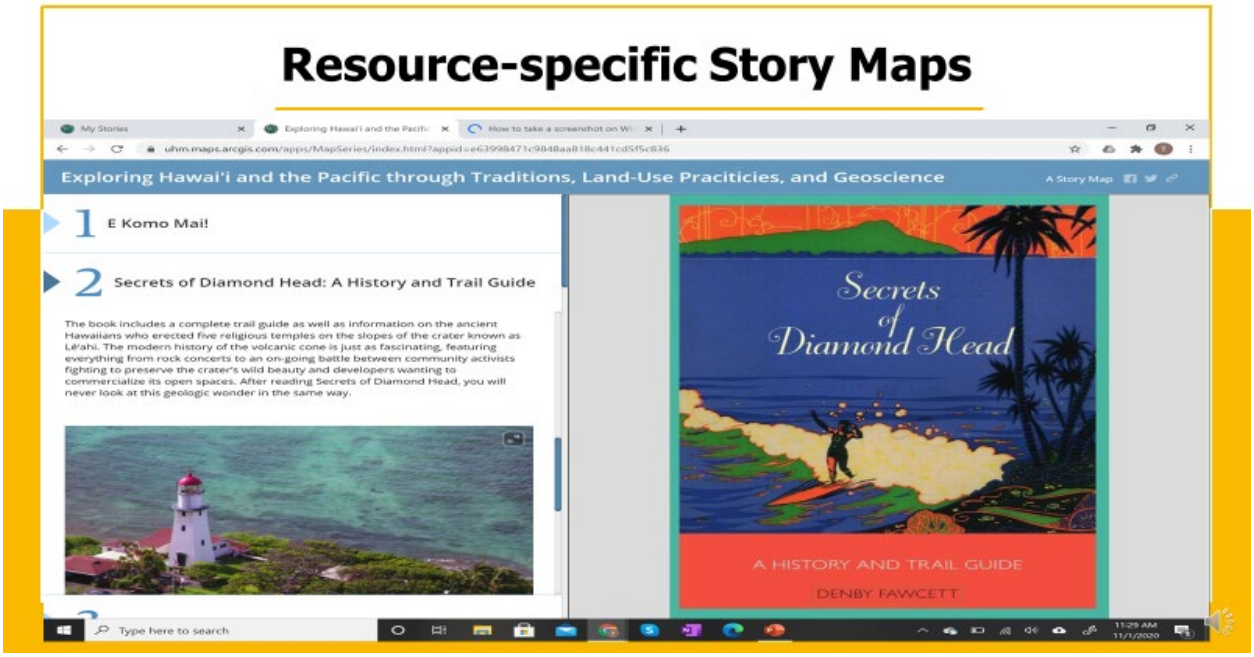

Figure 3.1 Example of a Resource-specific Story Map

The next three story maps are organized by geography, and correspond to the islands of Maui, Oahu, and Hawai‘i. Categorized as island-specific story maps, each of these story maps begins with a welcome (E Komo Mai) and introduction, and shares wind, cloud, and rain names specific to that island (Figure 3.2). The remaining pages share geology field guides and mo’olelo that are relevant to those field guide sites of interest or points.

