2011 原住民科學教育研討會

2011 Symposium of Indigenous Science Education in Taiwan

Funding Agency:

Department of Science Education, National Science Council, Taiwan

Executive Institution:

The Program Office for Indigenous Peoples' Science Education,

Institute of Cognitive Science, National Central University

Date:

13 & 14 July 2011

Venue:

Conference Room #13, Floor 2,

National Science Council

Agenda

Day 1 – Wednesday, July 13th, 2011

Time	Topic	Speaker	Moderator
08:30 09:00	Welcome		
09:00 09:30	Opening Remarks	國科會 科教處 陳國棟 處長 Prof. Gwo-Dong Chen 國科會 李羅權 主任委員 Prof. Lou-Chuang Lee 曾志朗 政務委員 Prof. Ovid Jyh-Lang Tzeng	洪蘭 教授 Prof. Daisy Lan Hung
09:30 10:40	Pedagogies of Hope: Conscientizing Culturally Relevant Teaching for Indigenous Learners in Science and Mathematics	Prof. Eleanor Abrams	郭重吉講座教授 Prof. Chorng-Jee Guo
10:40 11:00	Coffee Break		
11:00 12:00	1.Tribal Classroom-Developing Place-Based Ecological Curricula and Popular Science Activities in Indigenous Elementary Schools 2. "Learning Math Can Be Fun!!" — Tribal Classroom for Indigenous Students	顏瓊芬 教授 Prof. Chiung-Fen Yen	阮啓弘 教授 Prof. Chi-Hung Juan
12:00 13:30	Lunch		
13:30 14:30	Cognitive Austronesian Linguistics and Science Education of the Indigenous Peoples (淺談南島語言的認知體系與原住民科學教育)	李壬癸 院士 Prof. Paul Jen-kuei Li The 26th Academician, Academia Sinica, Research Fellow	洪蘭 教授 Prof. Daisy Lan Hung
14:30 15:30	The Impact of an Indigenous Science Fair on the Indigenous Participants' Science Related Attitudes	傅麗玉 教授 Prof. Li-Yu Fu	阮啓弘 教授 Prof. Chi-Hung Juan
15:30 16:30	Developing a comprehensive Health Education module for Indigenous students in Taiwan	周惠民 研究員 Prof. Hui-Min Chou	阮啓弘 教授 Prof. Chi-Hung Juan
16:30 17:30	Posters Presentations & Coffee Break		

Day 2 – Thursday, July 14th, 2011

Time	Topic	Speaker	Moderator
08:30 09:00	Welcome		
09:00 10:10	Educating for Science Literacy, Citizenship, and Sustainability: Learning from Native Hawaiian Perspectives	Prof. Pauline W. U. Chinn	馬哲儒 教授 Prof. Jer-Ru Maa
10:10 10:30	Coffee Break		
10:30 11:30	Studies on Indigenous Peoples' Science Education, Curriculum Development and Teaching Practice: cases of Tayal Communities in Hsinchu County, Taiwan(原住民族科學教育、課程發展與教學實施之研究一以新竹縣尖石鄉及五峰鄉為合作對象)	汪明輝 副教授 Prof. Ming Huey Wang tibusungu 'e vayayana	李俊仁 副教授 Prof. Jun-Ren Lee
11:30 12:30	Enhancing Indigenous Students' Literacy and Motivation in Science and Mathematics Learning (提昇原住民學生科學與數學識讀能力與學習動機之研究)	楊文金 教授 Prof. Wen-Gin Yang	李俊仁 副教授 Prof. Jun-Ren Lee
12:00 13:30	Lunch		
13:30 14:30	Integrating Paiwan Indigenous Culture into Elementary Science Teaching	高慧蓮 教授 Prof. Hui-Lien Kao	李俊仁 副教授 Prof. Jun-Ren Lee
14:30 15:30	Curriculum Development and Evaluation of Science Education through CPS Strategy Integrated with Indigenous Culture(融合原住民文化與CPS之科學課程發展與評鑑-以能源、機器人為例)	劉遠楨 教授 Prof. Yuan-Chen Liu	李俊仁 副教授 Prof. Jun-Ren Lee
15:30 16:00	Discussion		李俊仁 副教授 Prof. Jun-Ren Lee

Keynote Speaker　　Prof. Paul Jen-Kuei Li (李壬癸 院士)

李壬癸院士三十多年來的研究主要分為兩方面：一為台灣南島語言的調查研究，一為 台灣閩南方言的研究。關於前者已發表專書十四種：《魯凱語結構》、《魯凱語料》、《台灣南島語言的語音符號系統》、《宜蘭縣南島民族與語言》、《高雄縣南島語言》、《台灣南島民族的族群與遷徙》、《台灣平埔族的歷史與互動》、《台灣原住民史-語言篇》、《巴宰語詞典》、《巴宰族傳說歌謠集》、《台灣南島語言論文選集》、《噶瑪蘭語詞典》、《新港文書研究》、《珍惜台灣南島語言》，論文數十篇；關於後者也已發表論文五篇。這些論文大都在國內外學術期刊上發表，根據實際觀察所得的語言現象來驗證現有的一些語言理論，或提出個人的新看法。在本行已有一些具體的貢獻。對於歷史語言學而言，這些語言的現象提供了兩種新的看法：不同的年齡和性別差異都可能造成語言的演變。此外，秘密語言也可能促使語言的變遷。有關閩南語的研究，本人的研究主要是嘗試開闢新的研究方向，如「閩南語的兩個否定詞」，「台灣秘密語」觀察到一些新的語言現象，對於音韻理論提供了一些決定性的證據。 從一九九四年起，也進行東南地區南島語言的調查研究計畫。

Professional Experience

- Associate Research Fellow(1970-1976), Research Fellow (1976-1997), Director, Division of Language (1981-1986), Deputy Director (1990-1993), Institute of History and Philology, Academia Sinica
- Visiting Associate Professor (1974-1976), Professor(1976-1984), National Taiwan University (joint appointment)
- Professor and Director (1986-1989), Adjunct Professor (1990-1995), National Tsing-hua University
- Visiting Professor, University of Hawaii (1984.08-12)
- Visiting Professor, Ohio State University (1985.01-08)
- Visiting Professor, LSA Linguistic Institute, Cornell University (1997.06-07)
- Research Fellow and Director (1997-2000), Research Fellow (2000-2006), Distinguished Research Fellow (2006), Institute of Linguistics, Academia Sinica

Awards and Honors

- Life-time Achievement Award, Linguistic Society of Taiwan (2005)
- Academician of the Academia Sinica (2006), Academia Sinica
- Special Service Medal Award (2007), Academia Sinica
- Distinguished Alumnus Award (2007), National Taiwan Normal University
- Distinguished Research Award for Fellows with Special Contract (2008), National Science Council
- Honorary Member of the Linguistic Society of America (2008), Linguistic Society of America
- 2009 Presidential Science Prize (2009)

原住民科學教育研討會
國科會2011.07.13

淺談南島語言的認知體系與原住民科學教育

Cognitive Austronesian Linguistics and Science Education of the Indigenous Peoples

李壬癸Paul Li
中央研究院Academia Sinica

1

1. Language and thought 人類有語言，才有思想

- 人類跟人類最接近的靈長類動物—黑猩猩，其基因的差別，只有百分之一。
- 人類跟其他動物最大的差別是人類有語言，而其他動物都沒有。
- 人類有語言，才有思想，才可能產生各種文明、科學、技術、藝術...
- 人類有了語言，知識才能累積，知識才能無限。

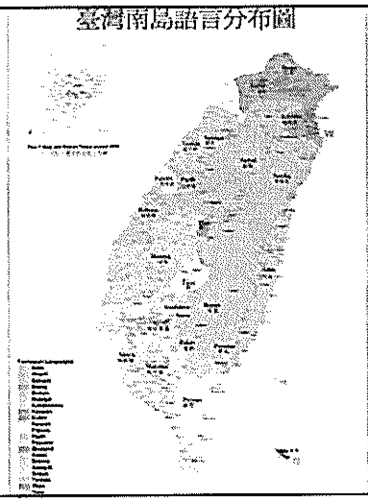
2

2. Sapir-Whorfian hypothesis: Linguistic relativity語言相對論

1) All higher levels of thinking are dependent on language
所有高層次的思考，都必須依賴語言才能運作。
2) The structure of the language one habitually uses influences the manner in which one understands his environment
一個人所使用的語言，其結構系統影響他對外界事物的了解，所以人們的宇宙觀因語言而異。

- 台灣原住民族都屬於南島民族。
- 南島語言的結構系統跟漢語和英語都有顯著的不同，思考模式也就有顯著的差異。

3



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3. Numerals in Formosan 台灣南島語言的數詞系統

1) 台灣南島語言的數詞系統跟漢語和英語都有很顯著的差異，他們彼此之間也有不少的差異。
2) 一般南島語言都採用十進法（decimal system），然而台灣南島語卻也有五進法，如平埔族巴宰語：6到9是5+1，5+2，5+3，5+4；賽夏語的7是6+1。
3) 泰雅、賽德克、邵語和西部平埔族語群的6是二個3（2x3），8是二個4（2x4），賽夏語的8也是二個4。
4) 數詞10以下的，除了用加法和乘法表示以外，還有用減法：賽夏、邵和西部平埔族語群的9是10-1。

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5) 賽夏語的數詞20是指「完整的人」sha-m'iLaeh < m̀a'iLaeh「人」。
   - cf. 法語的80是4x20 quatre-vingts

- 問題與討論：
  - 何以世界上的語言常是十進法、五進法、二十進法？
  - 一隻手有五個手指，二隻手有十個手指，手和腳共有二十指。台灣南島語言lima是「手」，也是「五」，如布農、魯凱、排灣、邵、西部平埔族。
  - 台灣南島民族的數詞系統既然有這些差異，會不會影響他們在數理方面的學習？這是值得進一步研究的問題。

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4. Human vs. nonhuman人與非人

- 南島語言的數詞有兩套不同的形式：人與非人（物）。例如，

鄒語	cihi一（人），	coni一（物）
	roso二（人），	ruso二（物）
邵語	ta-tusha一（人），	la-tusha一（物）
布農	ta-cini一（人），	tasa一（物）
排灣	ma-cidil一（人），	ita一（物）
卑南	mi-sasa一（人），	sasa-ya一（物）

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- 跟數詞有關的詞彙，包括「多少」：

邵	pa-piza多少（人），	la-piza多少（物）
噶瑪蘭	kin-tani多少（人），	u-tani多少（物）
阿美	pa-pina多少（人），	pina多少（物）
泰雅	pa-pia'多少（人），	pia'多少（物）
賽夏	piza'多少（人），	kuza'多少（物）

- 也包括「多」和「少」

噶瑪蘭	ma-zmun多（人），	m-waza多（物）
魯凱	ta-kaLa多（人），	ma-kaLa多（物）
魯凱	ka-bekel少（人），	bekel少（物）

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5. Natural phenomena, human body and language從自然景物和人體的觀點所發展出來的知識體系和語言現象

- 世界上許多語言，都是以日出的方向為「東」，如鄒語eosmonza hie「日出處」；日落的方向為「西」，如鄒語meovza hie「日落處」。
- 其他如泰雅語、魯凱萬山、卡那卡那富
  - 泰雅語：htgan wagi'「日出處」
  - 魯凱萬山：tase'ese'e'ae koli'i「日出處」
  - 卡那卡那富：talalaka taniare「日出處」

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- 南島語言以自然景物作為方向的指標（template），包括「內陸」（靠山）和「下游」（靠海）
  - 巴宰daya「東」，卑南Daya「西」< *Daya「內陸」
  - 卑南LauD「東」，巴宰rahut「西」，排灣Lauz「南」< *lahuD「靠海」
- 原來的語詞是以自然景觀作為方向的指標，後來卻轉移為指稱東西南北的方向，各種語言的語意才會有那麼大的差異。

