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Contents lists available at ScienceDirect

International Journal of Educational Development

journal homepage: www.elsevier.com/locate/ijedudev

Schooling and local environmental knowledge: Do they complement or substitute each other?

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ARTICLE INFO

Keywords:

Contextualized learning

Tsimane' (Bolivia)

Local environmental knowledge

ABSTRACT

Schooling and the knowledge acquired at school have been considered both a cause of loss of indigenous knowledge (because it opens pathways to the non-indigenous world and worldviews) and a potential remedy to its demise (if educational curricula is aligned with indigenous realities by giving instruction in local languages and incorporating local knowledge in school content). We test the association between academic and local environmental knowledge using data from a society of forager-horticulturalists in the Bolivian Amazon who were exposed to a partially contextualized school curriculum. We found that although schooling and academic knowledge bear a negative association with local knowledge the magnitude is low, probably because schooling was partially contextualized. Contextualized learning might help avoid that the provision of universal education comes at the cost of humanity's cultural diversity.

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1. Introduction

The relations between schooling and indigenous knowledge are an important topic of debate both in anthropology and education research (see UNESCO, 2009 for a recent compilation of articles in the topic). Schooling has been considered both a cause of loss of indigenous knowledge (because it opens pathways to the non-indigenous world and worldviews) and a potential remedy to its demise (if educational curricula is aligned with indigenous realities by giving instruction in local languages and incorporating local knowledge in school content).

In this article we contribute to research on the topic in two ways. First, we review the empirical literature on the association between (a) schooling and the knowledge and skills learned at school through formal education and (b) local environmental knowledge—defined here as people's knowledge of natural

resources and management practices learned primarily through experience and interactions outside school. We start by reviewing the education literature that examines whether contextualized learning enhances curricular knowledge acquisition. We pay special attention to studies that have used local environmental knowledge to contextualize school curricula. We then review the literature that examines the association between schooling and academic knowledge and local environmental knowledge, summarizing the empirical evidence that the increase of schooling is associated with a decline of local environmental knowledge.

In the second part of the article, we conduct a formal test of the associations between schooling and local environmental knowledge using data from the Tsimane', a society of forager-horticulturalists in the Bolivian Amazon who have high levels of local environmental knowledge. We selected the Tsimane' as a case study because they have been exposed for over three decades to a partially contextualized school curriculum.

The study of the association between schooling and local environmental knowledge has important policy implications for indigenous peoples. Research suggests that in indigenous societies local environmental knowledge produces positive returns to the individual (Mcdade et al., 2007; Reyes-García et al., 2007, 2008) in

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the same way that in Western societies schooling and the skills and behaviors learned in school do (Bonjour et al., 2003; Wolfe and Haveman, 2001; Wolfe and Zuvekas, 1997). For example, researchers have found that local environmental knowledge helps indigenous societies deal with pest infestations (Bentley and Rodriguez, 2001), cope with weather shocks (Kuhnlein and Turner, 1991), adapt to climatic change (Berkes and Jolly, 2002), select cultivars (Perales et al., 2005), manage natural resources (Atran and Medin, 1997; Berkes et al., 2000; Medin and Atran, 1999; Olsson and Folke, 2001), and enhance health and nutritional status (Etkin, 2000; Johns, 1996; Mcdade et al., 2007). If so, a better understanding of the relations between schooling and local environmental knowledge might help to determine whether school curricula can be designed to complement, rather than substitute, local environmental knowledge.

2. The association between school and local environmental knowledge: two diverging views

Recent works (UNESCO, 2009) review in detail the complexity of the associations between indigenous knowledge and schooling, so here we only review the literature reporting two divergent trends in the association between (a) schooling and the knowledge and skills learned at schools through formal education and (b) local environmental knowledge. On the one hand, researchers have argued that formal education which infuses traditional knowledge with the acquisition of academic skills will likely enhance learning outcomes in indigenous populations—the use of familiar learning styles and topics, such as local environmental knowledge, may enhance the comprehension of school content (Castagno and Braboy, 2008; Gilliland, 1995; Lipka, 1990; Lipka et al., 2001; Taylor et al., 1991).

On the other hand, researchers trying to understand the secular decline of local environmental knowledge have suggested that schooling and the academic skills learned in school are among the main causes for the devolution of local environmental knowledge. Authors argue that time and resources spent in school detract from time and resources spent learning local environmental knowledge (Sternberg, 1997; Sternberg et al., 2001).

Although the two arguments contrast, they are not necessarily mutually exclusive. It is possible that the incorporation of local environmental knowledge, or any type of cultural knowledge, in a school curriculum enhances the acquisition of school contents. However, this process could still detract from the acquisition of overall local environmental knowledge.

2.1. Does local environmental knowledge enhance the acquisition of school content?

The acquisition of academic knowledge is a complex process that can be affected by a large range of contextual factors (i.e., gender, social-class, or cross-cultural dynamics, parental influence) and motivations (i.e., value of schooling in the community, returns provided by the acquisition of knowledge) (Dillon et al., 1999; Gough, 1999; Kaufman et al., 2008; Levinson et al., 1996). From the many factors that might influence the acquisition of school content, researchers have highlighted that the contextualization of information (i.e., using familiar knowledge to enhance the comprehension of curricular knowledge) enhances learning, and so produces better school achievements than standard textbook and classroom instruction (Castagno and Braboy, 2008; Gilliland, 1995; Lipka, 1990; Taylor et al., 1991).

Specifically, the argument has been often made in relation to students from indigenous origin. For example, Taylor et al. (1991) report how an Indian mathematics teacher showed children rice fields opposite the school to illustrate how their elders used

straight lines and angles because children could not understand textbook explanations. Taylor et al. (1991) argue that contextualized learning should also include teaching methods more familiar than textbooks and lectures, such as group workshops, fieldtrips, hands-on experience, and the participation of parents and elders in instruction. Contextualized instruction improves students' comprehension because students are taught through familiar topics and learning styles. Students also seem to be more receptive to curricular content if they know that knowledge can be put into practice (Castagno and Braboy, 2008; Gilliland, 1995; Lipka, 1990; Taylor et al., 1991). Contextualized programs can also improve knowledge acquisition by empowering students and reinforcing their cultural identity (Hilliard and Sizemore, 1984).

