Hawaiian Math for a Sustainable Future: Envisioning a Conceptual Framework for Rigorous and Culturally Relevant 21st-Century Elementary Mathematics Education

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This article issues a call for culturally relevant, temporally relevant, and academically rigorous Hawaiian math curricula and proposes a framework for conceptualizing such curricula. Pairing traditional Hawaiian epistemology with contemporary theory in ethnomathematics, social justice mathematics, and critical mathematical literacy, the author offers suggestions for Hawaiian math lessons framed around three temporal categories of instruction: ka wā mamua (the past), kēia wā (the present), and ka wā mahope (the future).

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I open this article with a quotation from the Pulitzer Prize–winning author of *The World Is Flat: A Brief History of the Twenty-First Century* (Friedman, 2005b). Commenting that few young people in the United States today seem interested in the fields of science and engineering, Thomas Friedman challenged readers of his national best-seller: "I dare you to find an 11-year-old in America who wants to be an engineer today" (Friedman, 2005a, p. 30).

As Friedman (2005b) pointed out, the number of jobs requiring science and engineering skills in the United States labor force is growing by almost 5% per year while the number of Americans prepared for these careers is dwindling rapidly. More than half of America's scientists and engineers are 40 years old or older, and the average age is steadily rising (National Science Board, 2010).

According to the National Science Board (2010), only 5% of all bachelor's degrees earned in the United States today are in engineering. This is in contrast to 20% in Asia and 33% in China. Science and engineering degrees now represent more than half of all bachelor's degrees earned in Japan (63%), China (53%), and Singapore (51%). By contrast, the percentage of bachelor's degrees in science and engineering in the United States remains roughly at 32% (National Science Board, 2010).

After an extensive review of trends in the United States and abroad, a committee of the National Academies has expressed concern that "the [United States'] scientific and technological building blocks...are eroding at a time when many other nations are gathering strength" (Committee on Prospering in the Global Economy of the 21st Century, 2007). This is particularly alarming in light of our rapidly changing, and increasingly technological, global society (Seeley, 2009).

As Friedman's book *Hot, Flat, and Crowded* (2008) pointed out, we are facing an era focused on energy and climate, making it even more urgent to prepare students so that they can use mathematics and science to tackle these and other critical problems of the future. Tom Luce, CEO of the National Math and Science Initiative (2010), asserted:

> This new generation will have the opportunity to solve many global issues: healthcare, energy...and the global food crisis to name just a few. Given this, the missing ingredient is a better knowledge of math and science and its power to provide solutions to these problems. Technology can and

> will change the world. For this younger generation to be the force for good they want to be, they need to understand that the new literacy of the 21st century includes math and science. (p. 19)

Luce's assertion is especially true for Native Hawaiians and other Pacific Islanders who are disproportionately underrepresented in the fields of math and science (Native Hawaiian Science & Engineering Mentorship Program, 2009) and whose island communities are particularly vulnerable to these impending global crises. For instance, scientists predict that, within this century, Hawai‘i and other island communities will experience a 3-feet sea-level rise that will bring saltwater seepage into freshwater tables and will lead to the loss of beaches and coastal regions, which serve as the home to already threatened native plants and animals. It is predicted that the increasing acidity of the oceans will have a devastating effect on Hawai‘i's coral reefs and near-shore fish, and changes in rainfall patterns will bring not only more droughts but also more hurricanes and heavy rains (Fletcher, 2009). While these climatic changes will impact all of Hawai‘i, their effects will be felt most dramatically by Native Hawaiian communities who depend on native plants and animals, and reef and near-shore sea life, for livelihood and sustenance, and for whom the beaches and low-lying coastal regions hold important cultural, economic, and spiritual significance. To ensure a sustainable future for our Hawaiian community and our Hawaiian culture, we will need Hawaiian engineers and scientists who are prepared to deal with these and other impending crises.