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6. Human body as template 以身體作為指標

- 語言常以身體作為指標，如前面、後面、背後、左、右、（頭）上、（腳）下...
- 傳統的原住民族對於身體各部名稱都很清楚，包括身體外部和內臟：頭、臉、眼、鼻、口、舌、耳、頸、肩、胸、乳、腹、背、腰、肚臍、手、臂、腿、腳、指、指甲、毛/髮/鬚、皮、牙、膝蓋、尾、角、骨、髓、心、肝、肺、胃、腸、膽、膀胱、血、汗、尿、糞、淚、痰、鼻涕...
- 以上這些大都是日常生活的常用語彙（basic vocabulary），有族語能力的人大都可以說得出來，與傳統的狩獵有關。

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- 人體各部位的名稱常擴展（extend）到指稱其他有生命或無生命的東西，如山頭、山腳、山腰、山脊、山脈、山口、河口...
  - 泰雅語群的baki「大拇指」，卻由親屬稱謂baki「祖父」擴展而來，
  - 賽夏語的ba-baki 「大拇指」，也由親屬稱謂baki「祖父」擴展而來。
  - 噶瑪蘭的baqi「祖父」，由人擴展到動物「百步蛇」。
  - 噶瑪蘭的sna-razat「瞳孔」<razat「人」。

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7. Metaphorical usage of body part terminology人體名稱的隱喻用法

- 以現代科技的知識，大家都知道我們思維的巢穴和情緒的反應都在腦部，可是，過去的人卻常認錯了器官，漢人以為是「心」，如「我心裡所想的」。
  1) It touched my heart.
     感動了我的心。
  2) In your heart you know I'm an honest man.
     你內心也知道我是誠實的人。
  3) How to win her heart.
     如何贏得她的芳心。
  4) There's a man after my own heart.
     有一個男人很合我的心意。

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- 台灣南島語言也有類似的用法，例如，噶瑪蘭語（主＝主格，斜＝斜格）
  - **Kavalan**:
    5) mai aisu tu anem.
       沒 你 斜 心
       你沒良心。
    6) mpiray anem-ku kasi-anem tu waway-ku.
       累 心-我的 思想 斜 家事-我的
       一想到我的家事，我的心就煩了。
- 日語也有類似的用法：
  - 7) 心が変わる 變心，改變主意
    cf. to change one's mind

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- 其實，身體名稱的隱喻用法，在世界上的語言是很普遍的。只是不同的語言，可能使用不同的器官。
  8) 漢語說「膽大」，而日語說「肝粗」（肝が太い）
  9) 漢語說「嚇破膽」，而日語說「肝碎了」（肝をつぶす）
  10) 沙阿魯阿語以「腹」比喻內心，例如
      masiame civuka-ku.
      辣 腹-我的
      我的腹部很辣＝我的內心很難過。

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- 泰雅語汶水方言用法像漢語的，如
  11) balaiq 'a' tunux su'.
      好 主 頭 你的
      你的頭好＝你聰明。
  12) muxaal 'a' tunux mu.
      病,痛 主 頭 我的
      我的頭痛(沒生病)＝我傷腦筋
- **Kanakanavu**
  13) aaka=ku cepeng=aku.
      壞=我/主 心=我的
      我的心情不好。

16

- **Puyuma** (Tsuchida 1995:798)
  14) na-ngnu k-in-a-sahar mu,
      Nom-2sg thing-loved Top
      Hawlay ziya i Lima li.
      exist still Loc hand my
      'What you want is still in my hand
      = I can still dominate you.'
  15) na-ngnu zazek a lalak u ziya mu,
      Nom-2sg body Lig young 2p still Top
      Hawlay ziya i maTa li.
      exist still Loc eye my
      'Your figure in your youth still lies in my eyes
      = I still remember you when you were young.'

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- **Atayal** (Mayrinax dialect):
  16) aqih 'a' ngaquaq nia'.
      壞 主 口 他的
      他的嘴壞＝他口出惡言。
  17) rahual 'a' ngaquaq nia'.
      大 主 口 他的
      他的嘴巴大＝他愛亂講話。
  18) mamati' 'a' saik su'.
      硬 主 肝 你的
      你的肝硬＝你很固執。
  19) qanaruux 'a' hma' nia'.
      長 主 舌 他的
      他的舌頭長＝他貪心，愛佔人便宜。

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– **Saaroa:**

20) 'icevere mana vungu ripas-isa,
嫩心 當作 頭 鉛彈-它的
ku-pasikera na vungu tamulumula.
不-能夠 頭 白頭翁(鳥)
用嫩心當作鉛彈打白頭翁的頭，卻打不到
＝人還太年輕，不適合結婚（鉛彈＝睪丸）

21) a-uka-uka cu ka caLinga. (Tsuchida Text 1)
忘 了 主 耳
耳朵忘了＝我忘了。

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– **Thao:**

22) maqitan a punuq thithu.
好 頭 他
他的頭好＝他聰明。

23) mathuaw yaku antu maqitan a shnaw.
很 我 不 好 心
我的心情很不好。

– **Paiwan** (provided by Amy Lee)

24) pirakas a quvalj ti=sun.
erect Nom hair =2sg.Nom
'(Your) hair is erected. (= You look frightened).'

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–

25) inu-an a su-mudingan?
where Nom 2sg.Gen-face
'Where is your face? (= You are shameless.)'

26) me-liyaw a su-maca!
AF-many Nom 2sg.Gen-eye
'Your eyes (are) many. (= You are nosy.)'

27) djalaw a nu-lima.
fast Nom 2pl.Gen-hand
'You are pickpockets.'

28) neka nu su-va?
Neg. 2sg.Gen-lungs
'Don't you have lungs? (= You are reckless.)'

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– **Seediq** (Truku, provided by Amy Lee):

29) m-tutuy ubal tunux=na.
AF-stand hair head=3sg.Gen
'His hair stood up. (= He is/was very angry).'

30) naqih tunux=na.
bad head=3sg.Gen
'His head is bad. (= He is stupid.)'

31) m-pahung bi ka laqi nii.
AF-gall.bladder very Nom child this
'This child is very bad-tempered.'

32) m-hulis doriq=na ka uwa nii.
AF-laugh eye=3Sg.Gen Nom girl this
'The girl is very happy.'

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8.結語

- 台灣南島語言多采多姿，有豐富的內涵和知識體系，尚有待我們進一步去發掘。
- 可惜這些語言都有嚴重的傳承問題，其知識體系也將隨著語言的滅絕而消失了。
- 現在受教育的原住民，從小學到大學，絕大多數的人都不是以其族語為第一語言，而是漢語。

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Keynote Speaker　　　　Prof. Eleanor Abrams

任教於 University of New Hampshire，專長領域為師資培育與環境教育，包括：科教視導，專業發展，科學本質、課室中真確符實的科學學習、概念發展、地方感、以及永續發展等跨領域的教與學研究。Dr. Eleanor Abrams 致力於和職前與在職老師共同建置對環境友善的課程進行教學實踐，其中包含地方感與永續環境的教學模組的發展，同時運用這一些內涵來改進科學教學。對於「生物、文化多樣性知識」這個主題歷來多方努力，於近幾年間參與、主持過國際間，包括台灣，各場大大小小有關環境教育或科學教育專業研討會議。

Professional Experience

- 1999-current　Associate Professor Department of Education, University of New Hampshire
- 2004-2007 Director of Outreach Scholarship
  - Office of the Vice President for Research and Public Service
  - Developed and administered the UNH Outreach Scholars Academy
  - Chaired the Undergraduate Research Conference for three years
  - Provided leadership on the NEASC accreditation plan in one of three main focus areas of engagement through research and scholarship
  - Severed as an advisor on to incorporate outreach and engagement in multimillion dollar, interdisciplinary grant proposals to federal agencies

Honors and Awards

- 1998-2001 Hortense Cavis Shepard Professorship
- 1998　UNH Summer Faculty Fellowship
- 1993　Louisiana Educational Research Association Dissertation Award

Journal Editorial Board

- Editorial Board Member for the International Journal of Science Education (1998-Present)

Publications

- Sandmann, L., Williams, J., & Abrams, E. (in press). Higher education community engagement and accreditation: Becoming bedfellows through interpretive strategies, Planning in Higher Education.
- Gengarelly, L, & Abrams, E. (in press). Inquiry into research and the science classroom, Journal of Science Education and Technology.
- Potter, S., Abrams, E., Towson, L., Williams, J. & Wake, C. (in press). Intellectual growth for undergraduate students and faculty: Evaluation results from an undergraduate research conference, Journal on Excellence in College Teaching.
- Abrams, E., Towson, L., Williams, J. & Sandmann, L. (2007). Engaged Faculty at the University of New Hampshire, Journal of Higher Education Outreach and Engagement, 11(4).
- Mueller, A. & Abrams, E. (2005). Sense of Place Among New England Commercial Fishermen and Organic Farmers: Implications for Socially Constructed Environmental Education, Environmental Education Research, 11(5), 525-535.

Pedagogies of Hope: Conscientizing Culturally Relevant Teaching for Indigenous Learners in Science and Mathematics

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Abstract

The Collaborative for Indigenous and Rural Science Education (CIRSE) hopes to end the "culture of silence" where Indigenous students internalize the negative images of their culture created and propagated by the institution of schooling by creating virtual and relational resource corridors between Indigenous communities and their schools. This presentation will use the Jared Diamond's theory of cultural island biogeography as a framework to understand Indigenous students' perceived lack of motivation to learn science and the resulting low academic performance in science classrooms.

Diamond's theory on the influencing cultural factors might help us understand what factors affect a students' success of failure in school and might help us determine a more inclusive pedagogical response. This presentation will focus on two empirical studies that help us understand one case study, the Republic of Altai, to discuss some of the potential influencing factors that either support or challenge students from engaging with classroom science: a case study from the Altai Republic, and preliminary data from a study of standardized tests including Indigenous knowledge. Some factors to be discussed will be the history of colonization, the current gap between hegemonic and Indigenous cultures, the national agenda for science, the location of the Indigenous community in time and space, and the way science is taught to the Indigenous students.

The second part the presentation is a discussion of culturally relevant research practices as a way to determine and support "best practices" for the teaching science to Indigenous students in culturally and environmentally unique settings worldwide.

Informational Paper

Conscientization explicitly empowers knowledges and resources of repressed groups, by facilitating a learning process that becomes critical, "transitive" and potentially liberating. The objective for this presentation is to explore culturally relevant teaching of science to Indigenous learners. The Collaborative for Indigenous and Rural Science Education (CIRSE) hopes to end the "culture of silence" where Indigenous students internalize the negative images of their culture created and propagated by the institution of schooling as unable, historically and currently, to be producers of scientific knowledge and Indigenous students as low-achieving science learners.

Modern Indigenous students are characterized as facing the problem of living in two worlds, struggling to living in their culture and the mainstream culture (Barnhardt, 2005). This cultural tension has been used to explain Indigenous students' performance in school, where they often do not perform as well in science and mathematics as their mainstream counterparts globally (Chien, 1998; Fu, 2003; Lin, 1999). For example, U.S. Indigenous high-school students participate in advanced science courses at a much lower rate than do non-Indigenous students (U.S. Department of Education, 2001). Poor performance is reflected on test scores from recently implemented standardized state science tests and the addition of science testing by the National Assessment of Educational Progress (NAEP). NAEP testing in 2005 found 4th grade scores of American

Indian/Alaska Natives at 138 and their White counterparts scoring 162 out of 300, with similar discrepancies exhibited in both 8th and 12th grades (National Center for Education Statistics, 2010). Globally, Indigenous students follow similar trends in the TIMSS assessment.