Empirical evidence mostly supports the hypothesis that contextualized learning enhances the acquisition of curricular content among indigenous peoples. For example, Lipka (1994) analyzed school achievements of Yup'ok Eskimo students who used a culturally adapted mathematics program combining analytical, creative, and practical instruction. His results show that sixth graders who learned math through the contextualized curriculum did better in multiple-choice and short-answer items measuring memory and analytical, creative, and practical aspects of achievement than did children only exposed to textbook instruction. Similarly, in the evaluation of a Bilingual Intercultural Education Program in 114 Bolivian primary schools with Quechua-, Aymara-, and Guaraní-speaking children, Miller and Foy (2003) found that children who learned standard curricular knowledge in their native language had greater self-esteem and higher academic achievements in reading and writing than those taught in Spanish, Bolivia's national language.

Among the many types of contextualized learning, several studies have analyzed the impact of contextualized programs on the acquisition of school environmental knowledge, or scientific knowledge of environmental issues and concepts learned at schools or during formal environmental education (Bradley et al., 1999). Overall, those studies suggest that students most effectively learn school environmental knowledge when teachers relate textbook concepts to the local environment. For example, Taylor and Mulhall (2001) examined contextualized learning projects including agriculture, nutrition, and health in eight primary schools from Tanzania, Sri Lanka, India, and Ethiopia. From analysis of interviews with teachers and students about how local practices had assisted them in understanding the curricular content, they concluded that contextualized learning enhanced curricular knowledge acquisition because students could establish a link between theory and practice.

Likewise, Lieberman and Hoody (1998) conducted a comparative analysis on environmental knowledge acquisition among K-12 students from 14 US schools involved and not involved in a school program called 'Environment as an integrating context for learning' (EIC). The EIC program included natural and socio-cultural environments as the context for learning. Results show that students in the contextualized program earned higher grades and scored better in reading, writing, and math than their peers who were not involved in the program. School administrators attributed the better results to the contextualized approach.

In a study in Mexico with 72 preparatory school adolescents from Zapotecan origin, Ruiz-Mallén et al. (2009a) evaluated the impact on the acquisition of school and local environmental knowledge of an extra-curricular environmental education program contextualized in the local environment. Their results suggest that participation in the contextualized program enhanced students' school learning; for example, students who participated in the program had a 16.3% higher knowledge on school environmental concepts than students who did not participate.

In sum, education research mostly suggests that contextualized instruction can improve students' curricular learning. Specifically,

a growing body of literature suggests that the use of local environmental knowledge in formal education (i.e., environmental education, but also mathematics, literacy, and other topics) enhances students' comprehension of school environmental knowledge.

2.2. Does academic knowledge substitute local environmental knowledge? A review of the evidence

As we have seen, education research suggests that instruction contextualized with local environmental knowledge enhances students' comprehension of school environmental knowledge, but empirical research among indigenous peoples on the associations between school and local environmental knowledge mostly shows that the two forms of knowledge tend to be exclusive of each other. Cognitive psychologists and anthropologists have suggested that among indigenous groups, schooling and academic skills learned in school undermine aspects of traditional culture, such as indigenous languages and local environmental knowledge (Sternberg, 1997; Sternberg et al., 2001; Zent, 2001). These researchers argue that the divergence between both forms of knowledge might be due to the fact that people cannot commit the necessary amount of time to both; time and resources spent in school detract from time and resources spent learning local environmental knowledge (Sternberg, 1997; Sternberg et al., 2001).

Empirical studies among different indigenous societies mostly support the hypothesis of a negative association between schooling and local environmental knowledge (Quinlan and Quinlan, 2007; Srithi et al., 2009; Sternberg et al., 2001; Voeks and Leony, 2004; Zent, 2001). For example, in a study among the Piaroa Amerindians in Venezuela, Zent (2001) finds that Spanish fluency and schooling (measured as completed courses) are negatively correlated with local environmental knowledge, proxied by informants' abilities to identify trees in a plot. Similarly, in a study among Luo children in western Kenya, Sternberg et al. (2001) find that knowledge of the use of medicinal plants is negatively correlated with standard tests of academic performance. And in Brazil, Voeks and Leony (2004) find that knowledge of the names and uses of medicinal plants is negatively associated with the individual's schooling and literacy. Quinlan and Quinlan (2007) find that schooling in Dominica is negatively correlated with the number of medicinal plants a person could list. Finally, among the Mien in Thailand, Srithi et al. (2009) find that schooling is negatively associated both with the number of medicinal plants informants can identify from photographs, and with the reported frequency of use of the identified medicinal plants.

Other studies, however, find only partial evidence of a negative association between schooling and local environmental knowledge (Byg and Balslev, 2001; Levinson et al., 1996), no significant association (Benz et al., 2000; Guest, 2002; Ayantunde et al., 2008; Godoy et al., 2009), or even a positive association between both forms of knowledge (Ruiz-Mallén et al., 2009b). For example, in a study in Madagascar, Byg and Balslev (2001) find that the association between schooling and local environmental knowledge depends on how local environmental knowledge is measured. Thus, they find a negative correlation between completed years of schooling and number of uses reported for a locally important palm species; however, the association disappears when they use knowledge of the palm's useful parts and the palm's ecology as proxy for local environmental knowledge.

In another study in Ecuador, Levinson et al. (1996) tested possible differences in local ecological knowledge among non-schooled Huaorani children and Huaorani children attending formal school. They found that both schooled and non-schooled children could name the same number of wild species, but that only children who did not attend school were able to associate

names with specimens collected from the forest. They suggest that schooling was producing a loss of local environmental knowledge and affecting practical skills more than cognitive categories.

In studies in Niger (Ayantunde et al., 2008), Mexico (Benz et al., 2000), Bolivia (Godoy et al., 2009), and Ecuador (Guest, 2002) comparing knowledge of local plants and animals to schooling, researchers find no association between both measures of knowledge.

Lastly, contrary to what has been hypothesized, Ruiz-Mallén et al. (2009b) find a positive association between schooling and local environmental knowledge. Using data from indigenous adolescents in Mexico, the authors find that the number of local plants students can list – a proxy for local environmental knowledge – increases along with the academic courses they have completed.

Thus, the empirical evidence for the association between schooling and local environmental knowledge is still ambiguous.

3. Local environmental knowledge and schooling among the Tsimane'

We now move to our second goal: to test the association between schooling and local environmental knowledge using data from the Tsimane', a forager-horticulturalist society of about 8000 people, in the Department of Beni, Bolivia. Tsimane' adults provide an ideal case to test the associations between schooling and local environmental knowledge for three main reasons. First, the Tsimane' still hold a large body of local environmental knowledge which produces positive returns to individuals and to their society. Second, because schooling is not enforced among the Tsimane', they display variation in the level of formal schooling. Last, for over three decades Tsimane' adults have been exposed to a partially contextualized curriculum taught in their indigenous tongue.