Fortunately, thanks to the foresight of university programs geared toward recruiting and mentoring Native Hawaiian students in science, technology, engineering, and mathematics (STEM) careers, the number of Hawaiian university students studying math, science, and engineering is on the rise. Since the inception of the cohort-based Native Hawaiian Science & Engineering Mentorship Program (NHSEMP) in 2001, the enrollment of Native Hawaiian and Pacific Islander students in the College of Engineering at the University of Hawai‘i–Mānoa has steadily increased. Engineering is now the third most popular undergraduate major among the university's Native Hawaiian students, with 112 Hawaiian undergraduates enrolled in the College of Engineering in 2008 (Freitas & Balutski, 2009). Moreover, NHSEMP students are completing their engineering degrees in record numbers with a program retention rate of 70%, compared with a 56% undergraduate engineering retention rate nationwide (Fortenberry, Sullivan, Jordan, & Knight, 2007) and a 27% retention rate for indigenous Americans (Kaakua, 2010).

In collaboration with the Kamakakūokalani Center for Hawaiian Studies, NHSEMP integrates studies in renewable energy, smart development, and sustainable environmental practices with related service-learning projects in loko iʻa (fishpond) restoration, heiau (temple) restoration, and kalo (taro) farming. Through participation in this culturally relevant mentorship program, NHSEMP students come to realize how important their work as Hawaiian engineers is to the future of our island community (Kaakua, 2010).

With mentorship programs to recruit and retain Hawaiian students in STEM fields now in place at the university level, the onus is on those of us who work with Native Hawaiian students at the elementary school grades to ensure that our community's future leaders emerge from grade school with both the preparation to pursue further studies in math and science and the inclination to utilize math and science to become a "force of good" (National Math and Science Initiative, 2010, p. 19) in the world and our Hawaiian community.

Elementary educators play a critical, foundational role in the development of students' skill and interest in mathematics. This is particularly true for Native Hawaiian and other students of color for whom math is conventionally taught in ways that are unconnected to their lives and experiences. William Tate (2006), Gloria Ladson-Billings (1995), and Carter Woodson (1993), among others, argued that far too often conventional math pedagogy persuades students from historically marginalized communities to consider school mathematics as a subject divorced from their personal and cultural experiences and consequently leads these students to perform poorly in math classes and internalize negative self-images about their knowledge and ability in mathematics. Culturally relevant mathematics pedagogy, they contended, which connects school mathematics to the experiences of culturally diverse students, is thus essential to creating equitable conditions in mathematics education.

Culturally relevant mathematics pedagogy for Native Hawaiian students has been the thrust of my work in elementary teacher education for many years. However, over time I have come to the realization that developing a Hawaiian mathematics curriculum that is simultaneously culturally relevant, temporally relevant (i.e., applicable to students' present-day experiences), and academically rigorous is a formidable undertaking.

Drawing on my 20 years of experience in elementary mathematics education along with recent research in ethnomathematics (Anderson, 2006; Ortiz-Franco, 2006), social justice mathematics (Gutstein & Peterson, 2006), and critical mathematical literacy (Frankenstein, 2006), I offer below a framework that elementary teachers might consider when conceptualizing and implementing culturally relevant, 21st-century mathematics pedagogy for Native Hawaiian students.

Epistemological Underpinning

Different cultures have distinct ideas about how to best prepare their children for the future. In *Native Land and Foreign Desires*, Lilikalā Kame‘eleihiwa (1992) discussed the traditional Hawaiian worldview regarding the relative significance of the past, the present, and the future. Kame‘eleihiwa (1992) explained,

> In Hawaiian, the past is referred to as *Ka wā mamua*, or the "time in front or before." Whereas the future...is *Ka wā mahope*, or "the time which comes after or behind." It is as if the Hawaiian stands firmly in the present, with his back to the future, and his eyes fixed upon the past, seeking historical answers for present-day dilemmas. (p. 22)

Kame‘eleihiwa elaborated that this orientation is an "eminently practical" one, for while the future is always unknown, our Hawaiian past is "rich in glory and knowledge" (p. 22).

Following Kame‘eleihiwa, I contend that to prepare young Hawaiian leaders for an unknown future, it is essential that elementary educators go beyond conventional methods for teaching mathematics. We should go beyond teaching basic skills, beyond requiring students to know how to perform procedures, and beyond offering recipes for solving problems that look alike. If we are to prepare our students to seek sustainable, culturally appropriate solutions to global and societal problems that no one yet knows how to solve—or that no one has ever seen before—they will need a firm grounding in the accumulated wisdom of our ancestors coupled with excellent creative thinking and mathematical problem-solving skills.

