Museums and Planetariums: Bridging the Gap between Hawaiian Culture and Astronomy through Informal Education—A Case Study

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Abstract

Behavioral research supports informal education as fundamental to lifelong learning and responsible for much of what we know. Such learning occurs outside of formal schooling through venues such as the Internet, libraries, museums and planetariums. Unrestricted by the regulations of formal institutions, informal education can respond more quickly, flexibly and innovatively to the needs of a rapidly changing society. This paper outlines one science center's approach to bridging the cultural divide between research scientists and the Hawaiian community.

Hawaiʻi currently faces unresolved sovereignty issues and their resulting polarizing effects. One such case of growing discord involves a sacred and strategically important mountain named Mauna Kea—the highest peak in the Pacific. Traditionalists regard this mountain as the altar of Wākea, the Polynesian sky god and father of all indigenous Hawaiians, while astronomers extol its lofty summit as a premier platform for astronomical observations. To address this conflict, the University of Hawaiʻi at Hilo together with congressional support established the ʻImiloa Astronomy Center, a cultural science museum and planetarium, whose mission includes bringing the Hawaiian community and astronomers together to discuss and mitigate their differences. This paper explores the background behind these issues and the unique attempt of informal education to resolve them.

Introduction

One of the major consequences of C. P. Snow's *Two Cultures* was to bring to the forefront the existence of conflicting cultures (scientists and literary intellectuals) by articulating their differences and initiating a dialog between them (Snow, 1959). The cultural discord that Snow addressed involved an intellectual rift. Such academic conflicts are non-life threatening. As long as each understands the culture of the other, there is little need to mitigate their differences. But there are conflicts between groups where the issues are so threatening that mitigation is urgently needed to prevent irreparable damage to the society in which both cultures co-exist. This paper discusses such a case that exists in Hawaiʻi between research astronomers and the local Hawaiian community over a sacred mountain called Mauna Kea.

Mauna Kea—A Sacred Mountain

Towering 13,796 feet above sea level, Mauna Kea is the highest peak in the Pacific basin. Measured from its base at the ocean floor, this massive shield volcano is actually the tallest mountain on earth. According to Hawaiian tradition, Mauna Kea is the mountain altar of Wākea, the celestial father—sire of the indigenous Hawaiian race. This mountain is said to protect burials of the highest chiefs, the descendants of Wākea and Papahānaumoku, who gave birth to the islands. Mauna Kea is often eulogized as Hawaiʻi's piko—the umbilical cord connecting earth and sky. Hawaiian families, even today, travel to Lake Waiʻau, an alpine lake 750 feet below the mountain's summit, to offer the umbilical cords of their newborns. (University of Hawaiʻi Institute for Astronomy. About Mauna Kea Observatories. 2010)

In wintertime, the summit is often covered with snow—giving its name Mauna Kea, White Mountain. Reaching above 40 percent of the earth's atmosphere, its dry conditions have attracted thirteen astronomical observatories, more than on any other mountain peak on earth.

Volcanically dormant for over 4,000 years, this mountain has become the epicenter of recent social upheaval arising from disputes between those who worship its sacred altar to their sky father and those awed by its pristine views into the heavens.

Necessity—the Mother of Intervention

The recognition of Mauna Kea as a premier site for astronomical observations stemmed from unrelated happenstances and the necessity that followed. As is often the case, the road leading to its development and the consequential collision of cultures was paved with good intentions.

Surprisingly, prior to the early 1960s, Mauna Kea was never seriously considered a potential site for a major observatory. In fact, since the 1940s, the summit of Haleakalā on the neighboring island of Maui had been receiving the undivided attention of observational astronomers (Steiger, 2010). Haleakalā already held claims on a major solar observatory. Haleakalā's allure had even enticed world-renowned astronomer Gerard Kuiper, Director of the University of Arizona's Lunar and Planetary Laboratory, to Maui in 1963 to survey potential sites for a major observatory. So, with all of Maui's successful pioneering work in observational astronomy, why were sights eventually turned to Mauna Kea?

The answer rests with a combination of unrelated circumstances occurring soon after Hawaiʻi became a State in August 1959. At that time, one out of every twelve people employed in Hawaiʻi was in the sugarcane cultivation and processing industry. Statehood, however, brought with it the prospects of significantly increasing labor costs, which sharply contrasted with the cheaper labor found elsewhere in the Caribbean. Although sugar would continue to dominate the Hawaiian economy for another decade, leaders already sensed the impending demise of this once staple industry.