The Tsimane' still share a large body of local environmental knowledge which produces positive returns to the individuals holding the knowledge and to their society. For example, the Tsimane' reportedly know 414 wild plants species, of which only 11% have no recorded use. The remaining plants had a total of 571 different uses (Reyes-García et al., 2006). Furthermore, among the Tsimane' we do not find long-term decline of local environmental knowledge (Godoy et al., 2009), although we do find that engaging in occupations that occur outside Tsimane' villages and environment (e.g., wage labor) bears a negative association with ethnobotanical skills—a proxy for local environmental knowledge (Reyes-García et al., 2007a). Our research also indicates that local environmental knowledge produces positive returns for the Tsimane', as it is associated with improved nutritional status (Reyes-García et al., 2008), children's health (Mcdade et al., 2007), crop diversity (Reyes-García et al., 2008), and the reduction of the area of old-growth forest cleared for slash-and-burn agriculture (Reyes-García et al., 2007b). We also know that the Tsimane' rely on older cohorts, not only parents, for the transmission of local environmental knowledge (Reyes-García et al., 2009).

The second reason why Tsimane' adults provide an ideal case study to test the associations between schooling and local environmental knowledge is that their level of formal schooling varies between individuals. The Tsimane' have been exposed to schooling since the 1950s when the Bolivian government gave Protestant missionaries the responsibility for schooling remote lowland native Amazonian populations (Castro Mantilla, 1997). Missionaries offered promising Tsimane' young men scholarships to acquire basic academic skills and become teachers, while they worked as informants to translate the Bible into Tsimane' language. Teachers trained and paid by missionaries were in charge of Tsimane' education since the 1960s until 2006. But,

because the area has yet to experience significant technological changes, demand for schooling and academic skills remains modest and school attendance remains, in practice, voluntary. Because school attendance is not enforced, we observe variation in the level of education among the Tsimane'.

Nowadays, about 80% of Tsimane' villages have a primary school covering the first five grades. No Tsimane' village has a middle school or a high school, but four villages close to the town of San Borja have an education program for adults where Tsimane' with elementary schooling can earn a high-school diploma by attending classes one week per month. Theoretically, classes are held Monday to Friday from 8:30 to 12:00. One teacher is assigned for every 20 registered students, which often results in one or two teachers per village in charge of grades 1–5. Children join grade 1 at 6 years of age and often finish grade 5 by the age of 15. Some of the older children leave school without finishing the primary education in order to work for loggers or ranchers.

Mathematics, language, natural, and social sciences are the four topics mainly taught in Tsimane' schools. In practice, teacher and student absenteeism is high. Tsimane' teachers continue to practice subsistence activities, so it is not uncommon that classes are discontinued during the agricultural season, when the teacher decides to go hunting, or when he has to visit the local town for his monthly payment, a trip that can take up to one week. Children are not requested to stay in class full-time and they often leave the school during class hours. Parents take their children out of school when they need them to do chores in the house or farm. Recently, the government introduced the "Juancito Pinto" bonus, an annual donation of about \$25 US to students who complete an academic year in a public school (Barie, 2007; Stefanoni, 2007), resulting in an increase of school attendance from early ages.

The last reason why Tsimane' adults provide an ideal case to study the associations between schooling and local environmental knowledge is that, for over three decades, schooling has been partially contextualized for the Tsimane'. Partially because, in the aim to maintain lowland populations isolated to facilitate proselytizing, missionaries promoted instruction in village schools with Tsimane' teachers and in Tsimane' language and with educational material partially contextualized. For example, educational materials used in school – mostly booklets developed by the missionaries targeted to basic mathematical abilities and literacy – included references to elements of the Tsimane' local environment such as local plants and animals and reading material included stories set on the tropical forest. Educational materials, however, were not totally contextualized as they also included references to religious beliefs which are strange to the Tsimane'. Because Tsimane' children have remained in their cultural context, and taught by members of their community in their language, they might have seen schooling connected to their daily lives.

The educational system described contrasts with instruction for most indigenous children in the rest of Bolivia, who were taught in Spanish until the advent of Bolivia's 1994 Education Reform (Howard, 2009). The system contrasts even more with the instruction for most lowland indigenous children, who continue to be taught in Spanish or with materials contextualized to highland culture, given that the Intercultural Bilingual Education for speakers of indigenous languages only reached one of the Bolivian lowland indigenous groups, the Guaraní (Contreras and Talavera, 2003; Howard, 2009).

The missionaries' agreement with the Bolivian Government ended in 1985, but the missionaries continued, *de facto*, to be in charge of training Tsimane' teachers and developing educational materials until the arrival of the new Bolivian government headed by Evo Morales in year 2006. Since then, and despite the fact that the new Education Bill is awaiting parliament approval, the State has brought important changes to Bolivian educational system.

Contrary to the intercultural spirit and the priority given to local knowledge in the 2006 draft Bolivian Education Law (Howard, 2009), some of the changes brought by the new indigenous government have contributed to de-contextualize Tsimane' educational system. For example, in an effort to improve overall education, the government has started a program to replace non-qualified teachers. Since none of the Tsimane' teachers are officially qualified, the policy has resulted in an increase in the number of non-Tsimane' teachers in Tsimane' villages. Qualified teachers often come from the highlands and they remain very short time in the area, as they have difficulties to adapt to the lowland ecological and social context.

Furthermore, non-Tsimane' teachers receive little training in multicultural education, a pivotal skill for successful education in indigenous communities (Yagi, 1985; Castagno and Braboy, 2008). Secondly, when the responsibility for Tsimane' schooling passed from the missionaries to the Ministry of Education, teachers received new educational materials developed in other social and ecological environments (mainly the highlands). For example, the Ministry of Education provided Tsimane' schools with bilingual educational material in Quechua, Aymará, and Spanish, languages not spoken in the area.

4. Methods

4.1. Sample

We collected information during June to September of 2003, 2005, and 2006 from all adults (or people >16 years of age) in 13 villages along the Maniqui river, Department of Beni, Bolivia. Villages differed in their proximity to San Borja (mean = 25.96 km; SD = 16.70), the only town along the Maniqui river. The sample included 351 adult females and 345 adult males interviewed between one and three times each for a total sample of 1555 observations.