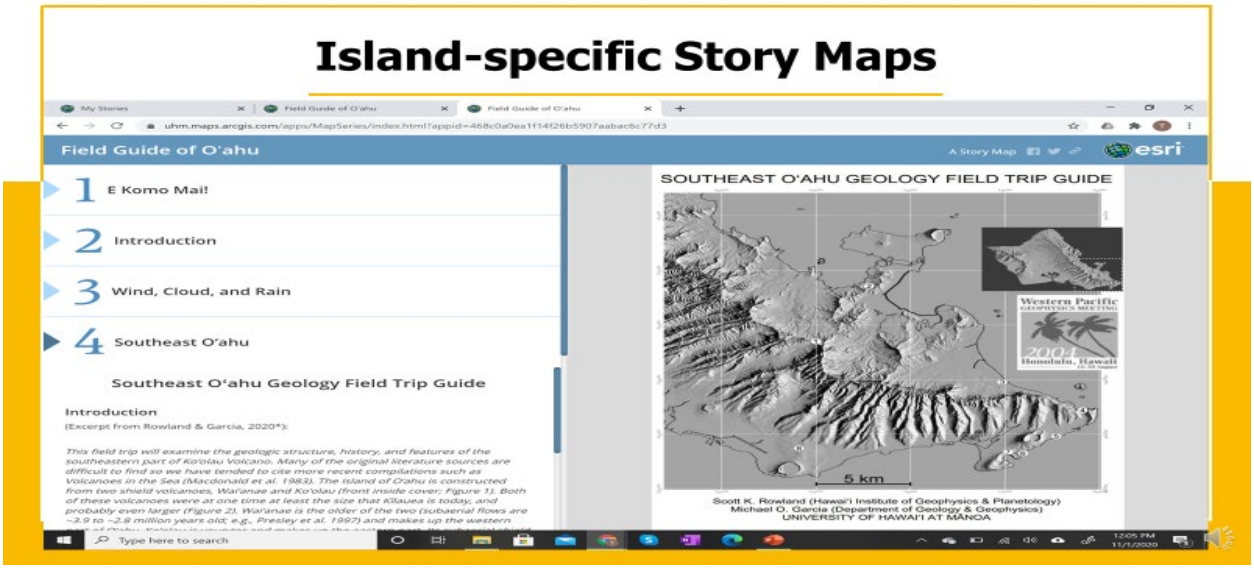

Figure 3.2 Example of an Island-specific Story Map

The sixth story map pertains to the State of Hawai‘i. Unlike the other story maps, it is topic-specific, with each page corresponding to a different theme (Figure 3.3). Sample themes (pages) are “Hawaiian Culture is Science”, “Site Cultural Protocol” and “Weather Forecasting”. Each of these pages highlights the interconnection between Hawaiian cultural values, traditional practices, and geoscience.

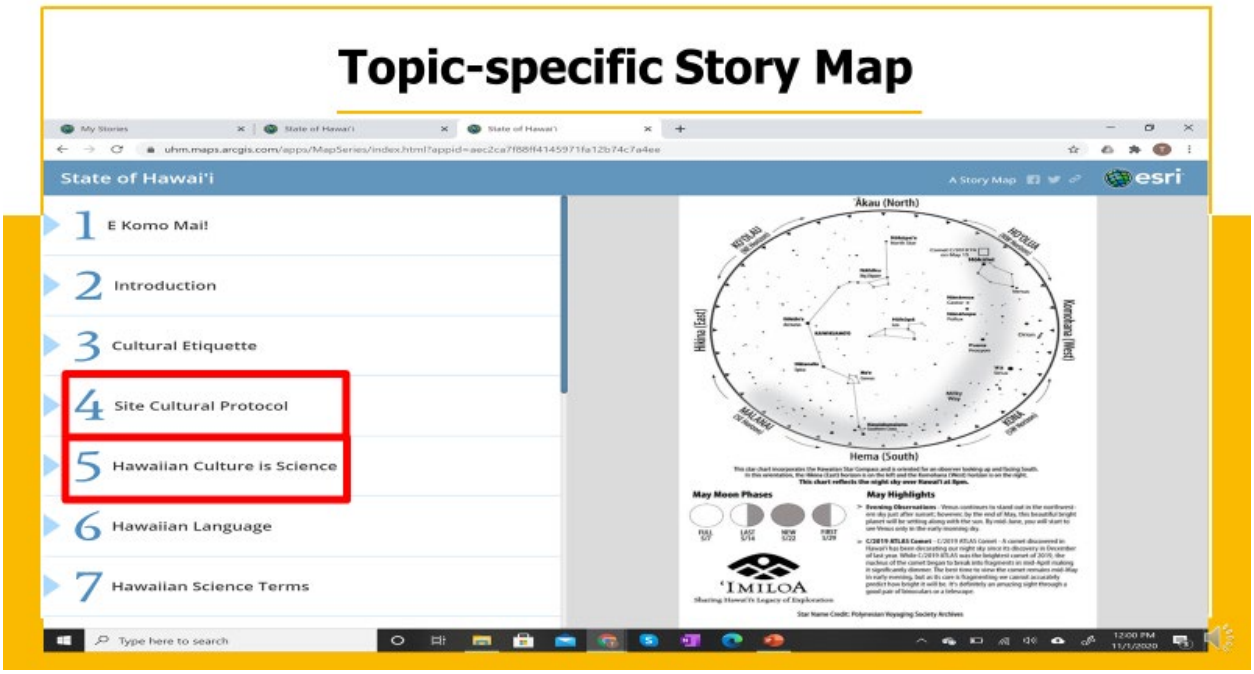

Figure 3.3 Example of a Topic-specific Story Map

Finally, I shared the ESRI Story Maps with SOEST affiliated geoscientists and educators and revised them based on the formative feedback received.