Much of the research in science education exploring the reasons why Indigenous students do not perform well in science classrooms or score well on international, national and local assessments focuses on the epistemological basis of knowledge construction of science and Indigenous Science (IS). Indigenous science (IS) is described as a holistic, contextualized process that has a high regard for nature in relation to humanity and is the result of observations, thinking and descriptions over an extended time period (Cajete, 1988). Alternatively, Western Modern Science (WMS) is described as based on logical empiricism (positivism), universal principles, and has an emphasis on control and manipulation of nature, and reliance on observation and experimentation over a limited period of time (Snively & Corsiglia, 2001). Many research projects have focused on merging the two worldviews of IS and WMS, describing for the students the differences in the two views or teaching the students to "border cross" from one view to another as a way to support Indigenous students' learning within science classrooms.

McKinley (2001) challenges that notion and makes clear that one cannot ignore the power relationships in the classrooms or the "relations between dominant and subordinate groups marked by histories of oppression" (pg 75) as a reason Indigenous students underperform in science. The curricula, teaching methodologies, and assessment strategies associated with mainstream schooling are based on a worldview that does not adequately recognize or appreciate IS (Kawagley et al., 1998) or the life of modern Indigenous youths (Abrams et al, 2010). The question arises whether the other factors including the role of science as a colonizing influence may be causing Indigenous learners to "opt out" of learning science (Abrams et al, 2009).

Students in Indigenous societies around the world have, for the most part, demonstrated a distinct lack of motivation for the experience of schooling in its conventional form, an aversion that might be attributable to an alien institutional culture rather than any lack of innate intelligence, ingenuity, motivation or problem-solving skills on the part of the students (Battiste 2002). McCarty in her 20 years of enthnographic work in one Navajo school found that Navajo students are forced to engage in as school system that fails to educate (2002). Indigenous students leaving small rural villages schools to enter a majority school experience obvious differences in living conditions, access to resources, and expectances for opprtunities. "Rigid schedules, impersonal relationships, inaccessible faculty, expectation of aggressive verbal participation and spotlighting in class, incomprehensible homework assignments, produce serious conflicts and pressures that require considerable adjustments for many Indigenous children" (Barnhardt, 2004).

But even these adjustments are not as difficult to manage as the differences in the ways of thinking that permeate majority schools. Indigenous students trying to survive in the majority school environment must acquire and accept a new form of consciousness, an orientation that not only displaces, but often devalues the worldviews they bring with them. For many, this is a greater sacrifice than they are willing to make, so they withdraw and go home, branded a failure. Those who do survive in the academic environment often find themselves caught between different worlds, neither of which can fully satisfy their acquired tastes and aspirations, and thus they enter into a struggle to reconcile their conflicting forms of consciousness (Kawagley 1995; Meyer 2001).

As part of the presentation, some preliminary results on one U.S. state efforts to develop culturally relevant standards for all of its learners as well as associated state test items will be discussed. Some interesting findings support the theoretical perspective that the solution to enhancing Indigenous students motivation and achievement in science might have school-wide and community implications.

The *Handbook of Research on Science Education* (2007) offers insight into the teaching and learning of rural students that might be applicable to Indigenous students. The author of the chapter of rural science education stated rural schools need: (1) rural teachers to teach science within a frame of reference that consciously builds in a cooperative inclusion of community, (2) recognition of the unique student and school needs in the community and (3) the inimitable capabilities of the teachers found in those schools (Oliver, 2007). These recommendations seek to focus the solutions on school-wide teaching of science rather than on the deficits of the students, teachers or curricula.

Enacting change at the classroom or school level is necessary and important but not sufficient to reconcile the dilemma of under-performing students since they do not address the prevailing conditions of communities and culture that act as influencing factors. For example, we can expect small or modest success for Indigenous students if the teachers skillfully interweave WMS and IS into a classroom and even if they are provided with high quality culturally relevant curricula. Each school in conjunction with the community needs to determine the "best practices" that would work for their students and their community.

However, the theory of island biogeography might help us frame the issue of low performance and motivation of Indigenous learners in a broader cultural context beyond classrooms that may give insight into influencing factors that also need attention. The theory was developed in the 1960s by ecologists, Robert MacArthur and E.O. Wilson as they attempted to predict the number of species that would exist in island habitats. An island is defined as any area of suitable habitat surround by an expanse of unsuitable habitat. There are factors influencing the success and continued existence of any species on island. Some of those factors are size of the island, length of isolation from other islands or mainland and habitat suitability. Jared Diamond (2005) co-opted this ecological theory into a cultural framework and applied five influencing factors (climate change, hostile neighbors, collapse of essential trading partners, environmental problems, and failure to adapt to environmental issues) that affect the success or collapse of a society. He studied 13 cultures as part of his study and found the ultimate determination of success or collapse of a society was decided by the society's cultural reaction to those factors.

We posit that Indigenous communities can be described as islands within the majority landscape, often unconnected to other Indigenous community islands. These islands have their own culture associated with each community. A unique aspect to Indigenous island cultures that differ from the Jared Diamond studied is the addition of schooling controlled by a majority culture. Schools are typically a reflection of the majority culture and have been a very effective vehicle for transmitting a culture's knowledge, believes, values and practices to the one's youth. Schooling has been used in the past to "educate" Indigenous students in the ways of the majority culture by repressing their Indigenous heritage and only teaching about the majority culture. Historic examples of this practice are numerous including the use of missionary schools for American Indians in the United States to boarding schools for Aboriginal children in Australia. If schools do not want to repeat this oppression, what should be the school's role to educate Indigenous students?

Diamond's theory on the influencing cultural factors might help us understand what factors affect a students' success of failure in school and might help us determine a more inclusive pedagogical response. This presentation will focus on two empirical studies that help us understand one case study, the Republic of Altai, to discuss some of the potential influencing factors that either support or challenge students from engaging with classroom science: a case study from the Altai Republic, and preliminary data from a study of standardized tests including Indigenous knowledge. Some factors to be discussed will be the history of colonization, the current gap between hegemonic and Indigenous cultures, the national agenda for science, the location of the Indigenous community in time and space, and the way science is taught to the Indigenous students.

The second part the presentation is a discussion of culturally relevant research practices as a way to determine and support "best practices" for the teaching science to Indigenous students in culturally and environmentally unique settings worldwide (Smith, 1999; Rogoff, 2003; Denzin et al, 2008). Our collaborative, CIRSE, values the diversity that exists within Indigenous communities and seeks to support the excellence of Indigenous students in science and mathematics and create science and mathematics classrooms that consciously builds an inclusive learning community. Part of the discussion will focus on the building of technological "corridors" connecting Indigenous community "islands" as way to facilitate the exchange of ideas and culturally relevant practices.

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Keynote Speaker Prof. Pauline W. U. Chinn

現職於美國夏威夷大學，為夏威夷大學-馬諾阿校區(University of Hawai'i-Manoa)資深教授，並曾於美國教育部和美國國家科學基金會的支持下取得 MBA 學位。曾在 Journal of Research in Science Teaching 擔任過三年的副主編，現為 Cultural Studies of Science Education 期刊編輯。其研究領域主要為科學教育，研究面向包括：永續性發展、地方本位教育、師/生教與學多樣性分析、原住民科學，以及跨文化、性別、語言等研究議題。在科學教育的領域的創新上，她將夏威夷原住民的智慧融合於課程的開發，在中、小學推廣以社區本位的環境議題，這些跨文化科學教育的研究成果豐碩並廣為人知。

Professional Interests

Dr. Pauline W. U. Chinn's research in science education focuses on indigenous science, sustainability, culture/gender/language issues, and teacher/student diversity. She is especially interested in inquiry, reflective, and collaborative teaching practices leading to more inclusive, place-based, community-oriented curriculum and instruction for ethnicity, race, gender and language minority students. She serves on the Culture Studies in Science Education Editorial Board and served three years as an Associate Editor for the Journal of Research in Science Teaching. She reviews for Multicultural Perspectives and co-edited a special issue of L1-Educational Studies in Language and Literature.

Publications

- Chinn, P. (In press). Educating for Scientific Literacy, Citizenship, and Sustainability: Learning from Native Hawaiian Perspectives. In M. P. Mueller, D. J. Tippins, & A. J. Stewart (Eds.), A Guide To School Policy And Legislation In Science Education: Assessing Schools For Generation R(Responsibility). NY: Springer.
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Educating for Science Literacy, Citizenship, and Sustainability: Learning from Native Hawaiian Perspectives

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Abstract

Native Hawaiian students often develop extensive ecological knowledge through informal and non-formal cultural and subsistence practices. This knowledge seldom connects to mainstream school science developed for middle class students in the continental US. Displacement of Native Hawaiian knowledge, values, and practices may contribute both to their underrepresentation in science as well as the decline of Hawai'i's sustainable social-ecosystems. Four elements of a Hawaiian cultural model of sustainability provide the framework for professional development oriented to sustainability: 1) a Hawaiian sense of place, 2) mālama, active care for a familiar place; 3) kuleana, responsibility; and 4) active inquiry situated in real world issues. Place-based lessons incorporating these elements orient science learning to sustainability, a fundamental cultural goal. Teachers reform their instruction when they recognize that students' communities, culture, and practices are resources for science education. Findings suggest reestablishing Mālama I Ka 'Āina, Sustainability, as a Hawai'i State science standard would connect formal to informal and non-formal science knowledge, support systems thinking, and engage students in problem solving and civic action for the common good.

Introduction

My views as a science educator are shaped by my work in Hawai'i, the world's remotest chain of islands. Prior to Western contact in 1778, cultural survival required constant monitoring, analysis, and responding to changing societal and environmental conditions. Long-term, place-based knowledge was associated with an ethic of care (mālama) and responsibility (kuleana) that supported resilience and sustainability. But the science I learned at school was shaped by texts and classroom-based instruction oriented to continental students. Later as a science teacher, I found many Native Hawaiian students in my Plants and Animals of Hawaii classes but few in my college preparatory and college level (Advanced Placement) classes. My doctoral research showed that long-standing differences between Native Hawaiian students' indigenous/marginalized and school/dominant cultures contributed to underrepresentation of Native Hawaiians in college preparatory mathematics and science courses (Chinn, 1999b). In my own College of Education, Native Hawaiians are now over-represented (13-19%, 2004 to 2010) in all programs compared to 10% Native Hawaiians and other Pacific Islanders statewide (U.S. Census Bureau, n.d.). But they remain underrepresented (2.9-12.5%) in an already small preservice secondary science program (<4% of enrollment). This paper explores underrepresentation in science of Native Hawaiians in the context of a wider national and international debate on science literacy, sustainability, and citizenship.

Many Hawaiian/Part Hawaiian families continue subsistence practices that build ecological knowledge that seldom connects to school science. Disconnects between knowledge valued at school and home may contribute to Hawaiian/Part Hawaiian children scoring 11% lower in math and 10% lower in reading than peers on the Hawaii State Assessment examinations (Hawai'i Department of Education 2010). At 28% of public school students, they are more likely to be taught by Japanese (29%) or Caucasian (23%) than Hawaiian/Part Hawaiian (9%) teachers (Hawai'i State Department of Education 2009). Castagno and Brayboy (2008) note: "The most obvious, but also most lacking, knowledge among teachers is an awareness and understanding of Indigenous cultures, histories, and political issues" (p. 972). An example in science education is the recent removal of a culturally grounded Hawai'i State science content standard, "Mālama I Ka 'Āina, Sustainability" as recommended by an outside consulting group.

The following story illuminates the intersection of culture, science, and education. Dr. Isabella Kauakea Aiona Abbott, the first Native Hawaiian woman to earn a PhD in natural science, a world authority on marine algae, and my mentor in Indigenous Hawaiian science education, told me that being Hawaiian was first among her identities as scientist, university professor, wife, and mother (Chinn 1999). Years later, an unscheduled visit to her laboratory shortly before a NOAA (National Oceanic and Atmospheric Administration) research and education cruise to the Northwestern Hawaiian Islands (now Papahānaumokuākea, a World Heritage) showed what this meant. When I commented on a small banana plant in a bucket, Dr. Abbott said a protocol offering the banana, symbol of Kanaloa, god of the sea would notify the akua (gods) and aumakua (ancestral gods) of the arrival of the NOAA vessel. Sabra Kauka, cultural practitioner and science educator, presented the banana and other culturally significant plants when they reached Papahānaumokuākea.