4.2. Measure of schooling

Every year, we asked adults about the maximum school grade they had attained and gave them tests to assess their math, writing, and reading, skills. To assess mathematical skills we asked subjects to add, subtract, multiply, and divide and assigned a one to each correct answer, so math scores ranged from 0 to 4. We judged writing ability by whether subjects could sign their name. We assessed subject's ability to read by requesting them to read a simple sentence written in Tsimane' language. We had three equally difficult versions of the math and literacy tests and chose one at random for each subject. We coded answers for writing and reading tests as 0 = unable, 1 = with difficulty, and 2 = well.

4.3. Measure of local environmental knowledge

Every year, we collected two proxy measures for local environmental knowledge. One proxy captured the *theoretical knowledge* of the informants—people's ability to name, identify, and report the use of natural elements. The other focused on self-reported *skills*, or people's ability to put theoretical knowledge into practice (i.e., the ability to use plants) (Atran et al., 2004; Reyes-García et al., 2007a). To avoid bias generated by changes in the format of the tests (Reyes-García et al., 2004), we used the same format across years but changed the content of the tests. In previous publications we have provided thorough descriptions of the tests conducted in 2003 (Reyes-García et al., 2007a) and 2005 (Reyes-García et al., 2009), so here we only provide a general overview.

We measured *theoretical knowledge* by reading informants the name of plants randomly selected from a list of Tsimane' useful

plants (Reyes-García et al., 2006) and asking them whether they knew each plant. We recorded positive answers as one and negative answers as zero. The test performed in 2003 included 19 useful plants, the test performed in 2005 included 15 useful plants, and the 2006 test included six medicinal plants. For each year, the measure of *theoretical knowledge* was the sum of all positive answers.

To measure *skills*, every year we asked participants to report their ability to use a different set of plants (e.g., “Have you ever used *coyoj* (*Zantedeschia* sp.) for medicine?”). If participants reported having used the plant, we coded the answer as one; otherwise, we coded the answer as zero. None of the questions were purposefully false. The list from 2003 included 18 objects made out from 15 plant species (Reyes-García et al., 2007a). The list from 2005 included 15 objects made out from 12 plant species (Reyes-García et al., 2009). The list from 2006 included four wild plants; we asked informants (i) whether they had used the plants as medicine, (ii) which part had a medicinal use, and (iii) how was it prepared. We coded each of those 12 questions ($12 = 4 \text{ plants} * 3 \text{ questions}$) as one if the subject gave the correct answer and zero otherwise, where correct was defined as the most common answer given by traditional healers.

4.4. Data analysis

We first assessed the intra-subject consistency of our measures across years. To do so, we ran a series of Pearson's correlations of the different measures of local environmental knowledge (theoretical and skills) for the different years of data collection. We further explored the internal consistency of our measures of schooling and local environmental knowledge with Cronbach's alpha and principal component analysis.

To assess the association between schooling and school-related abilities and local environmental knowledge, we used both correlation and multivariate analysis. For each year, we ran a set of correlations of schooling against skills and theoretical local environmental knowledge. We then ran a multivariate ordinary least square (OLS) regression of each measure of schooling (explanatory variable) against local environmental knowledge (outcome variable). Since our measures of local environmental knowledge had different ranges across years, to run the multivariate analysis across years, we first standardized the scores by transforming them to percentages. Regressions included controls that have been used in previous research (e.g., age, sex), a full set of dummy variables for years ($n = 3 - 1 = 2$), and a full set of village dummies ($n = 13 - 1 = 12$) to control for village attributes that remain fixed during the period of research. Regressions also included clustering by person. For the statistical analysis we used Stata for Windows, version 10 (StataCorp, College Station, TX).

4.5. Potential biases and limitations

Potential biases in our estimations relate to (1) measurement error, (2) omitted variables bias, and (3) reverse causality. First, we might have random measurement error in our measures of academic knowledge either from people overhearing answers to tests, or from people being too shy to answer questions to strangers. We might also have errors related to the construction of our measure of environmental knowledge. For example, to generate a proxy of local environmental knowledge we used less than 20 questions per test, which might not entirely capture people's local environmental knowledge.

Second, our estimations might be biased by the role of omitted variables. For instance, people of some ethnic groups might invest more in schooling and also have more local environmental knowledge than people of other ethnic groups. Failure to control

for this or other variables that influence attitudes might bias our estimations in an unknown magnitude and direction.

Last, we do not have convincing instrumental variables to control for the potential endogeneity of schooling. It is possible that schooling contributes to decrease local environmental knowledge, but the causality could also run in the other direction, if people who are good at learning local environmental knowledge decide not to attend school. Therefore, we cannot speak about causality and limit our discussion to the association between the variables explored.

This work has also one important limitation related to the use of statistical tools to analyze complex social processes such as the acquisition of academic and local environmental knowledge. The analysis of responses to survey questions allows one to provide an instant picture of the association between schooling and local environmental knowledge. The method, however, does not allow one to evaluate the educational impacts of contextualising curriculum or other educational material. To examine how local knowledge is incorporated in teaching in classroom and the impact of those methods, case study and qualitative analysis might be a better methodological approach.

5. Results

5.1. Tsimane' schooling and local environmental knowledge

Table 1 contains definitions and summary statistics of the schooling and school-related abilities reported for year 2003. The average adult in our sample had only completed around two years of schooling, but the variation between adults was large ($SD = 2.25$). Around 25% of adult men and 40% of adult women had no schooling. The average Tsimane' knew how to add (but not other mathematical operations). Only 28% of Tsimane' adults knew how to write their name and only 30% read well. Women scored lower than men in all measures. Correlation coefficients between measures of schooling and school-related abilities (i.e., math, reading, and writing) were high ($r > 0.65$) and statistically significant ($p < 0.001$) independently of the year when the measure was taken. Results of a Cronbach's alpha of our measures of schooling and school related abilities suggest that the measures of school and school-related abilities are highly inter-correlated ($\alpha = 0.98$). Results from a principal component analysis (not shown) confirm the association.

Table 2 contains definition and summary statistics of our measures of local environmental knowledge (theoretical and skills) for the three years of study. Table 3 shows correlation results between the six measures. The six measures correlated in a positive and significant way ($p < 0.05$), although correlation coefficients were generally low ($0.1 < r < 0.6$). The weakest correlation coefficients occurred between the tests conducted in 2006 and the test conducted in 2003 and 2005. Overall, the six

Table 1
Descriptive statistics of schooling and school-related abilities reported in year 2003 ($n = 534$).