Just past midnight on May 23, 1960 and not quite one year into statehood, the Big Island of Hawaiʻi was dealt a devastating blow. A tsunami towering 30 feet high, triggered by a major earthquake in Chile, inundated the island's major city of Hilo—killing 61 people in its wake and destroying the waterfront businesses along the city's expansive bay. Necessity prompted the Hawaiʻi Island Chamber of Commerce to intervene, searching for ways to pump up the island's failing economy. (Parker, 1994, p. 24)

Mitsuo Akiya, the Chamber's Executive Secretary, coincidentally learned of Kuiper's interest in Haleakalā and successfully persuaded him to consider Mauna Kea instead. Soon afterwards, then-Governor John Burns released funds to bulldoze an access road to its summit. Test observations verified that Mauna Kea was a superb site for an astronomical observatory. In Kuiper's own words, the mountaintop was "a jewel … probably the best site in the world." (West, 2005) His enthusiastic pronouncement has since stood the test of time.

Location-Location-Location

Energized by the race to the moon in the early 60s, astronomy and space exploration enjoyed favored status throughout the United States. Despite its as-yet unproven record in astronomical research, the University of Hawaiʻi (UH) was awarded funds from the National Aeronautics and Space Administration (NASA) to build a world-class observatory to be coupled with an expanded graduate program in astronomy and a research branch, called the Institute for Astronomy (IfA).

When this author arrived at the University of Hawaiʻi in 1967 to begin graduate studies in astronomy, construction of this observatory was newly underway. Severe snowstorms and technical problems, however, delayed its dedication until 1970. Once in operation, the UH's 88-inch (2.2-m) telescope became the eighth largest in the world and the first to be fully computer controlled. Word of the outstanding seeing conditions at this tropical peak spread quickly throughout the astronomical community.

By 1979, three larger internationally managed telescopes, along with two smaller 0.6-meter instruments, were operating at the summit. These included the 3.8-m United Kingdom Infra-Red Telescope, the 3.6-m Canada-France-Hawaiʻi Telescope, and the 3.0-m NASA Infrared Telescope Facility. Mauna Kea was on the fast track to becoming the world's finest location for astronomical observations.

During the 1980's, there existed little vocal opposition to these modern sentinels on the mountain. The directors of Hilo's Joint Astronomy Centre were well respected and viewed as community-oriented (Hapai, 2010). The most derogatory comments at that time were references to visual eyesores: "pimples on the mountain." These were only vague hints of the impending controversy that was lurking on the horizon.

By 1999, the tally of observatories had soared to thirteen, including the then largest telescopes on earth—the two 10-m telescopes at the Keck Observatories. With the turn of the millennium, astronomers were poised for more even greater projects. But intervening events had already broken the trust of the local community and created a rift between these two cultures.

By 2001 the growing dissension had reached national attention, when *Los Angles Times* science writer Usha McFarling wrote:

> The emotionally charged debate over modern and ancient uses of this rocky pinnacle is much more, though, than a fight over a telescope or a mountaintop. To many Hawaiians, nothing less than the future of their homeland is at stake. And it is a perfect example of the often-fumbling progress of science in a multicultural world.

> Once prized for the clean industry and jobs they brought to this economically challenged island, astronomers are now lumped in with the missionaries, whalers, plantation owners and golf-course developers who have taken turns carving up this island. (McFarling, 2001)

Vocal opposition to the development of Mauna Kea had erupted with a fury that both stunned and frustrated the astronomy community. In order to understand the undermining causes of this turmoil, one needs to examine the beliefs and behaviors of these two cultures in light of the volatile political situation that was concurrently surfacing in Hawai‘i.

Perfect Storm—The Making of a Culture Rift

During the 1990s, a series of events converged to create a perfect storm that stirred up this heated dispute over Mauna Kea.

With the centennial of the Hawaiian Kingdom’s overthrow looming ahead in 1993, vocal activism on sovereignty issues, unheard for several generations, was beginning to emerge within various Hawaiian factions. When Hawai‘i was annexed in 1898, the crown lands of the Hawaiian monarchy were ceded to the U. S. Federal government. These 1.8 million acres of ceded lands constitute about 25% of the total land area of Hawai‘i. Upon gaining statehood, these ceded lands were transferred to Hawai‘i and placed in trust to support among other things public education and the betterment of native Hawaiians. Disputes over the distribution of these revenues have resulted in various legal battles and social uproar.

The summit of Mauna Kea, along with its entire complex of observatories, falls within the boundaries of these ceded lands. In 1968, the UH was granted a 65-year lease on a section known as the Mauna Kea Science Reserve (MKSR), an area 2.5 miles in radius that is centered on the UH 2.2 m telescope. This includes an Astronomy Precinct of 525 acres upon which the observatories sit (University of Hawai‘i, “Voices and Visions of Mauna Kea”, March 2000). The UH leases this land for $1 a year and subleases portions of the MKSR to all other non-UH observatories.

