School and local environmental knowledge, what are the links? A case study among indigenous adolescents in Oaxaca, Mexico

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Understanding environmental learning is the first step to constructing successful environmental education programs. Little research has addressed the relation between the environmental knowledge learned inside and outside schools. Environmental educators and ethnobiologists have worked independently, without assessing how school and local environmental knowledge relate to each other. This research examines school and local environmental knowledge acquisition of 95 Mexican indigenous adolescents. Multivariate regression analysis was used to assess (1) school and local environmental knowledge overlap and (2) the association between individual environmental knowledge and socio-demographic characteristics. Data show that school and local environmental knowledge are not associated in a statistically significant way. A possible explanation for the finding is that the two forms of knowledge are complementary because they exist in parallel. Adolescents’ school and local environmental knowledge is associated with their level of schooling, but not with parental occupation in community forestry. The use of traditional pedagogical practices at school and the loss of traditional culture at home might hamper indigenous adolescents’ environmental learning.

Keywords: environmental education; environmental knowledge; ethnobiology; indigenous adolescents; Mexico

Introduction

In the last few years, social scientists have increasingly been interested in the growing search of natural resource conservation strategies. In the field of education, the interest has materialized in the field of environmental education. According to Sutherland (1998), education is essential to long-term natural resource conservation. For example, international comparative household studies suggest that education may deter forest clearance (Godoy & Contreras, 2001). Indeed, although conservationists mainly focus on biological issues, future conservation strategies should promote education programs designed to affect people’s knowledge, awareness, attitudes, and behaviors toward natural resources (Jacobson & McDuff, 1998). A first step to build successful conservation education programs is to understand the environmental learning process of the target audiences.
Environmental learning can occur in at least two different settings: the school and outside the school. In this paper, we use the term “school environmental knowledge” to refer to knowledge of environmental issues and scientific concepts learned at schools, what is commonly known as formal environmental education (Bradley, Waliczek, & Zajicek, 1999). We use the term “local environmental knowledge” to refer to people’s knowledge of natural resources and management practices learned primarily through experience and conversation with people outside the school (Dimopoulos & Pantis, 2003). Local environmental knowledge then matches with nonformal environmental education.

Previous research on environmental learning has mainly focused on one or the other form of environmental knowledge (but see Payne, 2005, for some work on the topic). Environmental educators have evaluated students’ school environmental knowledge, such as school science concepts concerning biology, ecology, or chemistry (see, e.g., Arvai, Campbell, Baird, & Rivers, 2004). Ethnobiologists, on the other hand, have paid attention to the study of people’s local environmental knowledge gained through interaction with their local environment (see, e.g., Etkin, 2000; Godoy, Reyes-García, Byron, Leonard, & Valdez, 2005; Reyes-García, Vadez, Huanca, Leonard, & McDade, 2007). But to date, environmental educators and ethnobiologists have mostly worked independently, without assessing how school and local environmental knowledge relate to each other.

In the present study, we assess the association between (1) school and local environmental knowledge and (2) school and local environmental knowledge and individual socio-demographic characteristics. To analyze the topic, we gathered data from adolescents (from 15 to 20 years of age) from a preparatory school in Ixtlan de Juarez, an indigenous community in the mountains of Oaxaca, Mexico. We focus on adolescents’ environmental knowledge because Mexican adolescents have been largely ignored in environmental education research (Barraza & Pineda, 2003). And we focus on indigenous peoples because indigenous groups have received more attention in ethnobiological research than in studies on school environmental knowledge. As a result, we know little about the association between school and local environmental knowledge among indigenous adolescents.

Environmental education research: school-based and locally acquired knowledge

Previous research on environmental learning has usually tackled either school or local environmental knowledge. Environmental education researchers, for instance, have mainly analyzed (1) children’s knowledge on science concepts in formal contexts and (2) the individual and household-level characteristics that affect school environmental knowledge acquisition.

Research on children’s learning of science concepts has reached two main conclusions. First, research suggests that environmental education programs improve formal learning. For example, in a research on 475 preparatory students from Texas, Bradley et al. (1999) measured knowledge gained after exposure to a 10-day environmental science course. They found students’ knowledge scores increased by 22% after they had completed the course. Lieberman and Hoody (1998) conducted comparative analyses on knowledge acquisition between two groups of students, one involved and one not involved in an environmental education program in 14 schools from the United States. Their data indicated that students in the environmental education program earned higher grades in reading, writing, and math than their peers in traditional programs.