4. CONCLUSION

Place-based education (PBE).provides personal learning opportunities, enriches traditional academic instruction, and emphasizes the interconnection of system relationships. Utilizing PBE in geoscience can inspire students to engage in content and pursue relevant careers. The goal of this Plan B project is to promote and expand PBE within SOEST by assisting faculty to introduce more and higher-level PBE practices into their classrooms. My approach is to create an online resource library and story maps to share relevant PBE resources with faculty. In this project, I interviewed 16 SOEST faculty, compiled a repository of 53 existing PBE resources, expanded the repository to include 138 additional PBE resources, and created six story maps to showcase

some of these resources. Ultimately, this will position SOEST to contribute more effectively to preparing a local, diverse geoscience workforce that can help meet the current and future workforce needs in the State of Hawai‘i.

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Appendix 1. PBE Resources Received from Participating SOEST Faculty

https://drive.google.com/drive/u/0/folders/1Dq7kXXlsU3Al2lCV08SsR0_TewKW87x2

Type	Title	Reference	Link
Book	Secrets of Diamond Head: A History and Trail Guide	Fawcett, D. (2014)	University of Hawai‘i at Mānoa (online library)
Book	Climate Change: What the Science Tells Us (2nd Ed.)	Fletcher, C. (2019)	University of Hawai‘i at Mānoa (online library)
Book	Living on the Shores of Hawai‘i: Natural Hazards, the Environment, and our Communities	Fletcher, C. (2010)	University of Hawai‘i at Mānoa (online library)
Book	Lā’au Hawai‘i	(Abbot, 1992)	University of Hawai‘i at Mānoa (online library)
Book	Hawai‘i: A Unique Geography	(Morgan, 1996)	University of Hawai‘i at Mānoa (online library)
Book	Surf Science: An Introduction to Waves for Surfing	(Butt, 2014)	University of Hawai‘i at Mānoa (online library)
Book	Kauai’s Geologic History; A Simplified Guide	(Blay & Siemers, 2013)	University of Hawai‘i at Mānoa (online library)
Book	Ancient Sites of Hawai‘i	(Van James, 1995)	University of Hawai‘i at Mānoa (online library)
PDF	Geologic Map of the State of Hawai‘i	Sherrod, D., Sinton, J., Watkins, S., & Brunt, K. (2007)	https://pubs.usgs.gov/of/2007/1089/Hawaii_expl_pamphlet.pdf
PDF	Kūlana Noi‘i	Kūlana Noi‘i. (2018)	http://seagrant.soest.hawaii.edu/wp-content/uploads/2018/06/Kulana-Noii-low-res-web.pdf
PDF	West Hawai‘i Field Trip	Sinton, J. (2011)	https://www.soest.hawaii.edu/gg/resources/docs/West_Hawaii_Field_Trip.pdf
PDF	Maui Field Trip	Sinton, J. (2006)	http://www.soest.hawaii.edu/GG/resources/docs/Maui_2006.pdf
PDF	Field Trip Guide: Kīlauea	Rowland, S. (2020)	https://www.soest.hawaii.edu/gg/resources/docs/Kilauea_fieldguide_latest.pdf
PDF	Hawaiian Cloud Chart (Front)	Businger, S., Shigesato, Nu‘uhiwa, K., & Nogelmeier, P. (No Date Provided, Accessed 2020)	https://coe.hawaii.edu/kahuaao/wp-content/uploads/sites/8/2020/02/Cloud-poster-front-OAHU-FLAT-NSF.pdf
PDF	Makapu‘u Field Trip Guide	Hammer, J., Sinton, J., & Rowland, S. (2018)	http://www.soest.hawaii.edu/GG/resources/docs/Makapuu_FT_F18.pdf