In an attempt to impress others over their cutting-edge instruments, astronomers often cited the exorbitant cost for observing time at these telescopes—estimated at $1 per second. This unwittingly gave the impression that the UH had found a golden goose—it was to become more of a golden noose. In contrast to the dollar-a-year lease the UH was paying, some began wondering where all the sublease funds were going. It didn’t placate matters to point out that these subleases were in-kind compensations to UH consisting of 10% of the observing time and that non-UH facilities were also responsible for road maintenance and other support. The perception was that the UH was benefiting handsomely from these ceded lands. It was difficult to see how this research bonanza was benefiting native Hawaiian students at UH or elsewhere.

In part, this resentment had sparked from the backfire of overstating a case. The damage had already begun. And still more was ahead.

In 1993, President Bill Clinton signed the United States Public Law 103-15 (aka Apology Resolution), which formally apologized for the overthrow of the Hawaiian monarchy 100 years before (Lang, 2002). As the *LA Times* succinctly put it:

> A once fledgling Hawaiian movement has grown into a vocal political power in the islands. There are calls for secession from the United States, a return of native Hawaiian lands and, on Mauna Kea, a moratorium on telescopes and even their removal. … The battle over telescopes has become a chance to reclaim, symbolically and practically, ground that their people lost long ago. (McFarling, 2001)

Soon after, other events conspired to widen the rift between the astronomers and the local community, including culturalists, environmentalists and recreationalists:

• In 1994, when construction trash blew down from the observatories and was left unretrieved, the Sierra Club's complaint was reportedly met with indifference by the astronomy staff. The trash was only removed several months later after local newspaper support was enlisted. This publicity started people wondering if other environmental laws were being circumvented or decisions being made without full public hearings. (Lang, 2002)

• Studies in 1996 revealed that the habitat of an endemic alpine insect, called the wēkiu bug, was being destroyed by the construction of the observatories. Measuring a quarter-inch long, this recently discovered insect is found only at the summit of Mauna Kea, where it can endure extreme cold due to an antifreeze-like substance in its body. (Lang and Byrne, 2005)

• Others voiced bitterness from personal experience. Kealoha Pisciotta, a native Hawaiian, once worked as a telescope technician at the summit's two sub-millimeter facilities. Honoring her Hawaiian tradition, she routinely brought offerings to the family's stone shrine that she had erected on the mountainside. Several times her altar was removed—on at least one occasion reportedly by an astronomy colleague. The ultimate desecration occurred when the ashes of her aunt were strewn across the cinder landscape when the shrine was vandalized again. While the astronomy community was not responsible for this act, it was an easy target for the understandable hurt feelings and anger. (McFarling, 2001)

• Perhaps, most damaging was a scathing 1998 legislative audit on the summit's management. That report essentially supported many of the claims levied by the Hawaiian and environmental communities and concluded that the IfA had "failed to develop and implement adequate controls to balance the environmental concerns with astronomy development." In response, the IfA proposed to limit access to the summit road. The community, however, saw this as a veiled attempt at self-protection rather than environmental control. (Peek, 1998; Ho, 2001)

Broken Trust—Widening the Cultural Divide

As a result of this audit, the university initiated the development of a new Mauna Kea Science Reserve Master Plan. This time, however, the university actively sought out community input. And, unlike before, the community spoke out in numbers with uninhibited "rancor about desecration of traditional sites, blocked access to gathering and spiritual sites, and about what was widely perceived to be general disregard for the care of the mountain." (Lang, 2002)

An impartial examination of the circumstances leading to this cultural divide suggests that both parties shared the blame, albeit in different ways. It wasn't so much the different beliefs that both cultures professed, but the behavior they exhibited when confronting those differences.

The astronomers' clinical view of the summit's use was pragmatic and altruistic. It was couched in academic idealism. Surely, such a pure, intellectually-minded endeavor was evidence enough to persuade all of the summit's strategic value. Besides, the summit's astronomical discoveries mirrored the explorations of ancient Polynesian navigators. From the vantage point of the astronomers, the horizon is a barrier to be pushed back beyond which new frontiers lie. Certainly, all people share astronomy's noble quest—to discover our origins and place in the universe.

In contrast, the community's cultural view of the mountain was steeped in heritage and spirituality. It was charged with the latent resentment of a disputed overthrow. Surely, such long-held, culturally-minded beliefs were enough to exhort all of the mountain's sacredness. Besides, the summit's pristine majesty reflected the unspoiled, untouched wonders of outer space. From the viewpoint of the Hawaiian culturalists, the horizon is an embracing shelter within which heritage is safeguarded. Certainly, all people are mindful of traditions—to preserve our origins and genealogical connections with the sky.

These were certainly different philosophies, different beliefs, different mindsets—potential reasons for disagreeing, but not justification for being disagreeable. Lost in the dispute was honest dialog. Both cultures felt misunderstood, or worse, ignored. There was lack of candor for fear of offending others and overstating cases to advance one's position. Public hearings often took on an adversarial atmosphere. What was sorely needed was a non-threatening venue where these two cultures could speak frankly and without accusation of bias. That venue wasn't to appear for several more years.