This paper will address three questions relevant to science education:

What is the deeper meaning of Dr. Abbott's protocol involving culturally significant plants?

What role may Indigenous Hawaiian cultural practices and values play in science education oriented to sustainability, citizenship, and science literacy?

What role may place-based teacher education play in science education oriented to sustainability, citizenship, and science literacy?

Before addressing these questions, I present an overview of major US educational ideologies, introduce place and culture-based education, and develop the concepts of sense of place, mental models, and cultural landscapes.

Locating Place-Based Education in Western Schooling

Schiro (2008) views US education as guided by four major western ideologies: scholar academic focused on acquisition of disciplinary knowledge; social efficiency focused on efficient preparation of learners to be productive members of society; learner centered focused on experience-based preparation for the future; and social reconstruction focused on problem finding and problem solving. Sternberg's (2003) research suggests educational ideologies have implications for student learning and society. He finds high stakes tests emphasizing content mastery (scholar academic and social efficiency) favor the success of middle class, mainstream students. He faults test-based accountability measures for producing pseudo-experts lacking community-based, experiential learning that fosters critical thinking and real world problem-solving skills.

Fairclough (2006) holds that "people need resources to examine their placing...between the global and the local...and need from education a range of resources for living within socially and culturally diverse societies" (p. 151). Gruenewald (2008) provides a place-based starting point: "What needs to be transformed, conserved, restored, or created in this place...[could] provide a local focus for socioecological inquiry and action that, because of interrelated cultural and ecological systems, is potentially global in reach" (p. 149). Woodhouse and Knapp (2000) note that place-based learning's multidisciplinary emphasis, experiential and service learning, broader focus than preparation for a consumer-oriented society, and understanding of self as part of a social-ecological system provides "knowledge and experiences needed to actively participate in the democratic process" (p. 33).

According to Moll, Amanti, Neff and Gonzalez (2001), place-based learning's inclusion of non-formal learning associated with cultural activities and informal learning associated with day-to-day experiences enables learners to connect school learning to community and culture-based "funds of knowledge" (p. 134). An Organization for Economic Co-operation and Development (OECD 2010) policy paper notes that recognizing out of school and non-formal knowledge can provide economic, educational, and social benefits by "allowing human capital to be used more productively," "improving equity and...access to...education," "making individuals aware of their capabilities and validating their worth" (p. 1) and encouraging life-long learning.

This analysis is particularly relevant to tourism, Hawaii's main economic activity, and what makes it unique: a Hawaiian sense of place. The Hawaii Tourism Authority (n.d.) defines its responsibility as "supporting programs that enhance and showcase Hawaii's people, place and culture in order to deliver an incomparable visitor experience." This explicit recognition of the value of place and culture-based knowledge highlights a critical issue between national policies oriented to test-based accountability and Hawai'i's ecological, societal, and economic realities.

Hawaiian Sense of Place: A Culturally Shaped Mental Model Oriented to Sustainability

Everyone has a personal sense of place, a mental model employed across a range of disciplines to connect human experience to constructed and natural settings. Craik (1943) first proposed the notion of a mental model as a representation of external reality coupling knowledge of past events with scenarios of possible actions to mitigate potential crises. Jackson (1984), a geographer, views place as shaping personal identity: "It is place, permanent position in both the social and topographical sense that gives us our identity (p. 152). Nisbett and Norenzayan (2002) observe that "Cultural practices encourage and sustain certain kinds of cognitive processes, which then perpetuate the cultural practices" (p. 3). A sense of place is thus a culturally shaped mental model with implications for identity and ways of thinking about and acting within the world.

Maly (2001) describes a Hawaiian sense of place as "the intimate relationship (developed over generations of experiences) that people of a particular culture feel for the sites, features, phenomena, and natural resources etc., that surround them" (p. 1). Abbott (1992) writes, "Hawaiians did not belong to a village but rather to an ahupua'a, a land division extending from the mountain heights to the sea" (p. 11). People lived sustainably within their ahupuaʻa through a system of mauka -makai, upland-coastal exchange. Hawaiian place names (Pukui, Elbert and Mookini 1974; Clark 2002) associated with resources and nature gods created storied, historical landscapes in which myth and reality entered "into all the affairs of daily life" (Beckwith 1940/1970, p. 2). Many stories, moʻolelo, such as those of the gods of fishing (Kūʻula) identify "authentic fishing grounds and stations for fishermen in island waters" (p. 20) and describe fish aggregation and spawning sites.

A traditional ʻōlelo noʻeau (proverb), "He ali'i ka 'āina he kauwā ke kanaka; the land is a chief, man is its servant" (No. 531, Pukui, 1983) expressed the relationship between humans and the land that sustained life. George Kanahele (1986) explained the difference between Hawaiian and western worldviews when he wrote: "If we are to be truly consistent with traditional Hawaiian thought, no one really owned the land in the past...The relationship was the other way around: a person belonged to the land. We are but stewards of the ʻāina and kai, trusted to take care of these islands on behalf of the gods, our ancestors, ourselves, and our children" (p. 208).

Webster's II New Riverside University Dictionary (Riverside Publishing Company 1984) definition of nature reveals a separation of culture and nature in the English language:

Nature: n. [ME, essential properties of a thing < Lat natura <nasci, to be born] 1. The material world and its phenomena. 2. The processes and forces that produce and control all the phenomena of the material world. 3. The world of living things and the outdoors (p. 786).

In the Hawaiian language, there are no words for nature or environment in the sense of a world outdoors or physical universe (Pukui and Elbert 1986). Kanahele's statement, "a person belonged to the land" unites economics and ecology as complementary concepts. These ideological differences between western and Indigenous worldviews are examples of Harding's (2003) observation that "all knowledge systems, including modern sciences contain at least traces of their particular histories and ongoing practices; they are all 'local knowledge systems' in this respect" (p. 58). She concludes that "all four conditions of inquiry processes—location in nature, interests, discourses, and ways of organizing inquiry—are shaped by a culture's (or subculture's) 'location' in social relations" (p. 59).

According to Wylie (2003), our location within a social system "systematically shapes and limits what we know, including tacit, experiential knowledge as well as explicit understanding" (p. 31). In the context of American economic and political influence and expansionism (Office of the Historian http://history.state.gov/milestones/1866-1898/Hawaii), it is not surprising that within 200 years of western contact in 1778, Hawai'i transitioned from a sustainable society to one importing 85% of its food and 95% of its energy (Hawai'i Sustainability Task Force 2008).

Hawaiians commented on this transition in more than 100 Hawaiian language newspapers published from 1834-1948 (Silva and Badis 2008). "Saving the Fish," a 1923 article in Ka Nupepa Kuokoa illuminates the role of competing cultural models in sustainability practices. The writer deplores the decline of fisheries within his own lifetime. He notes that sustainable fisheries were maintained by a knowledge-based kapu system enforced by harsh penalties. Practices that conserved and augmented marine resources included prohibiting fishing during spawning seasons and specific months, restricting locations and fishing rights, restricting certain fish to men or high ranking individuals, constructing and maintaining fishponds (Titcomb 1952/1972), and discouraging eating of fish roe (Titcomb 1952/1972; Barrows personal communication).

After US annexation in 1898, traditional resource management systems were abolished as commercial fishing and open access became the law of the land. But Indigenous Hawaiian views of sustainability persist as seen in a 1994-2005 Hawaiian science content standard "Mālama I Ka 'Āina, Sustainability;" a new 'ōlelo no'eau, "The ocean is our refrigerator;" biorestoration of Kaho'olawe Island a former bombing target guided by traditional practices (Gon 2003); and the Hawai'i 2050 Sustainability Task Force's (2008) recommendation that citizens "Preserve and perpetuate our Kanaka Maoli (Indigenous Hawaiian) and island cultural values" (p. 12).

Complex Systems, Tipping Points, and Cultural Orientation to Sustainability

In 1999 the National Research Council (NRC) prioritized research that "integrates global and local perspectives to shape a 'place-based' understanding of the interactions between environment and society" (p.10). A decade later, the NSF Advisory Committee for Environmental Research and Education (2009) warned that these interactions could lead to tipping points when the system shifted rapidly to a very different state unless society could learn from experience and respond to changes observed in the system.

Hawai'i's sustainable social-ecosystems relied upon long term, place-based knowledge constantly updated through monitoring, analysis, and action before tipping points were reached. Beckwith (1940/1970) observes that riddling competitions "between masters of learning" across Polynesian cultures were tests of knowledge in which the loser might pay with his life (p. 462). The knowledge required to live sustainably within ahupua'a spanning Mauna Kea's 13,800-foot summit to the open ocean is outlined in the answer to a riddle describing 23 wao (zones) on the Island of Hawai'i (Maly 2001). Within an ahupua'a, resource managers, konohiki, integrated knowledge of human and natural systems across levels of organisms, populations, communities, ecosystems, and biomes.

Abbott (1992) emphasizes the role played by the Makahiki na o Lono, an annual, island-wide event dedicated to Lono, "god of peace, planting, and fertility" (p. 16) in sustainability. For two months during the rainy season, while the king (mō'ī) or queen (mō'ī wahine), priests, and retainers visited each ahupua'a, fishing, farming, and warfare ceased and local knowledge was integrated into broader, island-wide understandings.

Indigenous Inquiry and Science Education: Perspectives from Hawai'i Educators

As a sustainable society, Hawaiian culture exhibits hallmarks of adaptive learning that parallel the US National Science Education Standard for inquiry, including "the dispositions to use the skills, abilities, and attitudes associated with science" (NRC 1996, p. 105). In what follows, educators in Kūlia I Ka Nu'u, a professional development project underwritten by an award from the Native Hawaiian Education Act provide insights into a kanaka maoli approach to inquiry and science education spanning formal, non-formal, and informal learning (Chinn, Abbott, Barrows, Kanahele-Mossman, Kapana-Baird, Kauka, Lee, Lelepali, Ross, and Walk 2011).

In early 2010 my team and I began planning for two culturally responsive, inquiry-based teacher education courses with the question, "What is Indigenous Hawaiian inquiry and what are implications for science teacher education?" Six themes emerged from discussions spanning several months.

The first five suggest the importance of preparing science teachers to recognize and connect cultural knowledge and practices to their instruction. The last describes barriers to implementation of place and culture-based inquiry.

1. Hula, Chants,'Ōlelo No'eau, and Mo'olelo

Hawaiian educators view traditional narratives as sources for indigenous inquiry. Moana Lee, an archeologist-educator observed that "Mo'olelo kept alive through hula are so much a part of indigenous research methods. There's a red flower [no longer seen] in a hula I was learning. What a loss that we still have our language but not the land to tie it to." Huihui Kanahele-Mossman elaborated on the ecological information contained in traditional oral literature:

That is the difference between scientists and Hawaiian practitioners—both hear the song, but when we cannot see what is being referred to it hurts us because our chants are also our genealogies. Our sources of research are these living things in our songs and stories, as books, journal articles and research studies are sources of information for western scientists.

2. Indigenous Identity and Cross Generational Cultural Expectations

Napua Barrows' turning point in connecting culture, stewardship, and science instruction came through participating in an invasive seaweed removal in a professional development class:

I thought [the native limu] should be restored. [Now] I work with limu restoring, replanting, since the area I live on Maui is where my tutu is from and I learned the family mo'olelo. She took me around, showed me all the lands and gave me the kuleana to take care of this. What I take care of at Waihe'e has extended to all of Maui and connected with other islands. It has generated a lot of excitement--we work with the communities, get the kids involved. We were raised with some of it and we're ready to get back. And I can hear my grandmother. That's where the knowledge is waiting there for us if we open that door. Then you have to go with it after that, you just can't drop it.