PDF	Southeast Oʻahu Geology Field Trip Guide	Rowland, S., & Garcia, M. (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/GG/resources/docs/Seoahu4.pdf
PDF	Waiʻanae Field Trip	Sinton, J., & Rowland, S. (2018)	https://www.soest.hawaii.edu/gg/resources/docs/Waianae_Field_Guide_2018.pdf
PDF	Introduction to the Geology of Oʻahu	Garcia (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Garcia1.pdf
PDF	Trace Element Geochemistry of the Honolulu Volcanic Series, Hawaiʻi	Clague (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Clague.pdf
PDF	Ultramafic Xenoliths from Salt Lake Crater - An Overview	Leeman (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Leeman.pdf
PDF	Geology and Petrology of Volcanic Rocks of Lualualei Valley, Waiʻanae Range, Oʻahu	Sinton (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Sinton.pdf
PDF	Guide to the Mauna Kawale-Kauaʻōpuʻu Ridge Rhyodacite Occurrence, Oʻahu, Hawaiʻi	Bauer (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Bauer.pdf
PDF	Road Log of Volcanic Rocks and Features of Part of Oʻahu	Garcia (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Garcia2.pdf
PDF	Geologic History of Maui	Sinton (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Sinton_Maui.pdf
PDF	Review of the Mineral Chemistry of Volcanic Rocks from Maui, Hawaiʻi	Fodor & Keil (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Fodor_Keil.pdf
PDF	Maui Field Itinerary	Sinton (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/Library/Sinton_Maui2.pdf
PDF	Nā Makani me nā Ua o Hawaiʻi: Winds and Rains of Hawaiʻi	Thomas, A. (2016)	https://laulima.hawaii.edu/access/content/user/athomas/winds%20and%20rains%20of%20oahu%2C%20hawaii%2C%20kauai%2C%20maui.pdf
PDF	Hawaiian Cloud Chart (Back)	Businger, S., Shigesato, Nuʻuhiwa, K., & Nogelmeier, P. (No Date Provided, Accessed 2020)	https://coe.hawaii.edu/kahuaao/wp-content/uploads/sites/8/2020/02/Cloud-poster_BACK_FLAT.pdf
PDF	ʻIke Wai Mission and Value Statements	ʻIke Wai: Securing Hawaii's Water Future (No Date Provided, Accessed 2020)	https://drive.google.com/drive/folders/1CrHfPT_xV8R6JcJq9pDmCHqesClBdw4J

PDF	ʻIke Wai Hawaiian Language Guide: Common Terms & Phrases	Smith, T., Okuhata, B., Tachera, D., Gibson, V., McKenzie, T., Barde-Cabusson, S., Viti, T., Arisdakessian, C., & Eason, D. (No Date Provided, Accessed 2020)	https://drive.google.com/drive/folders/1CrHfPT_xV8R6JcJq9pDmCHqesClBdw4J
PDF	Conversing with Pelehonuamea: A Workshop Combining 1,000+ Years of Traditional Hawaiian Knowledge with 200 Years of Scientific Thought on Kīlauea Volcanism	Kauahikaua, J. & Babb, J. (Comps. & Eds.) (2017)	https://pubs.usgs.gov/of/2017/1043/ofr20171043.pdf
Webpage	Ka Pili Kai	Hawaiʻi SeaGrant (2018)	http://seagrant.soest.hawaii.edu/resources/ka-pili-kai/
Webpage	Introduction	University of Hawaiʻi at Mānoa (No Date Provided, Accessed 2020)	https://coe.hawaii.edu/kahuaao/intro/
Webpage	Wind Maps of Hawaiʻi	University of Hawaiʻi at Mānoa (No Date Provided, Accessed 2020)	https://coe.hawaii.edu/kahuaao/wind-maps-of-hawaii/
Dataset	National Weather Service (Honolulu, Hawaiʻi)	United States Department of Commerce and National Oceanic Atmospheric Administration (No Date Provided, Accessed 2020)	https://www.weather.gov/hfo/#
Dataset	Normal Hourly Station Details (Honolulu, Hawaiʻi)	United States Department of Commerce and National Oceanic Atmospheric Administration (No Date Provided, Accessed 2020)	https://www.ncdc.noaa.gov/cdo-web/datasets/NORMAL_HLY/stations/GHCND:USW00022521/detail
Dataset	University of Hawaiʻi Sea Level Center	University of Hawaiʻi Sea Level Center (No Date Provided, Accessed 2020)	https://uhslc.soest.hawaii.edu/
Dataset	Sea Level Rise: Hawaiʻi Sea Level Rise Viewer	Pacific Islands Ocean Observing System (No Date Provided, Accessed 2020)	https://www.pacioos.hawaii.edu/shoreline/slr-hawaii/
Dataset	Sea Level Rise and Coastal Flooding Viewer	National Oceanic Atmospheric Administration Office for Coastal Management (No Date Provided, Accessed 2020)	https://coast.noaa.gov/slr/#/layer/slr/0/-11581024.663779823/5095888.569004184/4/satellite/none/0.8/2050/interHigh/midAccretion
Dataset	A Summary of Reported Cases of Notifiable Disease in Hawaiʻi	State of Hawaiʻi (No Date Provided, Accessed 2020)	https://health.hawaii.gov/docd/resources/reports/summary-of-reported-cases-of-notifiable-diseases/
Dataset	Bermuda Atlantic Time-Series Study (BATS) Datasets	Coral Reef Airborne Laboratory (No Date Provided, Accessed 2020)	http://bats.bios.edu/bats-data/