The broken trust between these cultures was instigated by real and perceived causes. Among those were the following:

• *Semantic Arguments*. One of the hotly debated issues at that time was how to count the number of telescopes at the summit. The 1983 Master Plan for Mauna Kea stipulated a maximum of thirteen. By 1999, when the new Master Plan was being crafted, there already were thirteen observatories, including the soon-to-be constructed Submillimeter Array (SMA), managed by the Smithsonian Astrophysical Observatory and Taiwan. Unlike the other twelve observatories that housed one telescope each, the SMA consisted of eight movable antenna dishes, each measuring 6 meters (20 feet) across. These dishes could be positioned in different configurations to take advantage of a resolution-improving technique called interferometry. The question was whether these eight dishes counted as one telescope or eight separate instruments? Compounding the issue was the newly proposed plan to install four to six small 1.8-m telescopes, called "outriggers," around the Keck Observatories. These were to work in concert with the two large 10-m telescopes, much like the interferometric technique used by the SMA. Astronomers claimed that these telescopes worked in tandem, so should count only as one telescope. While technically true, it was understandably viewed as the semantics of deception by the opposing side—a loophole to bypass the limit set by the initial Master Plan.

• *Overstating Cases.* As mentioned earlier, astronomers unintentionally created the illusion of being wealthy landlords by repeatedly citing the staggering $1-a-second cost for observing time at the summit. While payment was actually made in-kind rather than cash, the overstatement was more damaging than helpful. Overstatements are rarely persuasive and frequently appear self-serving. Unfortunately, neither did the Hawaiian community escape this pitfall. In an effort to emphasize their disapproval of observatories or any structure being placed at the summit, they often recited the claim that the summit was too sacred for even Hawaiian altars. Although none were ever found at the very peak, archaeologists had identified hundreds of shrines, burials, and culturally significant sites within the summit area. From the earliest days when Kuiper conducted his test studies, astronomers had avoided building on the summit's highest peak, called Puʻu Wēkiu. Nevertheless, the observatories were within the summit proper, and so drew constant admonition for encroaching upon land too sacred for any man-made structure. Then, in 1997 the Hawaiian community erected a spiritual altar, called an *ahu lele*, at the very peak of Puʻu Wēkiu. Had the rules changed? Or was overstatement to blame again?

• *Honoring vs. Patronizing.* The controversy already surrounding the aforementioned proposal to add several smaller telescopes around the Keck facility became more inflamed when astronomers suggested naming these add-on telescopes "outriggers." The metaphor was an innocent attempt to compare the spacefaring exploration conducted by the Keck telescope with the seafaring exploration of Hawaiians on canoes fitted with similar supporting outriggers. This reference, however, was viewed by some as condescending. A similar situation occurred at another sacred mountain in Arizona. Mount Graham (known as *dzil nchaa si'an* to the Apaches) has long faced the same controversy as Mauna Kea. In 1992, the innovative Large Binocular Telescope stirred up international protest over its originally proposed name, the Columbus Project (Helfrich *et al*, 2005; Puhipau and Lander, 2006).

• *Self-Imposed Silence.* When community dissent escalated in the early 1990s, astronomers probably felt blindsided. Prior to then, little objection was voiced on the development of astronomy facilities on Mauna Kea. Why didn't the community speak up before? And why now? After all, astronomy was partly responsible for rescuing the failing economy of the Big Island. By 1996, the last sugarcane plantation had closed. Topped only by tourism, the Big Island's astronomy industry today pumps over $150 million into the local economy and employs over 600 workers, many from the island itself.

The Hawaiian community claimed in their defense that their voices had been silenced with the overthrow of the Monarchy and their language suppressed. Indeed, from 1896 until 1986, it was illegal to teach the Hawaiian language in school. But was this claim a legitimate excuse or merely a rationalization? Did this self-acknowledged low self-esteem excuse the silence of the Hawaiian community or only explain it? Certainly, on this count astronomers were blameless.

At least now, the community was speaking up. The vocal dissension that arose in the 1990s had the positive effect of galvanizing the Hawaiian community into articulating the underlying causes of its resentments and demands to set them right. There were still some who vocally demanded the removal of the observatories, but public forums suggested those were in the minority.