3. Place-based Cultural Practices

Interaction with and knowledge of place are culturally inseparable from responsibility, kuleana, and active care, mālama. Sabra Kauka describes Nu'alolo Kai, a site that "shows the longest continuous sequence of occupation on Kaua'i" (Abbott 1992, p. 10):

Nu'alolo Kai chose us. In 1992 we took back our first re-interment as a result of the Native American Graves Protection and Repatriation Act (NAGPRA). The trail was only a goat trail so the kūpuna led us there. We realized that we needed to begin to mālama that special 'āina, we had to clean and clear. Nu'alolo Kai is still dynamic. We are studying it hoping to once again to live that place and bring others in to live that place.

4. Indigenous Knowledge, Practices, and Place-based Teaching

Michelle Kapana-Baird teaches both satellite navigation (global positioning system) technology as well as non-instrumental methods in her Maunalua Bay biorestoration project.

Recently our students were in charge of invasive algae cleanup. A member of the community organization asked, "What are your GPS markings?" I said, "I don't have one today." "So how do you know it's accurate? I knew she wanted to know the markings of my site, what are the points....these things, it's all the science. So I told my student, "Mele, Hawaiians didn't have GPS. This is what Ka'au told me when we used to sail into Kualoa. You'd find a high land mark and a low land mark." And I know the lady is listening. "What is a good landmark and what makes sense to you?" So I asked her to line it up with the hālau, (canoe house) a coconut tree, the Norfolk tree and the mountain. The lady came to me and said, "You triangulated your sights, I know you know what you're doing."

Mahina Hou Ross, a Hawaiian language immersion teacher on Moloka'i integrates traditional, place-based practices into his standards-based science lessons. Learning is useful; specimens are not discarded as in typical classroom dissections. His students learn marine ecology connected to place and sustainable fishing practices:

Uncle Mac Poepoe of Mo'omomi says, "If you can teach the kids what the kūpuna taught us, we have a chance." We have four sites we visit each quarter; the kids actually see the health of the different parts of Moloka'i. We take students into the water, look at the fish and check what they've been eating. Like kole (Ctenochaetus strigosus), to get the cycles and seasons for spawning, you've got to cut them open to find out. Then you've got to eat, so we fried them up. And show the learning is standards-based--they see the relevance of the curriculum when they go hunting, fishing, diving.

5. Place and Culture-based Professional Development

Ag-science teacher Matthew Kanemoto describes how place-based professional development connecting formal to non-formal and informal science helps teachers transform their instruction:

[Teachers] get to see, smell, feel and do. We built a bioremediation system for the agriculture program at Kohala High School and re-established lo'i that were over one hundred years old at a mountain stream. We visited Konawaena High School where Maverick Kawamoto built a bioremediation system that uses watercress, aquatic plants, kalo and mollusks to clean the nitrogen-rich effluent water from their fish tanks and cooked our food in an imu (underground oven). Educators take what they have learned and apply it in their own classrooms and communities. Hawaiian placed-based education can open up and unlock the hearts and minds of our local Hawaiian students and bring relevance and meaning to science concepts and curriculum by drawing upon what our kids already know and love...the 'āina (land) and the kai (sea).

6. Institutional, Cultural, and Societal Barriers

Institutional barriers to place-based, indigenous methods of inquiry include schedules that interfere with community-based learning, high stakes tests that discourage time-intensive inquiry projects, and teachers lacking interdisciplinary knowledge and culture-science preparation. Michelle noted that pollution and development of once-loved places and urban, consumer-oriented lifestyles have disrupted continuity of place-based knowledge and practices. Moana recalled comments about science from the Hawaiian community: "About 25 years ago I was at a public meeting. One of the things being rejected by the Hawaiian community was science. Scientists are no good. Science was outright rejected because it had nothing to do with culture."

Discussion

Three questions oriented the writing of this paper. The first, "What is the deeper meaning of Dr. Abbott's offering of a banana plant?" may now be addressed in light of understandings of culturally-shaped mental maps (Nisbett & Norenzayan 2002; Kanahele 1986; Craik 1943) and standpoint theory (Harding 2003; Wylie 2003) that view inquiry, values, and knowledge as being shaped by location and experiences in particular socio-ecological settings. As a prominent scientist, Dr. Isabella Aiona Abbott's culturally significant offerings from a NOAA research vessel signified the intersection of two cultural knowledge systems. The protocol recognized the Northwest Hawaiian Islands as a Hawaiian place; oriented research to sustainability, "He ali'i ka 'āina he kauwā ke kanaka; the land is a chief, man is its servant" (No. 531, Pukui, 1983); and symbolically challenged the "assumption that modern Western science alone has the most desirable resources with which to grasp nature's order" (Harding 2003, p. 55).

The second question, "What role may Indigenous Hawaiian cultural practices and values play in science education oriented to sustainability, citizenship, and science literacy?" is answered by the adoption of Mālama I Ka 'Āina, Sustainability, as a state science standard in 1994. It combined science literacy with a sustainability ethic and sought to connect formal, informal, and non-formal learning. Its recent removal in a standards review by an outside consulting group underscores the challenges of teaching in schools oriented to mainstream instruction and assessment. The revision enables teachers to address state standards of science inquiry and interrelations of science, technology, and society (Hawai'i Department of Education, n.d.) but omits the former standard's explicit connections to sustainability and active stewardship.

The third question, "What role may place-based teacher education play in science education oriented to sustainability, citizenship, and science literacy?" is answered by science educators who commented above on the importance of professional development that 1) integrates culture and science, 2) provides models of sustainability science programs, 3) develops a sense of place, and 4) supports collaborations enabling ongoing learning. Teaching and learning, concepts that differ in power and knowledge in English are unified in the Hawaiian word a'o, meaning both to teach and to learn (Pukui and Elbert 1986).

Matthew Kanemoto's comments on place-based teacher education capture key elements of a kanaka maoli (Indigenous Hawaiian) approach: teachers experience school science in the context of culture and place at a range of school, community, and field-based sites. His experiences transformed a conventional, production-oriented agriculture program into one that reflects place and culture through native and Polynesian plantings, teaches sustainability by using nutrient-rich aquaculture water to grow plants, and demonstrates values of responsibility (kuleana), care (mālama), and love of the land (aloha 'āina) through providing plants to family, school, and community gardens.

Implications for Place-based Teacher Education and Curriculum Design

Professional development as content, process, and journey echoes the Makahiki O Lono, the annual circuit of each island in which visits to each ahupua'a supported broad and deep understandings related to sustainable social ecological systems. Following a 4-5 day culture-science immersion (Chinn, 2006) in which teachers visit and service learn in a range of exemplary sustainability science sites, teachers research the ahupua'a in which they teach, interview elders about life in more sustainable times, then write and teach inquiry lessons relevant to their locale but connected to global issues (See Na Pua O Maunalua at http://manoa.hawaii.edu/coe/kulia/, a student-made video about teacher Michelle Kapana-Baird's culture-science program (Chinn, 2010.)

Teachers who recognize and can incorporate students' "cultural and cognitive resources with great potential (sic) utility for classroom instruction" (Moll et al. 2001, p. 134) do more than engage diverse students in meaningful learning. They provide educational, social, psychological, and future economic benefits to underrepresented and alienated students who otherwise might not persist in school. Science educators and policy makers find this difficult to reconcile with the reliance on test scores to measure student learning across states and nations. But science teachers who connect formal, informal, and non-formal learning find it personally meaningful, professionally empowering, and supportive of student academic success. They deserve greater support given Hawai'i's position as the least sustainable state in the U.S. yet one that relies upon its natural and cultural capital for its economic survival.

Conclusion

Both locally and internationally, scientists and policymakers are beginning to recognize the role of indigenous knowledge and practices in resource management and sustainability. The Secretariat of the Convention on Biological Diversity (2010) notes: "The loss of biodiversity is frequently linked to the loss of cultural diversity, and has an especially high negative impact on indigenous communities" (p. 7).

The saying "*'A 'ohe pau ka 'ike i ka hālau ho'okahi,* All knowledge is not taught in the same school" (No. 203, Pukui 1983) says one can learn from many sources. Two decades ago, *Mālama I Ka 'Āina*, Sustainability was chosen as a Hawai'i State Science Content Standard because it supports problem solving, systems thinking, and civic engagement oriented to sustainability. It foreshadowed the NRC's call for a "research framework that integrates global and local perspectives to shape a 'place-based' understanding of the interactions between environment and society" (1999, p.10). *Mālama I Ka 'Āina*, Sustainability, continues to inform professional development that connects school learning to culturally meaningful, inquiry and community-based learning because it recognizes the value of *kanaka maoli* culture to society at large.

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Chapter 16
Science, Culture, Education, and Social–Ecological Systems: A Study of Transdisciplinary Literacies in Student Discourse During a Place-Based and Culture-Based Polynesian Voyaging Program

Pauline W.U. Chinn

16.1 Introduction

As the world's most isolated islands with the highest number of endangered species per square mile anywhere on earth (Bishop Museum 2003), Hawai'i provides a unique setting for exploring questions concerning science, technology, and society. For reasons ranging from issues of health, safety, and schedules to adoption of science curricula developed for national audiences to science teacher education, relatively little of the science students learn in school relates to Hawai'i or connects to students' familiar environmental experiences and knowledge. Conventionally presented as a body of universal knowledge discovered through objective, impersonal, and culture-free experimentation, students perceive school science as largely unrelated to their places, practices, and personal knowledge.

16.1.1 Teaching, Learning, and Knowledge Building as Socially Situated

In reality, the doing of science is both a place-based and cultural activity as researchers take local contexts into account and communicate using the language and conventions of particular disciplines. Meyer's (1998) interviews with Native Hawaiian elders about indigenous knowledge building led her to conclude that "Sites of practice, where the product, process and context were Hawaiian – that

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(*sic*) was where both information and practice synergized and strengthened the threads of cultural continuity" (p. 143). If the word *scientific* replaces *Hawaiian* and *cultural*, it becomes apparent that the ongoing development of science knowledge, the continuation of science as a culture, and the processes of incorporating new members are active social processes, situated in places where participants' *shared practices*, tools, and language (i.e., discourse) (Gee 2004, 2005) develop and sustain particular ways of understanding (Bourdieu and Passeron 1977).

What are the connections among cultural and scientific knowledge building, cultural continuity, and social–ecological systems (SESs)? Research in Hawai'i suggests that transdisciplinary learning communities that include indigenous practices and knowledge are critical to building the capacity to respond to ecosystem changes (Kaneshiro et al. 2005). Folke's (2004) overview of the role of traditional knowledge in *ecosystem management* notes that knowledge systems that develop through a community's daily and long-term ecosystem interactions address "interactions across temporal and spatial scales and organizational and institutional levels" and may provide models for adaptive capacity, characterized as learning and responding during "periods of rapid change, uncertainty, and system reorganization." Davidson-Hunt and Berkes (2003) cited Folke et al.'s (2003) synthesis of four principles for building *adaptive capacity* in SESs: " (1) learning to live with change and uncertainty, (2) nurturing diversity for reorganization and renewal, (3) combining different types of knowledge for learning, and (4) creating opportunity for self-organization." Liu et al.'s (2007) synthesis of six coupled human and natural system studies across five continents underscores the importance of explicitly addressing "complex interactions and feedback between human and natural systems" to gain "unique interdisciplinary insights into complexities that cannot be gained from ecological or social research alone" (p. 1513).