The second conclusion of research on children’s learning on environmental science concepts is that school environmental knowledge acquisition is strongly related to household and individual-level characteristics. Children and adolescents learn more effectively
about environmental science concepts if their parents are involved in activities related to the
environment than if parents have other occupations (Barraza, 2001). Research also shows
that schools have the potential to improve school environmental knowledge acquisition
through the implementation of participative educational projects that connect students to
their parents and local environment (Paré & Lazos, 2003). Last, there is a strong association
between people’s attitudes, beliefs, and perceptions of the environment and their environ-
Interest and curiosity about the environment might contribute to the effective acquisition
of environmental knowledge.

Ethnobiologists have analyzed local environmental knowledge in various human soci-
eties (see, e.g., Hunn, 2002; Reyes-García, Huanca, Vadez, Leonard, & Wilkie, 2006; Zarger,
2002), often paying attention to the relation between local environmental knowledge and
schooling. For example, using data from a study of 85 children in a rural community
in Kenya, Sternberg et al. (2001) found that test scores on the use of medicinal plants
correlated negatively with test scores on school-based knowledge. The authors argue that
academic and practical intelligence are distinct constructs that operate apart from each
other, often in opposition. Time and resources invested in school might deflect from invest-
ments in folk knowledge because people cannot be in two places or studying two things
at the same time. Similarly, in Mexico, Benz, Cevallos, Santana, Rosales, and Graf (2000)
analyzed relationships between knowledge of plant uses and indicators of modernization
(i.e., primary school finished) among 259 informants from eight rural communities in the
Sierra de Manantlan. They found a negative correlation between plant knowledge and writ-
ing abilities. In Venezuela, Zent (2001) assessed the persistence of local plant knowledge
by analyzing the influence of factors such as formal education and bilingual ability that
might affect the maintenance of traditional ecological knowledge. He found that school-
ing and Spanish fluency correlated negatively with knowledge of trees among 104 Piaroa
Amerindians.

As environmental education researchers, ethnobiologists have also underlined the im-
portance of individual characteristics in explaining the distribution of local environmental
knowledge. Several studies suggest that socio-demographic characteristics (i.e., age, gen-
der, market integration) are associated with individual environmental knowledge (see, e.g.,
Heckler, 2002; Reyes-García, et al., 2005; Zent, 2001).

In sum, in research in developed countries, researchers in the field of environmental ed-
cucation have found that formal environmental education programs increase students’ school
environmental knowledge, whereas in research with indigenous populations, ethnobiolog-
ical studies have shown a negative association between schooling and local environmental
knowledge. What remains to be tested is the joint effect of schooling and socio-demographic
characteristics on indigenous children’s school and local environmental knowledge
acquisition.

The place and the people
Oaxaca is the most biologically and culturally diverse state in Mexico, itself a megadiverse
country (Mittermeier & Goetttsch, 1992). As elsewhere in Mexico, Oaxacan forest cover
loss has increased in recent years, particularly in the conifer forests (Valencia & Nixon,
2004). To reduce deforestation, indigenous communities of the Northern Sierra of Oaxaca
have adopted conservation strategies based on the sustainable management of forests.
Those strategies have the support of state and federal governments. One such strategy
is the creation of community forestry enterprises, which follow forest management plans
generated and administered by community technical services. These plans combine logging strategies, disease control, and a variety of reforestation and husbandry programs designed to maintain the health of the forest and to generate long-term forest management profits (Bodenhorn, in press). Through community forestry enterprises, indigenous communities attempt both to conserve and benefit from their forest resources.

Researchers working with Mexican indigenous communities involved in forestry have argued that the success of forestry plans greatly depends on political organization at the community level (see, e.g., Antinori & Rausser, 2007; Bray & Merino, 2004; Merino, 1997 for case studies of community-led forest management initiatives in Mexico, in general; Bodenhorn (in press) for Ixtlan, in particular). Among most indigenous peoples in Mexico, community-level political organization is dual. On the one hand, the municipality is composed of citizens who govern themselves through a General Assembly. The General Assembly has the responsibility to support state-sponsored public services, such as education, and to generate and maintain other public services such as water, electricity, and garbage management. On the other hand, the management of resources found on communal lands is the responsibility of the General Assembly of Comuneros. This organization is considerably smaller than the General Assembly and is based on restricted membership stemming from historically recognized collective ties to the land and passed on heritage rights.