Community input during the crafting of the new Master Plan included criticism "that native Hawaiian voices were not part of the advisory or decision making agencies. At the same time, some native Hawaiians mentioned that the voices that were loudest did not necessarily represent the majority of the community." (University of Hawaiʻi. "XII. Master Plan Responses to Community Input", March 2000)

Other, more practical concerns had surfaced in the community's overall testimony. What was in it for the Hawaiian community? How would their children benefit from these telescopes? While the majority felt that a limit had already been reached for building on the summit, the consensus opinion was to use what you have and give back to the community. These sentiments are best summed up by several testimonies presented when the new Master Plan was being formulated (University of Hawaiʻi, "Voices and Visions of Mauna Kea", March 2000):

> "The mountain is very sacred. Some of us feel that you need to remove these structures, but I must accept them. I know that our children need the education. They are gone because there are no jobs here. Just maintain what you have now."
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> —mk, local resident
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> "… this represents a crossroads of two important Hawaiian values: preserving the ʻāina [land] or protecting my ʻohana [family]. Nothing can be found in the past that can compensate for failure in the present." —sa, Keck Observatory employee

Bridging the Gap: ʻImiloa Astronomy Center

The new Mauna Kea Science Reserve Master Plan was finally adopted in 2000 after more than a year of discussions and meetings. This document established a new management board that included Hawaiian representation. It allowed for the building of three additional observatories and the redevelopment of five current facilities. Perhaps, more importantly, the new Master Plan explicitly included an educational outreach component for native Hawaiians and others. The plan essentially adopted the UH-Hilo's independently developed proposal calling for the establishment of the ʻImiloa Astronomy Center (then called the Mauna Kea Astronomy Education Center). *ʻImiloa* in Hawaiian fittingly means *to explore*. The Master Plan stated:

> Education, with an emphasis on outreach to indigenous community members, is a central feature of the Master Plan. Much of the philosophical framework for this finds expression in the proposed Mauna Kea Astronomy Education Center at the University of Hawaiʻi at Hilo. The Center will serve to facilitate formal astronomy education and the integration of science into indigenous cultures at all levels. It also will serve as the principal center in the world demonstrating how the latest science can be integrated with indigenous cultures of great antiquity to maintain unique cultural identity and knowledge while participating at the scientific forefront of the international global society. (University of Hawaiʻi. "VI. Education and Research." March 2000)

The ʻImiloa Astronomy Center was conceived in late 1993 by Marlene Hapai, who would eventually become its director during most of its construction phase. Like the driving force behind the observatories, the initial motivation for establishing this science center and planetarium sprang from employment concerns on the Big Island. (Hapai, 2010)

As dissension over Mauna Kea escalated during the 1990s, ‘Imiloa's mission expanded to include the improvement of relations between astronomers and the community by showcasing the connections between the rich traditions of Hawaiian culture and the groundbreaking astronomical research conducted at the summit.

The University of Hawai‘i at Hilo assembled a team of educators, scientists and community leaders to draw up the plans for the facility. Since ‘Imiloa was intended as a bilingual (Hawaiian and English) educational center, assistance from UH-Hilo's College of Hawaiian Language Studies was enlisted from the start. One of the driving forces behind this project was U. S. Senator Daniel K. Inouye, who was instrumental in securing $26 million of federal funds and NASA grants to design and construct the Center. The actual design phase began in 1999 with construction commencing in 2002. The facility officially opened in February 2006. (University of Hawai‘i at Hilo. ‘Imiloa Astronomy Center, 2010)

The three large titanium-clad cones that are the centerpiece of its unique architectural design symbolize the island's three largest volcanoes—Mauna Kea, Mauna Loa and Hualālai. ‘Imiloa features a 16-m dome planetarium and a 12,000 square-foot exhibition hall with over 300 displays.

All exhibits have bilingual captions. Although this doubles the amount of signage and departs from standard museum practice of minimizing text, bilingual labeling was seen as capitalizing on the revitalization of the Hawaiian language. By creating a fluent Hawaiian language setting, this approach is intended to engage Hawaiian youth in sciences while maintaining pride in their cultural identity.

The exhibits are divided into two main topics that link Hawaiian and scientific beliefs, theories and practices as they relate to Mauna Kea and the cosmos. The two themes are:

> • **Origins**, which focuses on the birth of the cosmos and the beginnings of life on earth.
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> One exhibit is a multi-media amphitheater dedicated to performing portions of the Kumulipo, a 2,000-line chant celebrating the Hawaiian creation story and genealogy. Paralleling this theme from the astronomy side is a second small amphitheater-style room that continually runs a 3D video of the Big Bang theory.
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> • **Explorations**, which features the tools and methods of discovery. Several exhibits are devoted to the Hawaiian canoe, wayfinding (non-instrument navigation) and the voyages of discovery made by the Polynesians. Complementing this are interactive astronomy displays where visitors engage in hands-on activities with astronomical instrument (such as, telescopes and infrared cameras) and become acquainted with the pioneering discoveries being made at the Mauna Kea observatories.

By setting the cultural and scientific exhibits side-by-side in this fashion, a learning environment is created in which Hawaiian cultural contributions are cherished and validated, and astronomical research endeavors are promoted and humanized.