Website	Rainfall Atlas of Hawai‘i	Giambelluca, T., Chen, Q., Frazier, A., Price, J., Chen, Y., Chu, P., Eischeid, J., & Delparte, D. (2013)	http://rainfall.geography.hawaii.edu
Website	Evapotranspiration of Hawai‘i	Giambelluca, T., Shuai, X., Barnes, M., Alliss, R., Longman, R., Miura, T., Chen, Q., Frazier, A., Mudd, R., Cuo, L., & Businger, A. (2014)	http://evapotranspiration.geography.hawaii.edu
Website	Solar Radiation of Hawai‘i	Giambelluca, T., Shuai, X., Barnes, M., Alliss, R., Longman, R., Miura, T., Chen, Q., Frazier, A., Mudd, R., Cuo, L., & Businger, A. (2014)	http://solar.geography.hawaii.edu
Website	Climate of Hawai‘i	Giambelluca, T., Shuai, X., Barnes, M., Alliss, R., Longman, R., Miura, T., Chen, Q., Frazier, A., Mudd, R., Cuo, L., & Businger, A. (2014)	http://climate.geography.hawaii.edu
Website	Ocean Surface Current Simulator (OSCURS)	National Oceanic Atmospheric Administration Fisheries Service (No Date Provided, Accessed 2020)	http://oceanview.pfeg.noaa.gov/oscurs/
Journal Article	Kahua ‘Ao-A Learning Foundation: Using Hawaiian Language Newspaper Articles for Earth Science Professional Development	Chinn, P., Businger, S., Lance, K., Ellinwood, J., Stone, J., Spencer, L., McCoy, F., Nogelmeier, M., & Rowland, S. (2014)	https://doi.org/10.5408/13-019.1
Journal Article	Hawaiian Oral Tradition Describes 400 years of Volcanic Activity at Kīlauea	Swanson, D. (2008)	https://www.higp.hawaii.edu/~scott/Kahua_Ao_geology/Swanson_2008_Keanakakoi_Hiiaka.pdf
Journal Article	Hurricane with a History: Hawaiian Newspapers Illuminate an 1871 Storm	Businger, S., Nogelmeier, M., Chinn, P., & Schroeder, T. (2018)	https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-16-0333.1
Journal Article	A Local Perspective of Hawai‘i’s Whaling Economy: Whale Traditions and Government Regulation of the Kingdom’s Native Seamen and Whale Fishery	Lebo, S. (2010)	https://www.semanticscholar.org/paper/A-Local-Perspective-of-Hawaii's-Whaling-Economy%3A-of-Lebo/147b56197612dc0ae3fd742ab8d6dc5fd0993191
PowerPoint Slides	O‘ahu	Rowland, S. (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/GG/FACULTY/ROWLAND/GG103/GG103_PowerPoints.htm
PowerPoint Slides	Maui	Rowland, S. (No Date Provided, Accessed 2020)	http://www.soest.hawaii.edu/GG/FACULTY/ROWLAND/GG103/GG103_PowerPoints.htm