This case study from Hawai'i illuminates the complexities of one such coupled human and natural system. Until a recent revision, Hawaii's science content standards included *Mālama I Ka 'Āina, Sustainability*, incorporating a Hawaiian perspective on active stewardship. Kanahele (1986) explained its cultural significance: "If we are to be truly consistent with traditional Hawaiian thought … we are but stewards of the *aina* and *kai*, trusted to take care of these islands on behalf of the gods, our ancestors, ourselves, and our children (pp. 208, 209)." *Konohiki*, a category of individuals with recognized expertise actively managed the SESs that sustained Hawaiian communities (Kumupono Associates 2008):

> Acknowledging the relationship of one environmental zone (*wao*) to another is rooted in *traditional land management* practices and values…These traditional *wao* or regions of land, districts, and land divisions included: *1–Ke kuahiwi*, the mountain; …*7-8–Ka wao ma'u kele and Ka wao kele*, the rain belt regions; …*10–Ka wao la'au*, the forested region; *11–Ka wao kanaka*, the region of people below;…*14–Ka pahe'e*, the place of wet land planting;…*18–Ka po'ina nalu*, the place covered by waves [shoreline]; *19–Ke kai kohola*, the shallow sea [shoreline reef flats];…*23–Kai popolohua-a-Kane-i-Tahiti*, the deep purplish black sea of Kane at Tahiti (Kihe in *Ka Hoku o Hawaii*, September 21, 1916; Maly, translator).

Values of respect and care for nature that indigenous Hawaiians view as sustaining their existence are also found in American Indian and Alaskan Native cultures

(Cajete 1999, 2000; Kawagley and Barnhardt 1999). Davidson-Hunt and Berkes (2003) described how individual learning becomes part of community knowledge among the Anishinaabe, a First Nations people located near the border of Ontario and Manitoba, Canada. Among the Anishinaabe, social processes exist for incorporating individuals with new knowledge into recognized categories of holders of social memory. Through extensive life experiences that develop detailed, place-based knowledge, an individual may be recognized as especially competent and knowledgeable and become an elder, a socially designated role that recognizes certain individuals as a source of authority and "legitimate social memories."

The mapping of the Hawaiian social–ecological landscape into the 23 *wao* described above provided a cultural framework for constructing, organizing, and transmitting knowledge and values supportive of *socio-ecological resilience*. These knowledge-processing frameworks enabled individual and group memory to be consolidated into a dynamic body of cultural knowledge able to respond to changes in the SES. For example, the *Makahiki na o Lono,* an important island-wide, annual ritual dedicated to *Lono*, god of crops and bringer of rain began in late fall at the first new moon following the appearance of the Pleiades. For 2 months, war as well as fishing, planting, and other forms of work ceased as the island's ruling chief, *mō'i*, chiefly retinue, and priests made a complete circuit of the island, visiting each *ahupua'a* and receiving tribute. In effect, the *Makahiki* (meaning year, yearly) served as an institutionalized, annual island-wide monitoring of a range of SESs, enabling consolidation of cross-scale, cross-temporal information for resource management oriented to sustainability.

Abbott (1992) suggested that the *Makahiki's* biological significance lay in the "two-month period when the land could rest, plants could grow without being harvested, and the ocean could replenish itself" (p. 22). When the *Makahiki* was not in force, lesser chiefs serving as resource managers, *konohiki,* in each largely self-sustaining resource unit, *ahupua'a,* enforced appropriate behavior with strict sanctions, *kapu*, that structured the lives of all classes of society. In twenty-first century Hawai'i, indigenous ways of thinking about SESs continue to provide a framework for a responsible relationship of people to place.

16.1.2 Reconnecting School Science to Place, Culture, and Practice

Davidson-Hunt and Berkes (2003) warned that the loss of indigenous values and the institutions that authorized and legitimized construction and transmission knowledge can lead to loss of resilience that is both social and ecological in nature. Unfortunately, the perception of many science teachers that science is objective and culture-free contributes to insensitivity to the sociocultural contexts of teaching and learning (Greenfield-Arambula 2005). The absence of authentic, personalized, *experiential learning* is a critical factor in successful schooling of Native Hawaiian students (Kawakami and Aton 2000) and in the persistence of underrepresentation of female students in college physical science and engineering programs (Chinn 1999).

The gap between Hawaiian ways of learning that lead to transdisciplinary, situated, active knowledge and conventional school learning that leads to decontextualized science knowledge suggests that delegitimization of traditional knowledge systems, values, and ways of learning may contribute to the underrepresentation in science of Native Hawaiians. Ten years ago, the goal of removing or narrowing this gap motivated the writer to design a science education course, EDCS 433 Interdisciplinary Science Curriculum, *Mālama I Ka 'Āina,* Sustainability with a place-, culture-, and inquiry-based focus.

Summer EDCS 433 courses allowed teaching and learning to be situated primarily in transdisciplinary, culture–science learning communities in which expert peer teachers, scientists, and community members provided models of place-based science programs. Course assignments asked teachers to view their communities as resources for writing lessons meeting the criteria of rigor (content-rich, standards-based), relevance (significant issue, meaningful to learners), and relationships (learning community). When external funding permitted, overnight *culture–science immersions* in school and community settings provided opportunities for diverse participants to learn from and to teach each other. The teacher in the case study reported below developed her place-based program into an exemplary model with the support of several years of funding from *Pīkoi Ke Kaula Kualena,* Focus on the Essential Core, an award to the Consortium for Hawai'i Ecological Engineering Education from the U.S. Department of Education, Native Hawaiian Education Act.

16.1.3 Theoretical Framework and Research Questions

The theoretical framework for this qualitative study is located in social learning research and theory associated with Bourdieu and Passeron (1977), Lave and Wenger (1991), Wenger (1998), and Gee (2004, 2005). Lave and Wenger's (1991) theory of knowledge acquisition is based on studies of learning situated in communities of practice focused on specific outcomes. A *community of practice* (Wenger 1998) has the characteristics of joint enterprise and mutual engagement among "people who engage in a process of collective learning in a shared domain of human endeavor." The reciprocal and dynamic nature of teaching and learning is captured in the Hawaiian word *a'o,* meaning instruction, teaching, doctrine, learning, advice, and counsel (Pukui and Elbert 1986).

Social learning theories acknowledge the role of modeling, observational learning, subjectivity, intentionality, and a plurality of sociocultural contexts productive of multiple identities and literacies. Learning is viewed as a social process with implications for identity-building that occurs over an individual's lifespan in formal and informal situations.

A sociolinguistic approach suggests that insight into learning may be gained in settings in which students use vernacular or home language and practices while learning and practicing academic and content area communication practices and skills. The analysis of *Discourse* – defined by Gee (2005) as "ways of combining and integrating language, actions, interactions, ways of thinking, believing, valuing and using various symbols, tools, and objects to enact a particular sort of socially recognizable identity" (p. 21) – is discussed below as a way to study teaching and learning.

Gee's (2004) critique of schooling relevant to equitable access to knowledge is based on the distance between "academic varieties of language connected to content areas" (p. 19) and the vernacular language of home and community. His research shows that children from nonmainstream cultural backgrounds learn forms of language that are discouraged in schools, whereas those from middle class homes learn forms that parallel academic speech valued in schools (e.g., providing explicit detail on a single topic). Gee thinks entry into a Discourse community with specialized language and practices (signified by a capital D) involves a trade-off between loss of vernacular, everyday language and gain of specialized language:

> So a crucial question in science education, for example, ought to be: *"What would make someone see acquiring a scientific variety of language as a gain?"* ... People can only see a new specialist language as a gain if: (1) they recognize and understand the sorts of socially situated identities and activities that recruit the specialist language; (2) they value these identities and activities ...; and (3) they believe they (will) have real access to these identifies and activities.... Thus science in school is learned best and most deeply when it is, for the learner, about "being a scientist" (of some sort) "doing science" (of some sort) (p. 93).

A view of *learning* as socially situated, supporting development of a new *identity* through the acquisition of an integrated set of language/knowledge/skills and occurring in sites of practice provides a research agenda that looks for evidence that language, identity, and knowledge change as a result of this type of learning. Gee's (2005) approach to discourse analysis is used to explore the following questions:

- What socially situated identities and activities are enacted?
- What Discourses are involved?
- What relationships appear among different Discourses?
- How does intertextuality function in texts?

16.2 Study Setting and Participants

Project Ho'olokahi is a school-based Polynesian Voyaging program led by Michelle Kapana-Baird, a certified physical education teacher and canoe paddler associated for many years with the Polynesian Voyaging Society. She was motivated to study Maunalua Bay by Myron Thompson, a prominent educator and leader in the Hawaiian community and Polynesian Voyaging Society. He had remarked on the appearance of alien seaweeds in Maunalua Bay, where her students applied their learning with the support of the canoe club and Polynesian Voyaging Society. Michelle enrolled in EDCS 433 in 2002 with the goal of developing a plan to restore the bay.

Maunalua Bay is located in the Waikiki *ahupua'a* between the tuff volcanoes of Diamond Head, *Leahi,* and Hanauma Bay. Its name, Maunalua, two mountains, signifies its position between two mountains. The eastern section is connected by two dredged channels to the remnants of the largest precontact fish pond in Hawai'i. In 1959, the 500+acre fishpond was designated private property in a landmark court case, permitting the development of a marina community designed for 50,000 but now home to 60,000 residents. Long-time residents observe that the number of hammerhead shark pups found in the 200-acre marina has declined over the years. The development of a park, boat ramp, and a large parking lot on the ocean side of the marina support year-round use by residents and tourists. Commercial activities include paddling, kayaking, jet and water skiing, scuba diving, coastal boat tours, snorkeling, and fishing. Michelle's canoe club, *Hui Nalu,* houses its canoes on one side of a channel; a bird sanctuary is on the other.

Students in *Project Ho'olokahi* learn and practice cultural protocols, Polynesian navigation, sailing, and a core *cultural value,* caring for the land that feeds, *mālama i ka 'āina.* Students are 15–18 years old and become lifeguard-certified as a prerequisite to ocean activities. Most who enroll in this elective course are Native Hawaiians. As often found with courses that provide active, hands-on learning, special education students were overrepresented in Michelle's class compared to their percent in school. The culture–science immersion documented by students occurred during the 2005–2006 school year.

The author-researcher was born and raised in Hawai'i. She used to fish and collect edible seaweed at Maunalua Bay, and she taught science at Michelle's school before becoming a university instructor. EDCS 433, an interdisciplinary place- and culture-based science curriculum course was underwritten by the Native Hawaiian Education Act, U.S. Department of Education.

16.3 Methodology

This qualitative case study seeks to understand how students in Project *Ho'olokahi* construct meaning and express themselves through journal excerpts and video clips they select as most important to telling the story of their culture–science immersion. Data sources include the videotape and transcript from *Na Pua O Maunalua,* The Youth of Maunalua. The researcher was a participant-observer during one of the three culture–science immersions, conducted site visits at the school and in the community prior to and following the immersions, and attended the community meeting announcing the establishment of the nonprofit *Mālama Maunalua.* Michelle Kapana-Baird reviewed the paper to ensure cultural and interpretive validity (Cohen et al. 2007).

Discourse analysis (Gee 2005) was applied to the transcript of a student-made video describing their 24-h culture–science immersion. The analysis examines sites of practice, language, activities, actors, and tools to detect Discourses that suggest learning and identity building; social languages associated with home, school, and disciplines; intertexuality of words as relating to words spoken by others; "and conversations" that relate to "themes, debates, or motifs that have been the focus of much talk and writing in some social groups … or society" (p. 21).

16.4 Results

Two years after beginning her culture–science program in 2003, Michelle led three community-based immersions at Maunalua Bay. The 24-h agenda received by students and parents revealed extensive integration of culture and science. Students would learn from graduate students, U.S. Geological Survey and Fish and Wildlife agents, science teachers, and a Master Navigator. Expertise spanned marine biology, Global Positioning System (GPS) mapping, water testing, Polynesian sailing, and navigation. Indigenous contexts for learning were seen in the frequent use of Hawaiian words and the following of Hawaiian protocol in *pule*, prayers or blessings, that focus attention on the place, activity at hand, and key participants and serve to connect natural, cultural, and spiritual worlds at key transition points. The agenda overall exemplified school *Discourse*, and the agenda content, Hawaiian and science words, tools, and activities exemplified cultural and science Discourses.