Our study community, the Zapotec community of Ixtlan de Juarez, was among the first communities in Oaxaca to implement a communal forestry enterprise. Ixtlan, with 19,310 hectares of common property, is the most important of the 18 communities integrating the Ixtlan municipality. Seventy percent of the economically active population of Ixtlan municipality works in forestry activities both in the primary and the secondary sectors (Mexican Government, 2006). Services and subsistence agriculture are also important economic activities in the area.

Ixtlan has the largest forestry enterprise in Oaxaca. The over-arching communal forestry enterprise was established in 1986 and since then has received international recognition for its sustainable resource management, i.e., Forest certification (Forest Stewardship Council (FSC), 2007). Forest and enterprise owners are locally known as comuneros. Comuneros are members of an ethnic group with collective access to portions of land forest. All decisions about forest management, from planting and husbandry to logging, furniture production, and sales, are taken in the General Assembly of Comuneros of Ixtlan. The General Assembly of Comuneros meets every month and is integrated by 384 comunero families. Most of the comuneros work at the communal forestry enterprise and contribute to the community by participating in compulsory and not-paid activities, such as communal services (tequios) or by holding a political position. Non-comunero people can also work in the forestry enterprise, but they cannot participate in collective decision-making process on forest management.

Although Ixtlan de Juarez is recognized as an indigenous community, new generations are losing their traditional culture and substituting the Western way of life. Two mechanisms that might speed acculturation among adolescents are access to mass media and parental acculturation. According to the last Mexican census (INEGI, 2005), 56% of the houses in the Ixtlan municipality have at least one television; there are 20 Internet free-access computers in the community public library, and several businesses offering low-cost Internet service. Parents are also contributing to their children’s loss of traditional culture. For example, since schooling is in Spanish, Zapoteco, the indigenous language, is mainly spoken at home. However, census data from the Ixtlan municipality show that Zapoteco is less spoken among the young generation: 80% of people between 55 and 59 years old and only 65% of people between 15 and 19 years of age speak Zapoteco.
The preparatory school of Ixtlan de Juarez, CECyTE-Plantel 3, forms part of a statewide system of science and technology preparatory schools and is the highest educational institution in Ixtlan. The school catchment’s area includes Ixtlan de Juarez and surrounding communities in the municipal district of Ixtlan. As with Ixtlan de Juarez, the other communities in the district depend on forest resources as part of their economic strategy. The preparatory school includes both generalized education and a three-year itinerary with concentrated vocational training in computer technology and nursing. At the time of the research, environmental information was part of the curriculum of 1st and 2nd years, through the ecology and biology topics. There was also an environmental education project consisting in an ethnobotanical garden. The ethnobotanical garden project involved several teachers and 2nd-year students who planted and cared of approximately 20 local herbs and shrubs in the school garden since 2003. The ethnobotanical garden is an uncommon educational experience in Mexican preparatory schools because the government does not give economic resources for constructing gardens nor remuneration to teachers who participate in extra-school activities.

Methodological considerations

Research suggests that parental occupation in forestry increases children’s receptivity to school science concepts and familiarity with local plants (Barraza, 2001, 2002), so we hypothesize that students having comunero parents will be (1) more exposed and familiarized with local environmental knowledge and (2) more receptive to school environmental knowledge than students whose parents are not engaged in the community organization. Our hypothesis focuses on communal forestry, rather than in other occupations related to the environment (such as farmers), because communal forestry implies more than just working near the nature. Comuneros descend from families who have always lived in the community, so comuneros might know their environment better than non-comuneros living in Ixtlan whose families were born in other places. Furthermore, Ixtlan comuneros belong to an organization with a strong commitment to manage forests in a sustainable manner, so comuneros might show more concern about local biological conservation than non-comuneros and, in consequence, they might have more interest in promoting environmental knowledge acquisition.

We also hypothesize that students’ interest in working in environmental issues will have a positive association to school and local environmental knowledge acquisition, because interest might activate knowledge acquisition (Fishbein, 1967; Hines et al., 1986–1987).

We tested our hypotheses using both school and local environmental knowledge as outcome variables. We defined school environmental knowledge (SEK) as adolescents’ ability to respond to a test on school environmental science concepts (see, e.g., Bradley et al., 1999). To assess local environmental knowledge (LEK), we followed the method established by ethnobiologists studying local environmental knowledge (see, e.g., Hunn, 2002) and defined LEK as adolescents’ ability to name local forest wild plants. Since many students in our sample seem to have little knowledge of their indigenous culture, the ability to name forest plants is a good proxy for LEK. Other methods designed to capture more sophisticated local environmental knowledge, such as measures of skills for using plants, might yield fewer responses in a nonexpert population.