In the sections that follow, I outline a general framework for conceptualizing Hawaiian mathematics curricula that inspire Hawaiian students to appreciate the mathematical accomplishments of our rich cultural past while simultaneously preparing them to meet the mathematical challenges of the present and future. Drawing from Kameʻeleihiwa (1992), I suggest the need for Hawaiian math lessons in three temporal categories of instruction: ka wā mamua (the past), kēia wā (the present), and ka wā mahope (the future). Arguing that lessons in each of these three categories are necessary for a rigorous and comprehensive Hawaiian math curriculum, in the three subsequent sections I pair theory in ethnomathematics, social justice mathematics, and critical mathematical literacy with preliminary suggestions for corresponding lessons in past, present, and future Hawaiian mathematics.

Ka Wā Mamua: Learning From Hawaiians' Rich Mathematical Past

In an impassioned speech in the critically acclaimed film *Stand and Deliver* (Musca & Menendez, 1988), teacher Jaime Escalante (played by actor Edward James Olmos) inspired and challenged his Mexican American mathematics students by exclaiming, "You burros have math in your blood!" Escalante explained that neither the Greeks nor the Romans were capable of using the concept of zero. It was the ancestors of Mexicans, the Mayans, who first contemplated the zero or the absence of value.

In an article with a similar title, mathematics professor Ortiz-Franco (2006) simultaneously outlined the long and distinguished Mayan and Aztec heritage in math and science (which is largely unknown or untaught in U.S. classrooms) and decried the comparatively poor performance of Mexican American students in U.S. math classrooms and the relatively miniscule number of Mexican Americans who are motivated to pursue mathematics-based careers in the United States today.

Arguing that the impressive history of mathematical achievements of non-European civilizations has been almost entirely ignored by U.S. schools, Ortiz-Franco (2006), Anderson (2006), and other ethnomathematicians asserted that it is time to "shatter the myth that mathematics was or is a 'white man's thing'" (Anderson, 2006, p. 44). Anderson contended that it is important for students to know that

"Europe is not now, nor was it ever, the 'civilizing center' of the world surrounded by wilderness and chaos" (Anderson, 2006, p. 44). Since the beginning of time, people around the world developed mathematical systems for quantifying and understanding the phenomena in their lives. Many early civilizations, including Native Hawaiians, achieved a high level of mathematical sophistication that allowed them to classify, order, count, measure, and otherwise mathematize their environment. However, the mathematical achievements and contributions of non-European cultures are largely overlooked in U.S. classrooms today.

Following Anderson and Ortiz-Franco, I believe that Hawaiian students could likewise benefit from explicit lessons in the rich mathematical heritage of our Hawaiian ancestors. Prior to European contact, Hawaiians had a thriving, self-sufficient, and self-sustaining civilization. Recent estimates suggest that our ancestors were able to support upward of 800,000 people on these small islands (Stannard, 1989). This was accomplished, in part, through sophisticated forms of community-based resource management developed from close observations of the moon and season cycles.

By noting recurring cycles that happened each season, year after year, Hawaiians were able to develop planting and fishing patterns in alignment with lunar patterns to produce optimum yields (Hui Malama o Moʻomomi, 2009). Our ancestors observed that each day, month, and season had its individual characteristics that would yield favorable or unfavorable results in fishing and farming, and thus they did all their fishing and farming in accordance with the various moon phases. They knew which days (or nights) would be good for fishing, because particular fish would be abundant, and on which days certain varieties of fish should be left alone because they were spawning. They knew which days were good for planting particular varieties of plants and which days should be set aside to allow the gardens to rest.

Through keen observational processes and problem-solving strategies, Hawaiians were able to meet their present food needs without compromising the ability of future generations to meet their needs. They developed intricate systems for sustainable resource monitoring and management that would rival any system of resource management in existence today (Friedlander et al., 2000).