A major component of the ‘Imiloa experience is its state-of-the-art planetarium. Designed with unidirectional seating for 120 visitors, this 16-m dome theater utilizes a fulldome projector with 3D stereoscopic capability. This digital projection system creates an immersive 360-degree viewing environment that allows audiences to vicariously experience voyaging aboard long-distance canoes, observing at the Mauna Kea observatories and journeying into outer space.

The planetarium's signature show, *Maunakea: Between Earth and Sky*, uses parallels to compare Hawaiian culture and astronomy research as related to Mauna Kea, while also touching on the controversy over its use. Audiences are aided in visualizing the creation stories of the Kumulipo and the Big Bang. The show also covers the geological formation of the Hawaiian Islands and recounts the legend of volcano goddess Pele's flight across them towards her eventual encounter with the snow goddess Poli‘ahu atop Mauna Kea. The projector's immersive, fulldome capability allows audiences to fly through the Gemini Observatory and sail along with Hawai‘iloa on his epic discovery of Hawai‘i. (Ciotti and Michaud, 2006)

Even the landscaping surrounding ‘Imiloa offers visitors a learning experience into Hawai‘i's native ecosystem. The garden consists of over 50 native plants, including the "canoe" plants brought to the islands by the early Polynesian explorers. These species illustrate the variety of flora found at the different elevations on the Big Island.

Imiloa also collaborates with the observatories on Mauna Kea to spotlight their astronomical discoveries and make them both accessible and interesting to the public.

According to Senator Inouye:

> The future of astronomy in Hawai‘i—the upgrading of equipment and a skilled local staffing pool—will in large measure depend on good relations with the community, especially those leading the efforts to advance Hawaiian language and culture. The future work opportunities for many young people growing up in Hawai‘i will require even greater preparation in astronomy and related fields. ‘Imiloa serves to unite efforts to advance knowledge of culture and astronomy, deepen understanding and respect for both, and thereby create opportunities for new generations of young people. (Office of Senator Daniel K. Inouye, 2010)

‘Imiloa—Assessing the Impact

Ka‘iu Kimura, ‘Imiloa's newly appointed Executive Director, was involved with the Center since its formative years as exhibits coordinator. Although no formal evaluation has been conducted to assess the success of ‘Imiloa, Kimura is still able to cite anecdotal evidence supporting the positive impact already made by this facility four years after its opening.

She already senses a growth in the community's trust level. Suspicion over hidden agendas and backroom decisions is diminishing. People are even willing to broach the issues with her at supermarkets and other local shops. Kimura feels that ‘Imiloa provides a safe, informal, non-confrontational venue for people to gather and air their differences; and this is proving more fruitful than the contentious atmosphere felt at adversarial public meetings. (Kimura, 2010)

Kimura believes that the community sees the new Master Plan as providing concessions to protecting the mountain, the culture and the environment. With the plan's explicit support of 'Imiloa, the community now appears more reassured of receiving direct benefits. Having been included in 'Imiloa's construction and staffing, the community also views itself to be a genuine stakeholder and integrally involved in 'Imiloa's operation. Kimura believes that by specializing in informal educational opportunities 'Imiloa is better positioned to create ties to the community than the observatories can.

Kimura notes that 'Imiloa is playing a major role in facilitating dialog over the newly awarded Thirty Meter Telescope (TMT) that is scheduled for construction on Mauna Kea beginning 2011. As part of TMT's presentation to the local community, one resident remarked that "the (Hawaiian) culture was here before, and the culture will be here after. We need to look at today," underscoring in her comments the need for jobs and economic development for the island (Gionson, 2009).

At a projected cost of $1.2 billion, the TMT is anticipated to rejuvenate the island's languishing construction industry and create 140 permanent jobs upon completion. Furthermore, the TMT will donate $1 million annually to the community to be used for locally chosen education programs and scholarships. 'Imiloa is already benefiting from TMT's community involvement.

Informal Education—Catalyst for Learning and Mending

The 'Imiloa Astronomy Center takes full advantage of the power of informal learning. Given that individuals generally spend four times as many years out of school as in, it's no wonder that much of what we know comes from experiences outside of formal schooling.

Informal learning can be defined by those "activities that occur outside the school setting, are not developed primarily for school use, are not developed to be part of an ongoing school curriculum, and are characterized by voluntary as opposed to mandatory participation as part of a credited school experience." (Crane *et al*, 1994, p. 3)

Besides keeping the public updated on current advances in science and advocating the importance of the science enterprise, informal education fosters a more informed public that is more likely to become involved in science issues and leverages its extracurricular experiences to support entry into science careers, especially for children who might not be exposed to science and technology.

Informal science education has especially enjoyed a long association with museums. Originally viewed as storehouses for oddities and curiosities of the wealthy and later on as archives for academic collections and public displays, museums were places to passively see things, not engage with them. A paradigm shift occurred in the twentieth century with the opening of the Deutsches Museum and eventual establishment of hands-on science centers like the Exploratorium. Museums transformed from static curatorial to active audience-centered venues. (Crane *et al*, 1994, p. 3).