Variable	Definition	Mean	SD
Schooling	Maximum school grade achieved by subject	1.83	2.25
Math	Score in math test; from 0 to 4	1.01	1.45
Write	Ability to sign name	Unable With difficulty Well	59.3 12.6 28.1
Read	Ability to read a simple sentence written in Tsimane'	Unable With difficulty Well	63.7 06.6 29.8

Table 2
Descriptive statistics of the score of theoretical local environmental knowledge and skills.

Year	Variable	Definition	n	Mean	SD
2003	Theoretical knowledge	Subject's score in a test on the knowledge of a set of useful plants. From 0 to 19	471	15.11	3.64
	Skills	Subject's score in a test on the self-reported ability of the subject to use a set of useful plants. From 0 to 10	433	4.19	1.8
2005	Theoretical knowledge	Subject's score in a test on the knowledge of a set of useful plants. From 0 to 15.	556	12.07	2.75
	Skills	Subject's score in a test on the self-reported ability of the subject to use a set of useful plants. From 0 to 12	556	4.93	2.65
2006	Theoretical knowledge	Subject's score in a test on the knowledge of a set of medicinal plants. From 0 to 6	541	2.41	1.51
	Skills	Subject's score in a test on the self-reported ability of the subject to use a set of medicinal plants. From 0 to 12	542	3.18	2.81
Overall	Theoretical knowledge	Subject's standardized scores in the three test of theoretical knowledge. From 0 to 100	1568	69.11	27.85
	Skills	Subject's standardized scores in the three test of self-reported ability to use plants. From 0 to 100	1531	36.10	22.64

Table 3
Correlations between measures of local environmental knowledge for years 2003, 2005, and 2006.

		2003		2005		2006
		Theoretical	Skills	Theoretical	Skills	Theoretical
2003	Skills	0.250***				
2005	Theoretical	0.534***	0.414***			
	Skills	0.318***	0.401***	0.508***		
2006	Theoretical	0.113**	0.170***	0.117***	0.207***	
	Skills	0.336***	0.178***	0.161***	0.185***	0.516***

Note: *, **, and *** significant at the 90%, 95%, and 99% confidence level. Probability adjusts significance levels for multiple comparisons using Sidák method.

variables were highly inter-correlated with a Cronbach's alpha of 0.70, suggesting that the six measures reflected one underlying dimension of local environmental knowledge. A principal component analysis confirms that the largest differences relate to the measures taken in 2006. Thus, while all the measures loaded positively onto the first factor (first eigenvalue = 2.46, explaining 41% of the variation in the data), the 2006 variables loaded negatively on the second factor whereas the 2003 and 2005 variables loaded positively.

5.2. The association between schooling and local environmental knowledge

Correlation coefficients of our measures of theoretical knowledge and skills against our measures of school were negative (Table 4). The associations were low ($-0.05 < r < -0.3$) but statistically significant, with the exception of the association between school and theoretical knowledge for year 2006.

Multivariate regressions of our measures of local environmental knowledge against our measures of schooling and school related abilities (Table 5) confirm the intuition of correlation results: all the measures of schooling and school-related abilities bear a negative and statistically significant association with

Table 4
Correlations between schooling and local environmental knowledge.

		n	Theoretical	Skills
Schooling	2003	471	-0.08*	-0.27***
	2005	544	-0.18***	-0.25***
	2006	531	-0.06	-0.07*

Note: *, **, and *** significant at the 90%, 95%, and 99% confidence level. Probability adjusts significance levels for multiple comparisons using Sidák method.

measures of local environmental knowledge. The magnitude of the association is, however, generally low. For example, in line [a] we find that one more year of schooling is correlated with a 0.443% decrease in theoretical knowledge ($p = 0.11$) and with a 0.96% decrease in skills ($p = 0.001$). Moving one level in our scale of mathematical abilities (i.e., from addition to subtraction) would be associated to a 1.3% less theoretical and 1.7% less practical knowledge.

We tested the robustness of our results in several different ways (not shown). First, we included the ability to speak Spanish as a control in the regression of schooling and theoretical and practical ethnobotanical knowledge. Second, we add a term for age square to test for non linear effects of the association. Third, we included controls for decade of birth, to separate cohort from age effects. Fourth, we included parental education. Fifth, we used clustering for village of residency, rather than for individuals. Village characteristics can affect overall schooling (i.e., the quality of teaching) or overall local knowledge (i.e., the presence of a healer). Sixth, we included total household wealth as control. Last, we ran the regression with the part of the sample that reported some schooling ($n = 448$). Results remained qualitatively unchanged irrespective of the model used.

In sum, our data support the hypothesis that when there are trade-offs in time and resources, schooling and local environmental knowledge become substitutable for individuals, although for the Tsimane' the trade-offs seem to be small in real terms.

Table 5
OLS of local environmental knowledge against schooling and school-related abilities and control variables.

		Theoretical [1]	Skills [2]
[a]	Schooling	-0.443	-0.962***
	n	1557	1519
	R ²	0.42	0.24
[b]	Math	-1.30***	-1.659***
	n	1535	1497
	R ²	0.42	0.25
[c]	Read	-2.05***	-2.23***
	n	1535	1497
	R ²	0.42	0.25
[d]	Write	-1.37*	-2.46***
	n	1534	1496
	R ²	0.42	0.25

Regressions include clustering by subject and the following (not shown): age, sex, constant, and full set of dummy variables for villages ($n = 13 - 1 = 12$) and years ($n = 3 - 1 = 2$). *, **, and *** significant at $\leq 10\%$, $\leq 5\%$, and $\leq 1\%$.

6. Discussion

We organize the discussion around the two main findings of this work. First, for the Tsimane', although school and school-related activities bear the expected negative association with local environmental knowledge, the magnitude of the association is low in real terms. Second, the negative association between schooling and local environmental knowledge is larger when using academic skills rather than years completed at school as a proxy for schooling, and when using skills rather than theoretical knowledge as a measure of local environmental knowledge. In the last part of this section, we discuss how our findings help us to predict future trends between schooling and local environmental knowledge in the context of current changes in the Tsimane' school system.