We used the following expression to model the association between environmental knowledge (Y) and covariates:

$$SEK_{iy} = \alpha + \beta CO_{iy} + \gamma IF_{iy} + \delta C_{iy} + \varepsilon_{iy}$$  (1)
Assume, first, that SEK captures the school environmental knowledge of an adolescent, where \( i \) is the adolescent and \( y \) the student’s year of schooling. We use SEK for ease of exposition, but the expression also applies to LEK. Student’s year of schooling might affect SEK because of the ecology school subject is taught in the 2nd year and LEK because of 2nd-year students’ participation in the ethnobotanical garden. \( C_{iy} \) is a dummy variable that captures whether any of the adolescent’s parents is a comunero. \( IF_{iy} \) is a dummy variable that describes whether the student \( i \) wanted to work in activities related to the environment in future or not. The term \( C_{iy} \) is a vector of control variables (such as gender and age) that might affect adolescents’ environmental knowledge. \( \varepsilon_{iy} \) is a random error term. If parental occupation influenced adolescents’ environmental knowledge, then the coefficient for \( \beta \) should be positive and statistically significant. If students’ professional interests influenced knowledge acquisition then the coefficient for \( \gamma \) should be positive and statistically significant.

For the analysis, we used ordinary least square (OLS) multivariate regressions with robust standard errors and clustering by school-year. We used clustering by school-year because students’ schooling is organized by year group, and students in the same group are exposed to the same time requirement and curricular material.

**Methods**

Data for this article were collected on the Ixtlan preparatory school site during April and May 2004. Data collection combined qualitative and quantitative techniques.

To collect information on students’ environmental knowledge and their socio-demographic characteristics, we constructed a written questionnaire. Below we describe the methods used to collect the data and to construct the proxy variables.

We also collected data regarding adolescents’ environmental learning activities inside and outside the preparatory school by using observations and informal conversations with their parents and several communal forestry workers and authorities identified as key actors. Ethnographic information helped us to contextualize our research.

**Students’ sample**

Our sample included 107 students randomly selected from the three academic years comprised from the CECyTE program. The sample represents 42% of the total number of students in the school: 36 students (33.60%) were enrolled in the 1st year, 28 students (26.17%) in the 2nd year, and 43 students (40.19%) in the 3rd year. Students were between 15 and 20 years old. Proportion of boys among chosen students was 46.3%. Only 9.50% of the students belonged to comunero families and only 10.50% of the students were interested in working in jobs related to the environment in the future. We did not have complete data for 12 students, so the final sample for multivariate regressions was 95.

**Questionnaire construction and pilot test**

Our written questionnaire included four different tasks: (1) Multiple-choice questions, (2) a free-listing exercise, (3) open-ended questions, and (4) a set of sentence completion techniques.

To construct the multiple-choice questions, we built on a textbook content analysis conducted by Ruiz-Mallén, Barraza, and Ceja-Ádame (in press) that included all the school curriculum books existing at the Ixtlan preparatory school library at the time of the research.
(n = 19). We first elaborated a list with all the environmental concepts in the school curriculum books and then randomly chose seven concepts from the list. We interviewed two science teachers to confirm that these concepts were covered in the classrooms. To assess whether students understood the written questionnaire, we pilot tested it in a classroom of 33 2nd-year students, who were not included in our final sample. Pilot testing allowed us to identify and modify unclear questions.

**Outcome variables**

**School environmental knowledge**

We asked students seven multiple-choice questions on the meaning of school environmental concepts. The concepts were (1) ecosystem, (2) food chain, (3) sustainability, (4) silviculture, (5) renewable resource, (6) forest ecological function, and (7) forest degradation consequences. We presented the concepts to the students and asked them to choose the right definition or example among four possible answers for each concept given. We selected the right answer based on information from textbooks available to students and invented the other three.

To create an individual score of SEK we followed three steps. First, we evaluated each of the seven multiple-choice questions assigning one point to each correct answer (as in the textbook) and zero to each incorrect answer. Second, we tested for intercorrelation between the responses to the various questions. A series of Pearson pair-wise correlations (not shown) showed partial negative correlation coefficients between responses to questions #3 and #4 and responses to the other questions. Therefore, in our last step we added the correct answers of the multiple-choice questionnaire excluding questions #3 and #4. For the regression analysis, we normalized the score of SEK by transforming it into a 0–100 score.