This change resulted partly from cultural shifts in society: "pluralism, system thinking, and multiculturalism have become more important … No single group is seen as having exclusive access to knowledge." (Crane *et al*, 1994, p.67).

A 1992 report by the American Association of Museums echoed these sentiments:

> Museums perform their most fruitful public service by providing an educational experience in the broadest sense: by fostering the ability to live productively in a pluralistic society and to contribute to the resolution of the challenges we face as global citizens … [museums no longer can] confine themselves simply to preservation, scholarship and exhibition independently of the social context in which they exist. (Excellence and Equity: Education and the Public Dimension of Museums, 1992)

In its *Blueprint for Change*, the National Council on the Revolution in Earth and Space Science Education reiterated this endorsement with special emphasis on its discipline by recommending the creation of "new opportunities for students and parents to learn about earth and space science in informal settings. Education should continue outside the classroom with strong support and involvement from parents and in collaboration with museums, science centers, planetariums and other centers of informal science learning." (Barstow *et al*, 2001)

The ʻImiloa Astronomy Center has embraced this philosophy through its efforts to integrate culture with astronomy as well as to revitalize the Hawaiian language.

A recent report by the *Committee on Learning Science in Informal Environments* that was commissioned by the National Research Council of the National Academies included the following findings:

- A great deal of science learning … takes place outside school in informal environments—including everyday activity, designed spaces, and programs—as individuals navigate across a range of social settings.
- Learning science in informal environments involves developing positive science-related attitudes, emotions, and identities; learning science practices; appreciating the social and historical context of science; and cognition.
- Members of cultural groups develop systematic knowledge of the natural world through participation in informal learning experiences and forms of exploration that are shaped by their cultural-historical backgrounds and the demands of particular environments and settings. Such knowledge and ways of approaching nature reflect a diversity of perspectives that should be recognized in designing science-learning experiences.
- Informal environments can have a significant impact on science learning outcomes for individuals from nondominant groups who are historically underrepresented in science.
- Partnerships between science-rich institutions and local communities show great promise for fostering inclusive science learning. Developing productive partnerships requires considerable time and energy. (Bell *et al*, 2009)

By adopting these guiding principles, ʻImiloa attempts to leverage its mission of inspiring and encouraging Hawaiian and other students to seek careers in science and technology, while remaining grounded in their traditions of family and culture. Its partnerships with the Mauna Kea observatories, the Hawaiʻi Volcanoes National Park and the National Oceanic and Atmospheric Administration (NOAA) serve to increase opportunities for informal science learning in ways relevant to the local culture—thereby bringing these two groups together as equal partners.

Planetariums have long played a major role in providing informal learning in astronomy. This is especially true for the United States, which has seen a checkered history in formal astronomy education. Prior to 1892, astronomy was required in high schools and academies. Thereafter, it was replaced by other physical sciences in the high school curriculum. This situation partially changed in 1957 with the launch of Sputnik. Numerous high schools and even elementary schools purchased their own planetarium when federal funds flowed abundantly under pressure from the space race with the Soviets. Today, an estimated 25% of college students enroll in astronomy courses despite the fact that astronomy remains an elective. Planetariums continue to act as major venues of informal learning—providing opportunities that for many people represent the only chance for exploring our universe. (Stroud *et al*, 2007, p.21)

Over 3,500 planetariums are in operation worldwide today with a total annual attendance of nearly 113 million people. (Petersen, 2010)

Recent meta-analysis of 19 studies that assessed planetarium instructional efficacy showed that planetarium experience improved student performance in most of the learning outcomes. It further demonstrated that planetariums could produce positive effects in student learning, especially for grades K–12. Furthermore, the results indicated that planetariums produce positive effects when supporting interactive observational astronomy instruction. The study concluded by recommending the inclusion of planetarium instruction within the K-12 science curriculum. (Brazell and Espinoza, 2009)

Conclusion

Informal venues hold the potential to serve as conduits for mitigating cultural differences. At least in one particular instance, by bringing astronomers and the Hawaiian community together in the safety of an informal environment, the ʻImiloa Astronomy Center has demonstrated initial success in reducing the controversy over Mauna Kea. However, as is true with museums elsewhere, ʻImiloa needs to conduct formal assessment on the quantity and quality of impact it has made in mitigating these cultural differences and influencing Hawaiian students to enroll in science and technology courses and to enter these careers. If the current success of ʻImiloa Astronomy Center is any indication, other communities experiencing similar disputes— such as, in Arizona over telescopes on Mount Graham or on Maui over Haleakalā's choice for the Advanced Technology Solar Telescope—may consider adopting this facility's approach as a model for overcoming their own differences.