Our main result, that school and school-related activities bear a negative association with local environmental knowledge, dovetails with results from previous research (Quinlan and Quinlan, 2007; Srithi et al., 2009; Sternberg et al., 2001; Voeks and Leony, 2004; Zent, 2001), but offers an important nuance: for the Tsimane' the magnitude of the association is low in real terms. Moreover, the low magnitude of the association ties in with two other striking findings from our past research among the Tsimane': that they continue to share a large body of local environmental knowledge (Reyes-García et al., 2003) and that this knowledge is not being lost (Godoy et al., 2009).

Reasons already advanced by other scholars for the trade-offs between the acquisition of both forms of knowledge (Sternberg et al., 2001) explain the negative direction of the association. As mentioned, among the Tsimane' most learning of local environmental knowledge probably still occurs outside schools and comes from people in older generations (Reyes-García et al., 2009). For example, mothers point out medicinal plants to their daughters while walking to garden plots and children play around elders while they make fishing bows; so attending school can limit opportunities for acquiring such skills and knowledge. However, an important finding of our work is that the magnitude of the association between school and school-related activities and local environmental knowledge is low.

Recall that the average Tsimane' adult has completed about two years of schooling. According to our results, completing one more year of schooling would be associated with a loss of 0.5% of theoretical and 1% of practical local environmental knowledge. Research in urban and rural populations of developing nations suggests that schooling can contribute to many outcomes, such as income, nutrition, and the adoption of new technologies, but only after individuals pass a threshold of around 5–6 years of schooling (Burns et al., 2003). Assuming that the association moves in a linear way, and since the average Tsimane' scored 69% and 36% in the tests of theoretical and practical knowledge, going from the average two years of schooling to completing the five years of primary education would result in a loss of 1.5% of theoretical knowledge (or going from an average score of 69% to an average score of 67.5%) and of 3% of practical knowledge (from an average score of 36% to an average score of 33%). The trade off seems relatively small.

What explains the low magnitude of the association? We argue that the partially contextualized instruction to which Tsimane' have been exposed, although not necessarily strengthening local systems of knowledge, might have helped lower the negative effect of schooling on local environmental knowledge. As mentioned, and contrary to many other indigenous children in Bolivia (Contreras and Talavera, 2003), the Tsimane' educational system was partially contextualized for the many environmental and cultural issues faced by the local population. Tsimane' children were taught in Tsimane' language, by Tsimane' teachers, and using educational materials in

Tsimane' language and with local referents. Our finding then supports the idea that contextualizing educational material to facilitate the acquisition of curricular content, although still failing to strengthen local cultural knowledge, might slow down the negative effect of schooling on local environmental knowledge. Because local knowledge is incorporated into educational programs, the Tsimane' are better able to combine time and resources spent on learning.

Our second important finding shows that practical environmental knowledge has a greater negative association with schooling and school related abilities than theoretical environmental knowledge, and that, correspondingly, school related abilities bear a larger negative association with traditional environmental knowledge than years of schooling. A possible explanation for this finding relates to the time that should be devoted to the acquisition of theoretical and practical knowledge of any kind. Skill acquisition requires practice and often more time than the acquisition of theoretical knowledge, so skills are less likely to be learned when time is spent on other activities like schooling. Furthermore, practical local environmental knowledge (such as tracking animals) is also more likely to be learned in contexts outside the classroom and is not easily transferable to the classroom, whereas theoretical knowledge (such as animal names) is more easily transferred to academic contexts. Although contextualized learning can minimize trade-offs in acquiring certain kinds of academic and other types of knowledge, there are still many things that cannot be transferred to the classroom environment and thus must compete with school in children's time and resources.

We devote the last part of this section to discuss how our findings might predict future trends in the association between schooling and local environmental knowledge in the currently changing Tsimane' school system. As mentioned, adults in our sample attended village schools with Tsimane' teachers and were taught in Tsimane' language. In contrast, Tsimane' children nowadays have access to more education but are increasingly taught by non-Tsimane' teachers and in Spanish. Over the last years, the State has increased the number of non-Tsimane' teachers in Tsimane' villages and has started a program to replace non-qualified teachers. Qualified teachers often come from the highlands and they remain for a very short time in the area, as they have difficulties to adapt to the ecological and social context. For example, non-Tsimane' teachers lack understanding of the local culture and complain about children being absent from class to carry out farm chores, or visits to relatives in distant villages, activities that are at the core of Tsimane' culture.

In addition to formal education programs, in 2006, the Bolivian government introduced the "Yo sí puedo" ("Yes, I can") program, an audiovisual program used through developing countries to promote adult literacy (Ortega et al., 2006; Steele, 2008). As part of the program, Tsimane' communities were equipped with TV and VCR sets powered with solar panels, an instrumental feature in popularizing the program and encouraging adults to attend classes. However, the program has only been adjusted for the indigenous and peasant populations of the highlands and it is fully taught in Spanish. The lack of contextualization of this adult literacy program and the use of the TV and VCR sets to watch movies are also generating important changes both in the time allocation of the Tsimane' and in their exposure to other cultures.

With more availability of schools and more incentives to attend school from young ages, in the years to come we should see an increase in the average educational level of the Tsimane'. However, with more non-Tsimane' teachers and less contextualized learning, we shall also see an increasing negative effect of schooling on local environmental knowledge.

7. Conclusion

Researchers have argued that the inclusion of cultural knowledge in the curriculum ought to enhance the comprehension of school content (Castagno and Braboy, 2008; Gilliland, 1995; Lipka, 1990; Lipka et al., 2001; Taylor et al., 1991; UNESCO, 2009). The Tsimane' case study adds to research on the importance of contextualized knowledge by suggesting that the incorporation – even if partial – of cultural knowledge in the school curriculum might help lower the negative effect of schooling on local environmental knowledge documented in several indigenous groups (Quinlan and Quinlan, 2007; Srithi et al., 2009; Sternberg et al., 2001; Voeks and Leony, 2004; Zent, 2001).

We conclude with a policy recommendation. If, as our research suggests, contextualized learning helps to lower the negative effect of schooling on cultural knowledge, then educational programs among indigenous peoples should place a larger emphasis on the inclusion of local knowledge in school curriculum. As the current changes in the Tsimane' educational system highlight, the recommendation is especially urgent for countries like Bolivia, which are embracing massive education reforms. Contextualized learning might help to avoid problems with the commendable goal of providing universal basic education which often comes at the cost of the country's cultural heritage and diversity. A major challenge lies in re-shaping the school curriculum so it includes not only the content but also the teaching methods (i.e., field trips, observation, and informal instruction) that societies have put in place for the transmission of local environmental knowledge.