Our Hawaiian ancestors had a long and rich tradition of impressive mathematical achievements, and it is important for Hawaiian students to know this. The sample lesson that follows below was adapted from Hui Malama o Moʻomomi's (2009) excellent curriculum on *Cycles and Hawaiian Traditions*. It is one of many possible examples of a ka wā mamua lesson in traditional Hawaiian mathematics that can instill within Hawaiian students a sense of pride in Hawaiʻi's mathematical heritage and enable them to see that we, too, have math in our blood.

Example: Moi Fishing in Ka Wā Kahiko

Imagine that you are a lawaiʻa (fisherman) living in ka wā kahiko (ancient times). Your kuleana (responsibility) is to catch moi (threadfish) for the aliʻi (chief). Moi is a reef fish that is best caught during low tide. You need to plan your fishing carefully because moi are rare fish that are fairly difficult to find. You must find the best time for catching moi while being careful not to disturb the moi's spawning cycle so that they can reproduce and replenish.

It is now the first day of Nana, and you will need to bring moi to the aliʻi once a month for the next 3 months (through Ikiiki). Using the relevant season, moon, and tide data from your local Hawaiian moon calendar and a local tide chart, follow the steps below to select the 3 best days (or nights) and times to fish for moi within the months of Nana, Welo, and Ikiiki.

STEP 1. Using your local Hawaiian moon calendar, first find the months in which moi fishing is kapu (prohibited) because the fish are spawning. Cross out those months on your calendar so that you are sure to leave the fish alone during that time.

STEP 2. Next, using the same moon calendar, find the good months for moi fishing. Circle the favorable moi fishing months on the calendar.

STEP 3. Using the moon calendar once again, circle the days (within the months of Nana, Welo, and Ikiiki) on which moi or reef fishing will be particularly good.

STEP 4. Now use the local tide chart to find the best tide periods for moi fishing. (Remember that low tide is the best time to catch moi.) On each of the days that you circled on the moon calendar in Step 3 above, record the hour of low tide.

STEP 5. Finally, mark the best 3 days (or nights) and times on your calendar, and explain why the weather and tide conditions for those days and times are ideal for moi fishing. (Adapted from Hui Malama o Moʻomomi, 2009)

This lesson provides students with problem-solving experiences in data analysis while simultaneously giving them a glimpse into the complex moon and season cycles that were central to the planning and practice of traditional Hawaiian conservation fishing. Students are challenged to analyze, interpret, and juxtapose data from both a local Hawaiian moon calendar and a local tide chart, and they are encouraged to make and justify predictions based on the data. In the process, they develop an understanding of the cyclical nature of tides and learn to appreciate the seasonal, monthly, and daily rhythms and patterns of nature, which our early ancestors have keenly observed and noted in the prediction of ocean and fishing conditions since ka wā mamua.

Kēia Wā: Connecting Math to Students' Everyday Lives

At the same time that I suggest that lessons in the mathematical accomplishments of our ancestors are necessary to enable Hawaiian students to connect math with our cultural and community histories, I do not mean to imply that lessons on historical achievements alone are sufficient to enfranchise Native Hawaiian students in mathematics. Like William Tate (2006), I believe that an academically rigorous and culturally relevant math curriculum should also connect mathematics to students' present-day lived experiences. It should give them opportunities to incorporate mathematical reasoning into their everyday lives.

Drawing once again from Kameʻeleihiwa (1992), I suggest that in order for Hawaiian students to "stand...firmly in the present" (p. 22), they should be also given opportunities to engage with a second category of math lessons that are grounded in their current circumstances or kēia wā. There are many possible ways in which this can be accomplished. One possibility is through lessons that enable students to simultaneously embrace both traditional Hawaiian culture and the contemporary global-technological culture.

As Kamanaʻopono Crabbe and Kaliko Baker suggested in a recent *Ka Wai Ola* article (Dashefsky, 2010), young Hawaiians are literally "wired in to the present" (p. 13) through iPods, video games, cell phones, and the Internet. The following kēia wā lesson capitalizes on contemporary Hawaiian students' interest in computer games and social-networking technology while challenging them to use mathematics to create more opportunities to practice the Hawaiian language in their everyday, technological lives. Students begin by designing and conducting a small-scale, statistical study to deepen their understanding of the order of usage of letters in the Hawaiian language (i.e., which letters are used most often and which letters are used least often). They are then challenged to apply the findings of their studies to one of two possible contemporary situations.