The author attended one of the three 24-h culture–science immersions from morning through the early afternoon. Michelle had divided her class into three groups as the *Hokulea*, the voyaging canoe on which they would spend the night did not have adequate space. Students paddled out to the reef flat to remove alien seaweeds in the company of botany graduate students and agency scientists. Each canoe held six paddlers, including an adult steersperson from the *Hui Nalu* Canoe Club. A small skiff towed by one of the canoes carried collecting bags, scoop nets, and other supplies necessary for site work. At all times students and adults were in close contact, working and learning together in various roles. The author observed an adult-to-student ratio of one adult to three students, in contrast to the 26 students to one teacher ratio in public schools.

16.4.1 Discourse Analysis of Transcript of Na Pua O Maunalua

Students' journal entries provided the narrative of a 5-min videotape of the October 2005 immersions. Students completed the 16-stanza videotape in May 2006. Different students spoke each stanza, defined by Gee (2005) as "sets of lines devoted to a single topic, event, image, perspective, or theme" (p. 127). Selected stanzas are elaborated upon below to highlight the way situated culture–science learning appears to support the simultaneous development of students' cultural and scientific literacy. (See Appendix for the complete transcript.[1])

Stanza 1 introduces a key role model and program mentor, master navigator Nainoa Thompson, who in 1980 became the first Native Hawaiian navigator in many centuries to navigate a double-hulled voyaging canoe between Hawai'i and Tahiti without instruments (http://pvs.kcc.hawaii.edu/finney80.html). He was given

[1]The program description, "Invasive Alien Algae Removal Efforts Aim at Restoration of Maunalua Bay" and *Na Pua O Maunalua*: A Video Documentary may be viewed at http://www.kaiser.k12.hi.us/minisites/catarticle/CAT.html.

this title by indigenous navigators following a series of long distance voyages. The dominant Discourse is academic discourse, providing descriptive detail of a single topic, the 24-h immersion.

Stanza 2 reveals the dual *Discourses* of school and Hawaiian culture that establish a Hawaiian context for the community-based activity. Using English at the beginning of the stanza to describe the purpose of the immersion establishes the activity as a school event but a shift to Hawaiian midway through emphasizes the cultural role of stewardship. The impersonal label and role "environmental stewards" becomes the culturally contextualized *haumana*, students, who will *mālama i ke kai o Maunalua*, care for Maunalua, the area of the sea they know, use, and enjoy and therefore must care for it. The canoe club's *hālau* houses canoes and gear and has served as their learning site since the project began. (*Hālau* is also associated with meetinghouse and place of learning.) The final phrase "*experiential learning*" in English returns to school Discourse but conveys place-based, purposeful, active Hawaiian ways of learning.

Stanza 3 is a hybrid of school, science/technology, and cultural Discourses. It opens with school Discourse (first activity of the day) and then shifts into science/technology Discourse when describing uses of GPS tools for scientific data collection and communication. The only use of Hawaiian/local cultural Discourse is to introduce an agency scientist as Aunty Annie. This positioning of a scientist as a member of an extended family, *'ohana*, establishes a pattern noted in succeeding stanzas that suggests the students' familiarity with scientists as role models.

Stanza 4 shows the blending of informal discourse with school, science, and cultural Discourses. The overall format, a detailed description of a single activity, clearing alien *limu*, reflects school and science Discourse. "Quadrate, square meter, scoop net, floating fragments, because, generate, colony" – representing the tools, terms, ways of seeing and measuring an objective world – indicate the students' scientific literacy.

The Hawaiian word *limu,* seaweed, is used four times and *kuleana*, right/responsibility, is used once without elaboration in English. The ability of video to convey meaning through action of *kuleana* – a core Hawaiian ethic oriented to personal responsibility and sustainability – indicate that it would be well known to the audience. This is an example of Gee's (2005) Conversations, themes that are generally known to particular social groups, in this case, Native Hawaiians, most residents of Hawai'i, and those familiar with *Mālama i ka 'āina, sustainability*, a former science content standard. Students' voices and feelings are expressed in the words "amazing how much there was in one square meter" and "a big patch of alien *limu*." Informal discourse recognizes the importance of affect, personal experience, and engagement in learning.

Stanza 5 continues the blending of school, cultural, and science Discourses. Aunty Kim and Aunty Dawn, botany graduate students, help students learn unfamiliar science in familiar settings and contexts. Alien *limu*, shown in photographs taken by Michelle (Fig. 16.1a, b), are given informal and scientific names, linking everyday discourse to scientific and school Discourses. Students wear gloves as they handle the *limu*, following safety procedures used by researchers. (In Stanza 6, a student

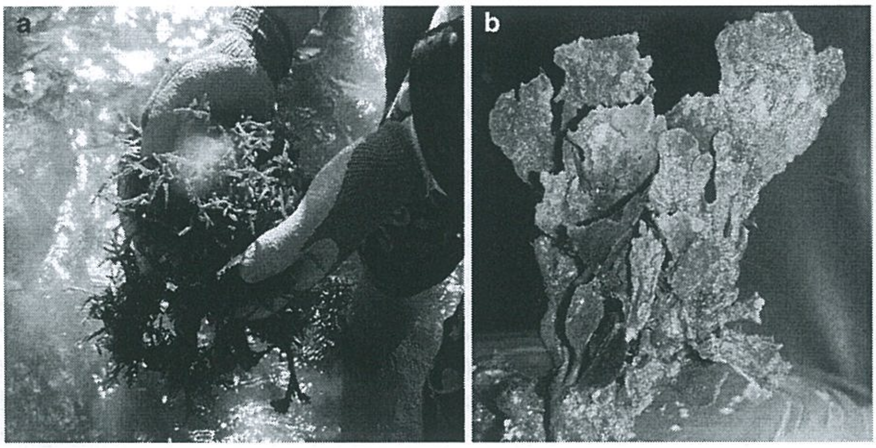

Fig. 16.1 (**a**) Gorilla *ogo,* or *Gracilaria salicornia.* (**b**) Leather mudweed, or *Avrainvillea amadelpha*

holds a bristly polychaete worm as the student narrator says: "Fire worms are the centipedes of the sea because when they sting you it feels like fire.")

In Stanza 7 a student evaluates personal experiences in scientific language, "Our class collected over 450 lb of alien *limu*," and affective language, "It was awesome to do something that was good and benefited nature." The student feels good that problem-based, active learning benefits a familiar SES. This Hawaiian way of learning produces active *science literacy*, "knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (p. 22, National Science Education Standards 1996).

Stanza 8 makes a direct connection between students' reef-monitoring activities and the practices of ancestors. As students paddle an outrigger canoe toward a coral reef, the student narrator evaluates paddling as "hard work [that] brought many of us back to the routes traveled by our ancestors in ancient Hawai'i." The use of outrigger canoes as research vessels produces insights that support simultaneous identification with hard-working ancestors and scientists.

Stanzas 10 and 11 are particularly revealing of the co-construction of indigenous, school, and scientist *identities*. The video shows students, instructors, and community members conducting water tests for salinity, dissolved oxygen, and nitrates and using dyes to examine current flows. Participants wear informal beach clothes and are sun-tanned; and many appear to be of Hawaiian ancestry. In contrast to conventional school science laboratory activities with predetermined outcomes, participants are engaged in authentic science inquiry with outcomes of interest to their real world concerns. The phrase "Uncle Eric turned the *hālau* into a science lab" conveys the reality of culture–science identities, knowledge, and practices coexisting in the same places and bodies.

These stanzas show that scientific Discourse, typically characterized by passive grammatical construction and tight connection of evidence, analysis, and possible outcomes, may be situated in cultural and informal contexts. The claiming of science Discourse as personal/informal and cultural is seen in placement of the student-as-scientist into the text as "we" and "us," the positioning of the science teacher leading the water and current tests as "Uncle Eric," and the carrying out of science activities at the *hālau*. The visuals and text indicate that doing science in this way is meaningful and that anyone can engage in authentic science inquiry oriented to informed care for familiar ecosystems.

Stanzas 12 and 14 reveal that ending the day with a sail in Maunalua Bay, "the reward for all this hard work" of doing science, is deeply cultural. "It truly was an honor" to sail on the *Hokulea*, learning to steer from "Uncle Nainoa," the Hawaiian navigator famous for developing a noninstrumental way-finding system. In the video, several students grasp the steering sweep as the *Hokulea* sails in the open ocean. Steering the *Hokulea* is cultural work able to be simultaneously described in physics terms. Learning to be a Polynesian voyager is also "hard work" as the student reported: "it was very challenging to keep control of the large steering sweep which weighs over 500 pounds." The theme of learning as hard work occurs in stanzas 3 (twice), 8, 12, 13, 14, and 16.

Master Navigator Nainoa Thompson in stanza 1 has become Uncle Nainoa in stanza 14, suggesting a familial yet respectful relationship grounded in interpersonal, *joint activity*. As for other uses of "aunty" and "uncle" in the transcript, the terms represent relatedness, respect, and imply reciprocal responsibility instead of the distancing and status recognition expressed by formal institutional roles and titles.

In final Stanza 16, language shifts from referring to instructors as aunties and uncles who shared thoughts and ideas, *mana'o*, to "leaders" and "planners." Positive evaluations of *experiential learning* are captured in the phrase, "This was one day that we all wished would never end." The use of Hawaiian terms, cultural references, and final video footage, a lingering shot taken from the *Hokulea* of the sun setting directly over *Leahi* (Diamond Head) convey the message that new knowledge and experiences are firmly situated in shared place- and culture-based learning activities.

A student recognizes that "By working together we developed a memorable experience that will last a lifetime." "Working together" suggests the Hawaiian word *lokahi*, unity and harmony, a word found in *Ho'olokahi*, the project's name. Meaningful learning as "memorable experience that will last a lifetime" is constructed through working together, co-planning, and willingness to share *mana'o*, the thoughts, ideas, meanings, and theories presented that day. In positioning the immersion as learning to care for the sea and land, *mālama i ke kai a me 'āina*, science learning is integrated with culturally responsive, place-based learning.

16.5 Discussion

A view of learning as socially situated looks for evidence that language, identity, and knowledge change as a result of this type of learning. Gee's (2005) approach to discourse analysis is used to explore the following four questions.

1. What socially situated identities and activities are enacted?
Michelle told the author a few years ago that she was initially put off by the first EDCS 433 classroom presentation that interpreted Hawaiian resource management practices through the lens of science. Her comments, echoed by other Native Hawaiian teachers, indicate that *learning about* science has much less value that *doing science* in the context of problem-solving and application in the real world. She and her Native Hawaiian colleagues who knew from personal experience that human activities often had negative ecological consequences appropriately evaluated science knowledge and technologies through the lens of cultural relevance and utility.

   Conducting science activities outdoors at the canoe *hālau* and from canoes serving as research vessels supports the simultaneous enactment and construction of science and indigenous identities. Students enact these identities through their use of science and Hawaiian terminology and appropriation of school, science, and indigenous Discourse patterns. The activities (*limu* identification, *pule*, paddling, sailing) and tools (GPS, quadrates, water test kits, canoes) allow multiple identities to develop and strengthen as participants with different knowledge and backgrounds teach and learn (*a'o*) together. Stanzas in which a student reports, "Uncle Dave taught us how to identify the fish, and it was neat to actually know their names" or in Stanzas that discuss water tests and *limu* species suggest that doing science with scientists enables students to think about, experience being like, and even identify with scientists even as the cultural and place-based contexts of the activities support indigenous meanings and identities. (See Appendix for a complete transcript.)