Acknowledgements

Research was funded by grants from the programs of Biological and Cultural Anthropology of the National Science Foundation (0134225, 0200767, and 0322380). Thanks go to the TAPS Bolivian research team for help collecting the information and for logistical support. Thanks go to ICRISAT-Patancheru for providing Reyes-García with office facilities. We thank two anonymous reviewers and the editor for their thoughtful comments.

References

- Atran, S., Medin, D., 1997. Knowledge and action: cultural models of nature and resource management in Mesoamerica. In: Bazerman, M., Messick, D., Tinbrunsel, A., Wayde-Benzoni, K. (Eds.), *Environment, Ethics, and Behavior*. New Lexington Press, San Francisco, pp. 171–208.
- Atran, S., Medin, D., Ross, N., 2004. Evolution and devolution of knowledge: a tale of two biologies. *Journal of the Royal Anthropological Institute* 10, 395–420.
- Ayantunde, A., Briejer, M., Hiernaux, P., Udo, H., Tabo, R., 2008. Botanical knowledge and its differentiation by age, gender and ethnicity in southwestern Niger. *Human Ecology* 36, 881–889.
- Barie, C.G., 2007. Bolivia: Cuánta Revolución Cabe en la Democracia? In: *Latin America and Caribbean Comment*. Fundación para las Relaciones Internacionales y el Diálogo Exterior.
- Bentley, J., Rodriguez, G., 2001. Honduran folk entomology. *Current Anthropology* 42, 285–301.
- Benz, B.F., Cevallos, J., Santana, F., Rosales, J., Graf, S., 2000. Losing knowledge about plant use in the sierra de Manantlan Biosphere Reserve, Mexico. *Economic Botany* 54, 183–191.
- Berkes, F., Colding, J., Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10, 1251–1262.
- Berkes, F., Jolly, D., 2002. Adapting to climate change: social–ecological resilience in a Canadian Western Arctic community. *Conservation Ecology* 5, 18.
- Bonjour, D., Cherkas, L., Haskel, J., Hawkes, D., Spector, T., 2003. Returns to education: evidence from U.K. twins. *American Economic Review* 39, 1799–1812.
- Bradley, J.C., Waliczek, T.M., Zajicek, J.M., 1999. The relationship between environmental knowledge and environmental attitude of high school students. *The Journal of Environmental Education* 30, 17–22.
- Burns, B., Mingat, A., Rakotomalala, R., 2003. *Achieving Universal Primary Education by 2015. A Chance for Every Child*. World Bank Publications, Washington, DC.
- Byg, A., Balslev, H., 2001. Traditional knowledge of *Dyopsis fibrosa* (Araceae) in Eastern Madagascar. *Economic Botany* 55, 263–275.
- Castagno, A.E., Braboy, B.M.J., 2008. Culturally responsive schooling for indigenous youth: a review of the literature. *Review of Education Research* 78, 941–993.
- Castro Mantilla, M.D., 1997. La viva voz de las tribus: El trabajo del ILV en Bolivia, 1954–1980. [The live voice of the tribes: the work of the ILV in Bolivia, 1954–1980] Ministerio de Desarrollo Sostenible y Planificación, Vice Ministerio de Asuntos Indígenas y Pueblos Originarios, La Paz, Bolivia.
- Contreras, M.E., Talavera, M.L., 2003. *The Bolivian Education Reform: 1992–2002. Case Studies in Large Scale Education Reform*. The World Bank, Washington, DC.
- Dillon, J., Kelsey, E., Duque-Aristizábal, A.M., 1999. Identity and culture: theorizing emergent environmentalism. *Environmental Education Research* 5, 395–406.
- Etkin, N.L., 2000. *Eating on the Wild Side: The Pharmacologic, Ecologic, and Social Implications of Using Noncultigens*. University of Arizona Press, Tucson.
- Gilliland, H., 1995. *Teaching the Native American*. Kendall/Hall, Dubuque, IA.
- Godoy, R.A., Reyes-García, V., Broesch, J., Firzpatrick, I., Giovannini, P., Martínez-Rodríguez, M.R., Jha, N., Huanca, T., Leonard, W.R., Tanner, S., McDade, T.W., TAPS study team, 2009. Secular changes of indigenous knowledge of useful plants: separating age and cohort effects. *Journal of Anthropological Research* 65, 51–67.
- Gough, A., 1999. Kids don't like wearing the same jeans as their mums and dads: so whose 'life' should be in significant life experience research? *Environmental Education Research* 5, 383–394.
- Guest, G., 2002. Market integration and the distribution of ecological knowledge within an Ecuadorian fishing community. *Journal of Ecological Anthropology* 6, 38–49.
- Hilliard, A.G., Sizemore, B., 1984. *Saving the African American Child*. National Alliance of Black School Educators, Inc., Washington, DC.
- Howard, R., 2009. Education reform, indigenous politics, and decolonisation in the Bolivia of Evo Morales. *International Journal of Educational Development* 29, 583–593.
- Johns, T., 1996. *The Origins of Human Diet and Medicine: Chemical Ecology*. University of Arizona Press, Tucson.
- Kaufman, J.S., Ewing, M.S., Hyle, A.E., Montgomery, D., Self, P.A., 2008. Women and nature: using memory-work to rethink our relationship to the natural world. In: Reid, A., Scott, W. (Eds.), *Researching Education and the Environment. Retrospect and Prospect*. Routledge, New York, pp. 63–80.
- Kuhnlein, H.V., Turner, N.J., 1991. *Traditional Plant Foods of Canadian Indigenous Peoples: Nutrition, Botany and Use*. Gordon and Breach Science Publishers, Quebec.
- Levinson, B.A., Foley, D.E., Holland, D.C., 1996. *The Cultural Production of the Educated Person: Critical Ethnographies of Schooling and Local Practices*. State University of New York Press, New York, p. 338.
- Lieberman, G.A., Hoody, L., 1998. *Closing the Achievement Gap: Using the Environment as an Integrating Context for Learning*. State Education and Environmental Roundtable, San Diego, CA.
- Lipka, J., 1990. Integrating cultural form and content in one Yup'ik Eskimo classroom: a case study. *Canadian Journal of Education* 17, 18–32.
- Lipka, J., 1994. Culturally negotiated schooling: toward a Yup'ik mathematics. *Journal of American Indian Education* 33, 14–30.
- Lipka, J., Wildfeuer, S., Wahlberg, N., George, M., Ezran, D., 2001. Elastic geometry and storyknifing: a Yup'ik Eskimo example. *Teaching Children Mathematics* 7, 337–343.
- McDade, T.W., Reyes-García, V., Blackinton, P., Tanner, S., Huanca, T., Leonard, W.R., 2007. Ethnobotanical knowledge is associated with indices of child health in the Bolivian Amazon. *Proceedings of the National Academy of Sciences of the United States of America* 104, 6134–6139.
- Medin, D., Atran, S., 1999. *Folkbiology*. MIT Press, Cambridge, MA.
- Miller, M., Foy, J.E., 2003. *Ensuring the Rights of Indigenous Children*. Innocenti Research Centre, United Nations Children's Fund, Washington, DC.
- Olsson, P., Folke, C., 2001. Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken watershed, Sweden. *Ecosystems* 4, 85–104.
- Ortega, D., Rodriguez, F., Miguel, E., 2006. Freed from illiteracy? A closer look at Venezuela's Robinson Literacy Campaign. Wesleyan University, Middletown, CT, Wesleyan Economics Working Papers.
- Perales, H., Benz, B.F., Brush, S.B., 2005. Maize diversity and ethnolinguistic diversity in Chiapas, Mexico. *Proceedings of the National Academy of Sciences of the United States of America* 102, 949–954.
- Quinlan, M., Quinlan, R.J., 2007. Modernization and medicinal plant knowledge in a Caribbean horticultural village. *Medical Anthropology Quarterly* 21, 169–192.
- Reyes-García, V., Byron, E., Godoy, R., Vadez, V., Apaza, L., Perez, E., Leonard, W., Wilkie, D., 2004. Measuring culture as shared knowledge: do data collection formats matter? Cultural knowledge of plant uses among the Tsimane' Amerindians of Bolivia. *Field Methods* 16, 135–156.
- Reyes-García, V., Huanca, T., Vadez, V., Leonard, W., Wilkie, D., 2006. Cultural, practical, and economic value of wild plants: a quantitative study in the Bolivian Amazon. *Economic Botany* 60, 62–74.
- Reyes-García, V., McDade, T., Vadez, V., Huanca, T., Leonard, W.R., Tanner, S., Godoy, R., 2008. Non-market returns to traditional human capital: nutritional status and traditional knowledge in a native Amazonian society. *Journal of Development Studies* 44, 217–232.
- Reyes-García, V., Vadez, V., Huanca, T., Leonard, W.R., McDade, T., 2007a. Economic development and local ecological knowledge: a deadlock? Quantitative research from a native Amazonian society. *Human Ecology* 35, 371–377.
- Reyes-García, V., Vadez, V., Tanner, S., Huanca, T., Leonard, W.R., McDade, T., 2007b. Ethnobotanical skills and clearance of tropical rain forest for agriculture: a case study in the lowlands of Bolivia. *Ambio* 36, 406–408.