Appendix 2. PBE Resources Received from Outside Sources

https://drive.google.com/drive/u/0/folders/1Dq7kXXlsU3Al2lCV08SsR0_TewKW87x2

Type	Title	Reference	Link
Video	E Komo Mai	Hualalairesort (2010)	https://www.youtube.com/watch?v=ZXB6gGqIUAM
Video	E Ho Mai	Call it Quits Hawai‘i (2008)	https://youtu.be/32vcntOp0i4
Video	Na Kilo ‘Āina	Hawai‘iSeaGrant (2016)	https://www.youtube.com/watch?v=i9bN_esYc-U
Video	Weather in a Hawaiian Perspective	KHON2 News (2020)	https://youtu.be/OUGKU99lx0A
Video	Ho‘i ka ‘Ōlelo: The Revitalization of Hawaiian Language in the Education System	O'Hara, L. (No Date Provided, Accessed 2020)	https://vimeo.com/427688830
Video	Worldwide Voyage: The Star Compass	Oiwi TV (2014)	https://youtu.be/TWm52IPPZjI
Video	What to Say after Aloha?	iHula Hawai‘i (2019)	https://youtu.be/ltqHUWdSaoA
Video	Hōkūle‘a: How to Navigate without Instruments	KHON2 News (2014)	https://youtu.be/dla3RoQo37M
Video	Loina	Kamehameha Publishing (No Date Provided, Accessed 2020)	http://www.kumukahi.org/videos/video_single_player/loina
Video	‘Ōlelo Hawai‘i	Kamehameha Publishing (No Date Provided, Accessed 2020)	http://www.kumukahi.org/units/na_kanaka/kaaike/olelo
Video	Mo‘olelo	Kamehameha Publishing (No Date Provided, Accessed 2020)	http://www.kumukahi.org/units/na_kanaka/kaaike/moolelo
Video	Kumulipo	Kamehameha Publishing (No Date Provided, Accessed 2020)	http://www.kumukahi.org/units/ka_hikina/kumulipo
Video	The Honi: A Polynesian Greeting	Matador Network (2017)	https://youtu.be/44c7Ft_181I
Video	Hawai'i Aloha	Playing for Change (2016)	https://youtu.be/uDa0YmZD0Jk
Video	All Hawaii Stand Together by Liko Martin	Project Kuleana (2013)	https://youtu.be/LV5qNZox4T8
Video	Dr. Pualani Kanahele: Living the Myth and Unlocking the Metaphor	TEDx Talks (2012)	https://youtu.be/8PDipPnD2d8
Video	The Enduring Power of Aloha ‘Āina: Education and the Futures in our Past.	TEDx Talks (2013)	https://youtu.be/KUd4KzRekoI
Video	Lessons from a Thousand Years of Island Sustainability: Sam ‘Ohu Gon III, PhD	TEDx Talks (2014)	https://www.youtube.com/watch?v=l9fv_2XIJBk