2. What Discourses are involved?
Evidence from the videotape and transcript suggests that *hybrid Discourses* of culture, science, and schooling are learned by students. Even when science Discourse dominates, a word or phrase, such as calling a science instructor "aunty" or "uncle," conveys a cultural Discourse. The overall language pattern of each stanza reveals academic Discourse in the description of a central topic. Possibly an outcome of revising journal entries during storyboarding, the process reinforces the use of academic Discourse as students learn to revise informal, expressive language toward the expected forms of disciplinary discourses.

3. What relationships appear among different Discourses?
The context for Michelle's science activities is the cultural imperative to study and care for (*mālama*) community resources for current and future generations. Thus, the student transcript suggests that both the wisdom of ancestors and Western science are valued as providing tools for teachers, students, and community to learn about and care for the sea and land, *mālama i ke kai a me 'āina.* Her program conveys and her students learn an adaptive cultural Discourse that includes scientific and academic Discourses as appropriate to the purposes of the activity and participants.

   Through her situatedness in diverse settings over the years, Michelle has successfully established a transdisciplinary *knowledge network* that includes agency and university scientists engaged in conservation biology and community-based management. As someone with access to place-, culture-, and community-based knowledge, her relationships with researchers appear egalitarian and collegial. She has developed a unique, science-based understanding of Maunalua Bay and in 2006 won the Hawai'i's Living Reef Program's Educator award (http://www.hawaiireef.net/awards/winners.shtml).

In the 713-word transcript, the number of terms associated with the Discourse of science and technology exceed those associated with Hawaiian language/culture/activities, which greatly exceed terms associated with school and classroom learning. The student selection of learning logs for the transcript suggests that they recognized the potential for science and technology to support and inform indigenous practices oriented to sustainability.

4. How does *intertextuality* function in these texts?
The texts generated by students exemplify intertextuality in their borrowing of words and phrases from other Discourses. The first two lines in stanza 4, above, show language associated with Hawaiian (*limu, kuleana*), science (quadrate), and academic (focus on a single topic) Discourses. It also contains informal, expressive discourse in the nonscientific description of "a big patch" of alien *limu*.

Intertextuality involving Hawaiian words functions to interrupt dominant Discourses and images of science in stanzas 10 and 11, giving science a Hawaiian voice and sensibility. Intertextuality in student writings thus connects cultural identity to emerging science and academic identities. Intertextuality also shows the origins of language used by students when words and phrases echo those used by the teacher, as in the use of "immersion." Similarly, the student who spoke of voyaging in the "routes traveled by our ancestors" echoed Michelle's words in her project overview that reflect the phrasing used in Polynesian Voyaging Society texts. The shaping of language through affiliation suggests the socially situated shaping of identities and construction and continuity of culture.

16.5.1 Implicvations for Teacher Education and Student Learning

Michelle modified the EDCS 433 model of a school- and community-based culture–science program into a version appropriate to her site and Project *Ho'olokahi*. The range of participants and experts involved in her immersions showed that she established a social network that shared her interests in monitoring and restoring *Maunalua* Bay. Analysis of student texts suggests that science done in the context of real world cultural and environmental issues is engaging and meaningful. Michelle's original interest in incorporating science into her culture-based program is reflected in her students' assessment of their learning and experiences.

This case study suggests that place-based professional development in science that is congruent with Native Hawaiian knowledge, values, and practices has the potential to empower teachers as curriculum designers. Teachers who utilize the resources in their students' communities in their lessons engage students in richly contextualized, personally meaningful learning that supports access to academic content. In Michelle's program, co-learning with community members and scientists is central to this process. Participating in a *transdisciplinary learning community* composed of diverse participants who share a common purpose enables students to explore different Discourses in authentic contexts. Students recognize that learning to be a member of a Discourse community is hard but meaningful work. One of Michelle's expectations is that her students learn in order to teach others who come to Maunalua Bay to help and learn.

Gee's (2004) position that learning science (or other Discourse) is noted as the gain of socially situated, specialist language and identity appears to be supported in this study. The transcript video, and researcher's site visits indicated that students "recognize and understand the sorts of socially situated identities and activities that recruit the specialist language … and value these identities and activities" (p. 93). Some of Michelle's students have entered into activities that indicate their experiences supported "real access to these identifies and activities" (ibid, p. 93). In 2008, I met one of several of her students participating in summer youth conservation programs.

The evidence from this study suggests that learning another Discourse need not involve loss of vernacular language and identity, but new languages and identities are gained, each appropriate to its Discourse community. Participating in a transdisciplinary learning community enables learners to become knowledgeable about, able to communicate with, and potentially identity with and become members of multiple Discourse communities.

16.5.2 Implications for Adaptive Learning Relevant to Social–Ecological Systems

This case study of school and community-based management suggests that teacher education oriented to place-based curriculum development supports teachers as leaders in curriculum innovation. Two years after Michelle began incorporating monitoring and restoration into her Polynesian Voyaging program, and shortly after her series of 24-h immersions, community supporters including the Polynesian Voyaging Society and Hui Nalu Canoe Club established a nonprofit *Malama Maunalua* "dedicated to creating a more culturally and ecologically healthy Maunalua."[2]

Although this study reports on one teacher's development of a diverse community of learners, other community-based monitoring and restoration programs have been initiated or strengthened by Native Hawaiian teachers following their participation in EDCS 433 (Chinn 2006). Community-based efforts led by Native Hawaiians

[2] See *Malama Maunalua* website for historical information and current projects: http://malamamaunalua.org.

such as Uncle Henry Chang-Wo's *limu* restoration efforts on Oahu and former EDCS 433 teacher Alyson (Napua) Barrows on Maui are sustained by those who consider it their *kuleana* to respond to changes in their local ecosystems.

The twenty-first century presence of indigenous Hawaiian knowledge/practices/values and cultural frameworks connecting ecological information to real-time human behavior suggests that place- and culture-based professional development in science can provide teachers with the tools to write and teach lessons that develop active science literacy.

However, challenges to place-based science education and teacher empowerment in Hawai'i include continued reliance on science texts designed to meet the needs of large U.S. mainland states, school policies and schedules that impede off-campus learning during the school hours, and accountability systems focused on narrow, test-based measures of student learning.

16.6 Conclusion

Discourse analysis reveals that transdisciplinary, place-based programs such as Michelle's Project *Ho'olokahi* help students develop *multiple literacies* as they become familiar with the tools, language, values, and identities of scientists and indigenous ancestors. These findings indicate that situating teacher education and student learning in communities that incorporate indigenous, local, and science knowledge supports educational, scientific, and cultural literacy.

Including indigenous and/or local, place-based practices and values in *teacher education* has the potential to prepare teachers with the situated scientific, cultural, and place-based knowledge to engage all students, particularly indigenous students, who tend to be underrepresented in science in Hawai'i, as well as other states and countries, in meaningful academic and scientific Discourses oriented to adaptive learning in a time of rapid and uncertain ecosystem change.

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Appendix: Transcript of *Na Pua O Maunalua* Videotape

Completed in May 2006, the student videotape won a second place award in a high school environmental video competition and has been broadcast on public access cable television. The following narrative, divided into stanzas read by various students, was compiled from student journal entries.

1. In October the Kaiser HS Ho'olakahi Voyaging class began a series of 24 immersion sails with *Hokulea* master navigator Nainoa Thompson.
2. The purpose of this immersion was to help us become environmental stewards who *mālama i ke kai o Maunalua*. The *haumana* met at the *Hui Nalu* Canoe Club's *hālau* to begin this experiential learning.
3. The first activity of the day was to learn how to use a GPS, or Global Positioning System. Aunty Annie taught us how to track points on a map so that later on we would be able to tell others exactly where we had worked on the reef. The GPS sends a signal out every 5 s to a satellite that tells us where we are in the world.
4. We paddled out to a sandbar about 100 yards from shore to do a *limu* cleanup, continuing the work we had begun last year. We placed our quadrate on a big patch of alien *limu*. Our *kuleana* was to clear the *limu* in our quadrate. It was amazing how much there was in one square meter. We used the scoop net to catch floating fragments of *limu* because the smallest piece could generate a whole colony of alien *limu*.
5. Aunty Kim and Aunty Dawn helped us to identify the different types of *limu*. One of the major *limu* that we had to get rid of was gorilla *ogo*, or *Gracilaria salicornia*. Another is leather mudweed, or *Avrainvillea amadelpha*, and *Acanthophora spicifera*. These are the alien *limus* in Maunalua Bay.
6. We also had to chart the fish and invertebrates. We found *opa'e*, mantis shrimp, and fire worms. Fire worms are the centipedes of the sea because when they sting you it feels like fire. We also looked for crabs and sea cucumbers. We recorded the data of all the fishes and invertebrates that we found.
7. It was awesome to do something that was good and benefited nature. Our class collected over 450 lb of alien *limu*. It felt great to clean up Maunalua Bay. The spaces that we cleared will become homes to native species of *limu* that we will plant in the future.
8. Then we paddled out to Blue Hole to do a reef check. The paddling experience was hard work and brought many of us back to the routes traveled by our ancestors in ancient Hawai'i. Blue hole is truly a big hole of sand surrounded by a reef of very beautiful, low coral.
9. Uncle Dave taught us how to identify the fish, and it was neat to actually know their names. Like *manini*, yellow tang, Moorish idol, surgeon fish, goat fish, and baby saddle wrasse. We also saw a spotted puffer fish.
10. After lunch back at the *halau* we tested for water quality at three different locations at the canoe site. Uncle Eric turned the *halau* into a science lab. The tests showed that the salinity, dissolved oxygen, and nitrates were at safe levels.
11. Bright green dye showed us which way the current was flowing since this can affect the growth of *limu*. We discovered that there were more than five different currents all flowing into one area of the bay.
12. The reward for all this hard work is that we got to sail on the *Hokulea*. It truly was an honor.

13. Aunty Catherine taught us the safety procedures before we sailed. Experienced crew members provided hands-on training on how to open and close the jib and mainsail. As we worked with the ropes, we learned about the bronco lines for the sails.
14. Uncle Nainoa taught us how to steer the canoe. If you pull to the left the boat goes to the right and vice versa. It was very challenging to keep control of the large steering sweep, which weighs over 500 pounds.
15. We could see all the different *ahupua'a* on shore. After Niu Valley we made a port tack and threw the escort boat a towline, which took us back to Maunalua Bay.
16. By working together we developed a memorable experience that will last a lifetime. We are grateful to our leaders who planned this immersion and were willing to share their *mana'o* to *mālama i ke kai a me 'āina*. This was one day that we all wished would never end.

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The Impact of an Indigenous Science Fair on the Indigenous Participants' Science Related Attitudes

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Historically, it was hard for many indigenous students to participate science fair. This study describes an annually held indigenous science fair named the “ASUS Indigenous Science Education Award” and the evaluation of the indigenous student participants' science-related attitudes in the science fair. Topics and research issues of the projects submitted to the fair must be culturally responsive. Participants undertake their fair-related projects on the Internet via web-based applications. The completed project was uploaded to the science fair website (http://yabit.et.nthu.edu.tw/2011yabit/rules.html). The participants interact on cloud computing. All participant teams of 2010 were required to upload project logs during the time when they were working on their projects. Six basic criteria for project evaluation are cultural contents, scientific contents, applicability to tribal village values, project log, and interaction with elders. All fair-related activities, including an interview that participants undergo with the judges, are processed via cloud computing. According to the pretest and posttest results of a test of science related attitudes, the indigenous fair significantly enhances the participants' attitudes towards "Social Implications of Science", "Normality of Scientists", “Attitude to Scientific Attitudes”, “Adoption of Scientific Attitudes”, and ” Enjoyment of Science Lessons”.

Keyword：indigenous science, science fair, science attitudes