- Reyes-García, V., Broesch, J., Calvet-Mir, L., Fuentes-Pelaez, N., McDade, T.W., Parsa, S., Tanner, S., Huanca, T., Leonard, W.R., Martínez-Rodríguez, M.R., 2009. Cultural transmission of ethnobotanical knowledge and skills: an empirical analysis from an Amerindian society. *Evolution and Human Behavior* 30, 274–285.
- Reyes-García, V., Godoy, R.A., Vadez, V., Apaza, L., Byron, E., Perez, E., Leonard, W.R., Wilkie, D., 2003. Ethnobotanical knowledge shared widely among Tsimane' Amerindians, Bolivia. *Science* 299, 1707.
- Ruiz-Mallén, I., Barraza, L., Bodenhorn, B., Reyes-García, V., 2009a. Evaluating the impact of an environmental education programme: an empirical study in Mexico. *Environmental Education Research* 15, 371–387.
- Ruiz-Mallén, I., Barraza, L., Bodenhorn, B., Reyes-García, V., 2009b. School and local environmental knowledge, what are the links? A case study among indigenous adolescents in Oaxaca, Mexico. *International Research in Geographical and Environmental Education* 18, 83–97.
- Srithi, K., Balslev, H., Wangpakattananawong, P., Srisangac, P., Trisonthi, C., 2009. Medicinal plant knowledge and its erosion among the Mien (Yao) in northern Thailand. *Journal of Ethnopharmacology*.
- Steele, J., 2008. Yo, Sí Puedo: south–south educational collaboration in practice. *Society for International Education Journal* 5, 29–44.
- Stefanoni, P., 2007. Siete preguntas y siete respuestas sobre la Bolivia de Evo Morales. *Nueva Sociedad* 2007, 46–65.
- Sternberg, R., 1997. *Successful Intelligence*. Plume, New York.
- Sternberg, R., Nokes, C., Geissler, P., Prince, R., Okatcha, F., Bundy, D., Grigorenko, E., 2001. The relationship between academic and practical intelligence: a case study in Kenya. *Intelligence* 29, 401–418.
- Taylor, D., Stevens, E., Peregoy, J., Bath, B., 1991. American Indians, mathematical attitudes, and the standards. *Arithmetic Teacher* 38, 14–21.
- Taylor, P., Mulhall, A., 2001. Linking learning environments through agricultural experience—enhancing the learning process in rural primary schools. *International Journal of Educational Development* 21, 135–148.
- UNESCO, 2009. *Learning and Knowing in Indigenous Societies Today*. UNESCO, Paris.
- Voeks, R.A., Leony, A., 2004. Forgetting the forest: assessing medicinal plant erosion in eastern Brazil. *Economical Botany* 58, S294–S306.
- Wolfe, B., Haveman, R., 2001. *Accounting for the Social and Non-market Benefits of Education*. University of Wisconsin, Madison.
- Wolfe, B., Zuvekas, S., 1997. Non-market outcomes of schooling. *International Journal of Educational Research* 27, 13–25.
- Yagi, K., 1985. Indian Education Act project in the Portland public schools, 1984–85 evaluation report. Portland Public Schools Evaluation Department, Portland, OR.
- Zent, S., 2001. Acculturation and ethnobotanical knowledge loss among the Piaroa of Venezuela: demonstration of a quantitative method for the empirical study of traditional ecological knowledge change. In: Maffi, L. (Ed.), *On Biocultural Diversity: Linking Language, Knowledge, and the Environment*. Smithsonian Institution Press, Washington, DC, pp. 190–211.