References

Barstow, Daniel, Ed Geary, Harvey Yazijian, and Sandra Schafer. "Revolution in Earth and Space Science Education." In *Blueprint for Change: Report from the National Conference*, 72-73. Snowmass, Colorado: 2001.

Bell, Philip, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder, eds. *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington, D. C.: National Academies Press, 2009.

Brazell, Bruce D., and Sue Espinoza. "Meta-analysis of Planetarium Efficacy Research." *Astronomy Education Review* 8, no. 1 (September 2009). doi: 10.3847/AER2009033. http://dx.doi.org/10.3847/AER2009033

Ciotti, Joseph, and Peter Michaud, dirs. *Maunakea: Between Earth and Sky*. Fulldome Digital Planetarium Show. Produced by Evans and Sutherland. Hilo, Hawaiʻi: ʻImiloa Astronomy Center, 2006.

Crane, Valerie, Heather Nicholson, Milton Chen, and Stephen Bitgood. *Informal Science Learning: What the Research Says about Television, Science Museums, and Community-Based Projects*. Dedham: Research Communications Ltd., 1994.

Excellence and Equity: Education and the Public Dimension of Museums. Edited by Ellen C. Hirzy. Washington, D.C.: American Association of Museums, 1992.

Gionson, T. Ilihia. "Mauna Kea Telescope Debate Continues: TMT's Draft EIS Released." *Ka Wai Ola Newspaper* (Honolulu), June 2009. http://www.oha.org/kwo/2009/07/story03.php (accessed March 12, 2010).

Hapai, Marlene. Telephone interview by author, December 30, 2009.

Helfrich, Joel, Dwight Metzger, and Michael Nixon. "Star Struck: The Astronomical Abuse of Indigenous Sacred Sites." *Pulse of the Twin Cities*, June 1, 2005.

Ho, Nelson, "More Light Shed on the Mauna Kea Controversy," *Nature* 411 (June 2001): 737-738.

Office of Senator Daniel K. Inouye. " ʻImiloa." E-mail message to Joseph Ciotti, March 9, 2010.

Kimura, Kaʻiu. Interview by author, ʻImiloa Astronomy Center Hilo, Hawaiʻi, February 23, 2010.

Lang, Leslie. "Mauna Kea Summitry: Sacred Temple or Window on the Universe—or Both?" *Honolulu Weekly*, March 27, 2002.

Lang, Leslie, and David Byrne. *Mauna Kea: A Guide to Hawaiʻi's Sacred Mountain*. Honolulu: Watermark Publishing, 2005.

McFarling, Usha Lee. "Science, Culture Clash over Sacred Mountain." *Los Angeles Times*, March 18, 2001, Sunday Report edition.

Parker, Barry. *Stairway to the Stars: The Story of the World's Largest Observatory*. New York: Plenum Press, 1994.

Peek, Tom. "Respecting Mauna Kea." *Sky & Telescope*, December 1998, 10.

Petersen, Mark C. More about Tallying the World's Planetarium Attendance. http://www.lochnessproductions.com/pltref/more_attend.html (accessed March 10, 2010).

Puhipau, and Joan Lander, dirs. *Mauna Kea: Temple under Siege*. 2006. DVD. Naʻalehu, Hawaiʻi, Nā Maka o ka ʻĀina, 2006.

Snow, C. P. *The Two Cultures*. 12th printing. 1959. Reprint, Cambridge: Cambridge University Press, 2009.

Steiger, Walter. Origins of Astronomy in Hawaiʻi. http://www.ifa.hawaii.edu/users/steiger/history.pdf (accessed March 6, 2010).

Stroud, Nicholas, Meghan Groome, Rachel Connolly, and Keith Sheppard. "Toward a Methodology for Informal Astronomy Education Research." *Planetarian* 36, no. 2 (September 2007): 20-26.

University of Hawaiʻi. "Voices and Visions of Mauna Kea." March 2000. Mauna Kea Science Reserve Master Plan. http://www.hawaii.edu/maunakea/ (accessed January 18, 2010).

University of Hawaiʻi. "VI. Education and Research." March 2000. Mauna Kea Science Reserve Master Plan. http://www.hawaii.edu/maunakea/ (accessed January 18, 2010).

University of Hawaiʻi. "XII. Master Plan Responses to Community Input." (March 2000). Mauna Kea Science Reserve Master Plan. http://www.hawaii.edu/maunakea/ (accessed January 18, 2010).

University of Hawaiʻi at Hilo. ʻImiloa Astronomy Center. http://www.imiloahawaii.org/ (accessed February 20, 2010).

University of Hawaiʻi Institute for Astronomy. About Mauna Kea Observatories. http://www.ifa.hawaii.edu/mko/about_maunakea.htm (accessed January 29, 2010).

West, Michael J. *A Gentle Rain of Starlight: The Story of Astronomy on Mauna Kea*. Waipahu: Island Heritage Publishing, 2005.

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