Example: Creating a Hawaiian Scrabble Application and Designing a Hawaiian Language Keyboard

OPTION 1: CREATING A HAWAIIAN SCRABBLE APP. What if you wanted to create a Hawaiian language Scrabble game app for your iPhone or iPad? How many tiles would you make available for each letter and what would be their respective point values?

OPTION 2: DESIGNING A HAWAIIAN LANGUAGE KEYBOARD. What if you could alter the design of the onscreen keyboard on your iPhone when sending Hawaiian language text messages to your Hawaiian-speaking friends? What letters and diacritical markings would you place on your newly designed Hawaiian language keyboard and where would you position them?

SUGGESTED PROCEDURE. Before proceeding with either of these projects, design and conduct a small-scale statistical study to explore which letters of the Hawaiian alphabet are used most frequently and which are used least frequently. For instance, you could take a single piece of Hawaiian language literature and tally the number of times each letter appears on the page. Or you might decide to gather a diverse sampling of Hawaiian language resources and tally the letters from a single sentence or paragraph in each of the different resources. Collect the data for your study, and then interpret and apply your study findings to the design of your Hawaiian language keyboard or Scrabble game.

This lesson engages students with several concepts in the area of statistics. They are posed with a question and are challenged to collect, organize, and analyze data in an attempt to answer that question. In the process of designing and conducting their statistical studies, students grapple with issues of sample size and sampling bias and consider the inferences or generalizations that can reasonably be made from their particular data sample. Finally, and perhaps most significantly, students apply the findings of their statistical studies to contemporary real-world situations.

Too often math is taught in ways divorced from the real world. Students learn and practice mathematics skills without seeing the connection between these skills and situations that they encounter in their daily lives. When math is isolated to pages upon pages of abstract textbook problems, the not-so-subtle message is that math is basically irrelevant except for achieving success in future math classes. The alternative is to teach mathematics in a way that helps students to see math as a powerful and useful tool for solving problems that confront students in their everyday lives. Activities such as this kēia wā lesson make mathematics more lively, accessible, and personally meaningful for students, who in turn are more engaged and learn math in more depth (Gutstein & Peterson, 2006).

Ka Wā Mahope: Problem-Posing for a Sustainable Future

As Kame‘eleihiwa (1992) suggested, the future that lies “behind” us is out of sight and largely unknown. Consequently, preparing young Hawaiian leaders to solve global and societal problems that no one yet knows how to solve—or that no one has ever faced before—will require creative thinking and mathematical problem-solving skills far beyond rote or formulaic problem-solving experiences. Hawaiian leaders of the future will need experiences in what the late Brazilian educator Paolo Freire termed “problem-posing” education.

In *Pedagogy of the Oppressed*, Freire (1993) contrasted the oppressive, “banking” approach to education with the more liberatory, “problem-posing” approach. According to Freire (1993), the banking approach to education, in which teachers deposit knowledge into the heads of students, produces “automatons” (p. 55) who receive and accept the world (and their lot in it) as “passive entities” (p. 57). By contrast, Freire noted that through problem-posing education, students are challenged to understand and eventually transform the problems in their communities and the broader world. In the process, they learn to view the world not as a "static reality" (p. 64), which they have no choice but to accept, but as a "reality in process" (p. 64), which they can transform through creative problem solving. Whereas the banking method reinforces students' "fatalistic perception[s]" (p. 66) of difficult situations, the problem-posing method presents these very situations to them as problems which, through creativity and collective action, they, themselves, can control.

Freire's concept of problem-posing education emphasizes that problems with neat, pared-down data and clear-cut solutions give students a false picture of reality (Frankenstein, 2006). Real-life problems are messy. They intersect and interact and may not have a single, clear-cut solution. In real-life problems, it is rare that a person will be given all the information that he or she needs in one tidy package. Instead, the person has to collect the data from a variety of sources. There is rarely one possible method or strategy for solving real-life problems; instead the person must select one strategy from several possible options. Moreover, one does not always know for sure if the solution one comes up with is the "right" one; one decides on a solution that one thinks is "best," and it may be only later, if ever, that one can evaluate one's choice. Whereas conventional math problems "isolate and simplify particular aspects of reality in order to give students practice in techniques" (Frankenstein, 2006, pp. 21–22), Freirian problem-posing is intended to reveal the "inter-connections and complexities of real-life situations" (Frankenstein, 2006, pp. 21–22).