Video	Roots of Wisdom: Native Knowledge. Shared Science - Turtle Bay Exploration Park, Redding CA	Turtle Bay Exploration Park (2019)	https://youtu.be/kzZARyYy6ms
Video	Sciences and the Sacred: The Geological and Hydrological Phenomena of Mauna Kea	University of Hawai‘i Sea Grant College Program (2019)	https://www.facebook.com/uhseagrant/videos/1480161448804911/
Video	Decoding Ancestral Hawaiian Knowledge for Climate Change Adaptation and Resilience	350Hawai‘i (2020)	https://youtu.be/iDuoqf-BO14
Video	Sacred Stones (O‘ahu)	Aloha Authentic (2017)	https://youtu.be/8Vmt1kQyWDg
Video	Naupaka Street	Aloha Authentic (2019)	https://youtu.be/IDKBFLKp7RU
Video	O‘ahu	Kamehameha Publishing (No Date Provided, Accessed 2020)	http://www.kumukahi.org/units/ka_honua/paeaina/oahu
Video	Restoring a Sanctuary: Ka'ena Point	Mara Films (2009)	https://youtu.be/vK5S7jyG7D4
Video	Ku‘u Home O Kahalu‘u	Project Kuleana (2018)	https://youtu.be/Vq2TbXQkmCE
Video	King Kamehameha the Great	Aloha Authentic (2020)	https://youtu.be/ynQh-nu12s8
Video	Lehua St.	Aloha Authentic (2019)	https://youtu.be/uSh7UpYiJoQ
Video	Pele St.	Aloha Authentic (2019)	https://youtu.be/QbgZ3bWxc2c
Video	Hawai‘i	Kamehameha Publishing (No Date Provided, Accessed 2020)	http://www.kumukahi.org/videos/video_single_player/hawaii
Video	The Cultural Significance of the ‘Ōhi‘a Tree	University of Hawai‘i News (2016)	https://youtu.be/vPU8YDmET34
Video	Hilo Hula	Project Kuleana (2018)	https://youtu.be/lO0r-cWqYfc
Video	The Legend of Pele	KHON2 News (2018)	https://www.youtube.com/watch?v=H4RGMBNzLFw
Video	Pele	Kamehameha Publishing (No Date Provided, Accessed 2020)	https://youtu.be/ku2zyAncSoo
Video	Fly-through of Pu‘uhonua o Honaunau NHP, Honaunau, HI.	HABS HAER HALS (2016)	https://youtu.be/P-qVsq5wBI0
Video	Pu‘uhonua o Honaunau National Historical Park in 64 Seconds	U.S. National Parks of the Pacific Islands (2012)	https://youtu.be/4cZ8g2tZuOE
Video	Maui	Kamehameha Publishing (No Date Provided, Accessed 2020)	http://www.kumukahi.org/videos/video_single_player/maui
Video	Haleakalā Hwy.	Aloha Authentic (2019)	https://youtu.be/aHclCNGWwUg
Video	Hāna Medley	Project Kuleana (2018)	https://youtu.be/Bkc36p-vPDo

Video	Kupua	Kamehameha Publishing (No Date Provided, Accessed 2020)	https://youtu.be/P3CCAtz3vp0
Book	Hawaiian Mythology	Beckwith, M. (1970)	University of Hawai‘i at Mānoa (online library)
Book	Trailer: Hawaiian Airlines presents Ka Huaka‘i - The Journey to Merrie Monarch	Hawaiian Airlines (2020)	https://youtu.be/PzZiBmHWcmo
Book	Hawaiian Mythology	Beckwith, M. (1970)	University of Hawai‘i at Mānoa (online library)
Book	The Wind Gourd of La'amaomao: The Hawaiian Story of Pāka'a and Kūapāka'a: Personal Attendants of Keawenuia'umi, Ruling Chief of Hawaii and Descendants of La'amaomao (Rev. Ed.)	Nakuina, M. (2005)	University of Hawai‘i at Mānoa (online library)
Book	Resource Units in Hawaiian Culture (4th Rev. Ed.)	Mitchell, D (Ed.D) (1992)	University of Hawai‘i at Mānoa (online library)
Book	Encyclopedia of Caves (2nd Ed)	Culver, D., & White, W. (Eds.) (2012)	University of Hawai‘i at Mānoa (online library)
Book	Hawai‘i: The Pacific State (2nd Ed.)	Rayson, A. (2012)	University of Hawai‘i at Mānoa (online library)
Book	A Pocket Guide to the Hawaiian Language (2nd Ed.)	Schütz, A. (2010)	University of Hawai‘i at Mānoa (online library)
Book	Hawaiian Legends of Ghosts and Ghost-Gods	Westervelt, W. (2011)	University of Hawai‘i at Mānoa (online library)
Book	Welina: Traditional and Contemporary Ways of Welcome and Hospitality. Honolulu, Hawai‘i: Curriculum of Research & Development Group, the University of Hawai‘i	Chun, M. (2006)	https://books.google.com/books?hl=en&lr=&id=xcGkEHan1lgC&oi=fnd&pg=PA4&#v=onepage&q&f=false
Book	In the Beginning: Archipelago: The Origin and Discovery of the Hawaiian Islands (1st Ed.)	Grigg, R. (2012)	University of Hawai‘i at Mānoa (online library)
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