Furthermore, Freire inspired us to look for solutions to problems in a variety of intellectual traditions. Freire reminded us that far too often "the intellectual activity of those without power is...characterized as non-intellectual" (Freire & Macedo, 1987, p. 122). However, all people have rich intellectual traditions, and all people are continually creating knowledge and doing intellectual work (Frankenstein, 2006).

As Frankenstein (2006) attested, up until now, American society's near-exclusive reliance on Western perspectives and intellectual traditions has left most of the "burning social, political, economic, and ethical questions of our time" (p. 28) unanswered. Although the United States is a society of enormous wealth, it still has significant hunger and homelessness. Although American doctors have engaged in medical and scientific research for hundreds of years, they are not much closer to changing the prognosis for most cancers (Frankenstein, 2006). Following Freire

(Freire & Macedo, 1987), problem solvers of the future will benefit from opening themselves up to learning from the perspectives and philosophies of a variety of intellectual and cultural traditions and bringing these fresh perspectives to bear upon persistent societal problems.

But how do we begin to prepare young Hawaiian students for this future reality? Surely, we cannot expect them to be solving world problems from their early years in grade school. However, we can begin to lay the foundation by engaging the students in in-depth mathematical explorations that are rigorous and meaningful, and that empower them to understand and transform the problems of the world rather than passively accept them. We can challenge them with complex, real-life problems to which answers are not yet known, problems that intersect and interact, which require the collection of data from a variety of sources, and which may not have a single, clear-cut solution. Finally, we can encourage them to look for solutions in a variety of intellectual traditions, and to consider how the lessons of our ancestors' rich mathematical past can help us to "more wisely build the future" (Freire, 1993, p. 65).

Example: Subsistence Farming in Ka Wā Mahope

The year is 2040. Fuel prices have skyrocketed and, correspondingly, so have the prices of shipped-in produce. To offset the high produce prices, over the past year, your ʻohana (family) has relocated from Honolulu to Kainaliu, 5 miles south of Kailua-Kona, where you have plans to start a small, subsistence farm, with dry-land kalo and ʻuala (sweet potato), in your backyard. After consulting a Honolulu-based moon calendar, you note that the calendar suggests planting kalo and ʻuala in Kaulua (in the middle of the wet season) and harvesting them in ʻIkuwā (near the end the dry season and before the start of the winter rains). However, after spending the past year in Kainaliu, you have observed that the dry and wet seasons in Kainaliu seem to be the reverse of what is indicated on the Honolulu moon calendar. As far as you can tell, it seems that the summers in Kainaliu are wetter than the winters.

PART 1. Working in your cooperative ʻohana groups, use the National Oceanic and Atmospheric Administration (NOAA) graphs (http://www.prh.noaa.gov/peac/kona/total.php) to compare the average precipitation data in Kainaliu from month to month. Do the data support your conjecture that the dry and wet seasons in Kainaliu are the reverse of what is indicated on the Honolulu-based moon calendar? Is the wettest time of year in Kainaliu indeed in the summer? Juxtaposing the Honolulu moon calendar with the Kainaliu average precipitation data, explain any modifications that you would make to the Honolulu moon calendar farming schedule when planting and harvesting your subsistence farm to account for the unique seasonal rainfall pattern in Kainaliu.

PART 2. After a few years of success with your modified planting and harvesting schedule, you have recently been informed by NOAA that the coming year will be a strong El Niño year, which is predicted to significantly alter plant growth and agricultural production in the Kona district over the next 2 years. Working again in your cooperative ʻohana groups, use the NOAA graphs (http://www.prh.noaa.gov/peac/kona/total.php and http://www.prh.noaa.gov/peac/kona/anomaly.php) to compare the "normal" or average monthly precipitation data for Kainaliu with the monthly precipitation anomalies for Kainaliu in El Niño years. Using these two sets of data along with the Kainaliu planting and harvesting calendar, which you developed in Part 1, explain any changes that you will make to your Kainaliu planting and harvesting schedule for both the coming El Niño year and the year after the El Niño event.

Whereas this article's initial, ka wā mamua, lesson focused on appreciating Hawaiian knowledge of the past, and the second, kēia wā, lesson was firmly grounded in the present, this ka wā mahope lesson challenges students to combine elements of traditional Hawaiian knowledge with present-day scientific knowledge to forecast a course of action for the future.

In Part 1 of the lesson, students begin with traditional harvesting and planting data from a Honolulu moon calendar and make modifications to the calendar based on monthly average precipitation data for the Kainaliu district. This is similar to a task that one might do in ka wā kahiko but with the addition of contemporary scientific data. Hawaiians were keenly aware that, given the number and variety of microclimates on each island, there simply was not one universal planting and harvesting calendar that would work for all the islands. Hawaiian months and the planting calendars were exceedingly place-based and differed from one island to the next, and sometimes from one ahupuaʻa (land division) to the next, based on close observations of the unique climatic patterns of each particular district. In Part 1 of this lesson, students access and interpret 30-year average precipitation data from a NOAA website to draw conclusions about the typical climatic patterns in Kainaliu and develop a corresponding planting and harvesting schedule for this particular community.

Part 2 of the lesson adds another layer of complexity to the problem as it urges students to consider how Kainaliu's typical climatic patterns may be affected in a strong El Niño year and challenges them to adapt their planting and harvesting schedule accordingly. Students once again access the NOAA website—this time to examine and interpret data about rainfall variations for the Kainaliu region during past El Niño years—and they apply the data to make predictions about the effects of an upcoming El Niño on agricultural production in their region.

This is a complex, real-life problem with real-life consequences, which continues to engage the interest of NOAA scientists today. There is considerable concern that global warming produced by increased carbon dioxide emissions may be contributing to greater fluctuations in sea temperatures and more intense and severe El Niño events, causing distinct and dramatic changes in local and regional weather patterns around the globe (National Oceanic and Atmospheric Administration, n.d.). Predicting, and being proactive in planning for, local and regional changes in precipitation and temperature during El Niño (and La Niña) events is essential to agricultural interests in the Kona district and worldwide as the growing process for many crops is highly sensitive to rainfall and temperature variations.

In addition to being significant, this problem is also deep, complex, and messy. It has the potential to challenge students and scientists alike for hours, days, weeks, months, or years as they continue to identify and explore additional technological tools and external mathematical resources to deepen their understanding of the problem and develop possible solutions.

In the face of gloom-and-doom future forecasting, this Freirian-inspired problem-posing lesson empowers students to be proactive in dealing with the challenges that await them in the future. As Freire (1993) suggested, the oppressive, banking model of education presents the world as "a fixed entity, as something given—something to which people, as mere spectators, must adapt" (p. 120) and conform. In contrast, Freirian, problem-posing education is a "practice of freedom," a "means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world" (Freire, 1993, p. 16). In a similar spirit, this ka wā mahope lesson denounces the fatalism of gloom-and-doom future forecasts and boldly asserts that Hawaiians are "transformative beings and not beings for accommodation" (Freire & Freire, 1997, p. 36).

Conclusion

The most pressing goals and challenges of the future, both globally and in Hawai'i, will include mitigating the effects of climate change, finding local sources of renewable energy, and sustainably managing food resources. The future leaders who will be challenged to solve these global and local crises 30 years from now are today's children.

To devise creative and sustainable solutions to these challenges, Hawai'i's future leaders will need a solid foundation in the accumulated wisdom of our Hawaiian ancestors, a firm grasp of current technological and mathematical advancements, and exceptional skill in complex, mathematical problem solving. Through thoughtfully conceptualized lessons in past, present, and future Hawaiian mathematics, contemporary educators can engage Hawaiian students with a rigorous and culturally relevant mathematics education—one that will prepare these future leaders to "stand...firmly in the present" (Kame'eleihiwa, 1992, p. 22) while applying historical wisdom to future dilemmas.

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