**Local environmental knowledge**

We used free listing (Bernard, 1995) to gather information on local environmental knowledge. We asked students to write the names of all the plants known to them in Ixtlan forests. We reviewed existing literature on botanical records in the community forests (Linares, 2005) to verify the existence of all the plants mentioned in free listing. We also asked a local forest manager technician to examine the list and select the plants (wild and cultivated) that are actually present in the communal forests. We selected this particular key informant because he had previously collaborated in botanical studies in the community and was pointed to us as the most knowledgeable person on forest plants in Ixtlan. To calculate the individual scores of LEK, we gave one point for each plant named during free listing and found locally in the wild. We only included in the final lists plants that appeared in the botanical reference and were mentioned by the key informant as found in Ixtlan forest but not in domestic contexts. For the regression analysis, we transformed the score of LEK into a 0–100 score.

**Explanatory and control variables**

**Comunero**

We asked each student whether either of his/her parents belonged to the communal organization that decides on forest management. The variable was coded as 0 if neither of the
parents were members of the communal organization and 1 if one or both of the parents were comuneros.

**Professional interest**

We asked students to complete in writing the following sentence about their future professional life: *When I am 30 years old, I will work in...* Answers for each student were coded as 1 if the student showed interest in working on issues related to the environment (e.g., forestry, biology, or agriculture) and 0 otherwise.

**Controls**

We collected information about students’ age (in years), gender, and school level at the time of answering the questionnaire.

**Potential biases**

Potential biases in our estimations relate to (1) small sample size, (2) omitted variables, and (3) possible reverse causality. First, our sample was small \( n = 95 \) although it represented 42% of the school population. Small sample size made our estimates more conservative. We are especially concerned about the small comunero sample size \( n = 10 \), but it was representative of the comunero population in Ixtlan, which represented only 8% of the total population. Second, our estimations might be biased by the role of omitted variables. For example, parents’ level of education might affect in the transmission of environmental knowledge. Parents with higher education might be able to understand and explain to children more school environmental concepts than parents without formal studies. If so, adolescents with parents with more schooling might have higher school environmental knowledge than adolescents with parents with less schooling. Last, we did not have convincing instrumental variables to control for the potential endogeneity of our explanatory variables. For example, it is possible that career orientation contributes to the acquisition of environmental knowledge, but causality could also run the other way, so people more apt to learn environmental knowledge might feel more attracted to work on issues related to the environment. Since we cannot control for the potential endogeneity of our variables, we cannot speak about causality but about association between the explored variables.

**Results**

**Descriptive statistics**

Table 1 contains definitions and summary statistics for the variables used in the regression analyses.

Of the five questions on school environmental concepts included in the score of SEK, students answered an average of 3.34 questions correctly \( \text{SD} = 1.09 \), which represents 67% of the questions. Only one student got a zero score in the SEK test. The most well-known concepts were “forest ecological function,” which was defined correctly by 91% of students, and “ecosystem,” which was defined correctly by 79% of students. Sixty-one percent of the students knew the “consequences of forest degradation,” 60% of them knew the concept of “food chain,” and only 43% knew the meaning of “renewable resource.” The concepts of “sustainability” and “silviculture,” which were not incorporated into the
elaboration of the final SEK score, had relatively low percentages of correct answers, i.e., 55.8% and 45.2%, respectively.

Students quoted 72 different plant species in the free-listing exercise (data not shown). According to the forest manager technician and the existing literature, only 30 of those plants are present in Ixtlan communal forest. From the remaining, 10 are not present in Ixtlan and 32 are present in the community surroundings but not in the forest. On average, each student listed 2.51 (SD = 1.61) Ixtlan forest plants. The mean score for the variable LEK was 36% (SD = 23.09). Nine students (9.47%) got a zero on the LEK score; two students listed only plants that are not present in Ixtlan forest, and seven did not list any local plant.

After normalization, we found that the average SEK score was higher than the average LEK score. We tested for intercorrelation between the two scores and found that they were not correlated (Pearson correlation, $r = 0.09, p = 0.38$).

**The covariates of environmental knowledge**

Table 2 shows results from OLS regressions using as outcome variables the two proxies for environmental knowledge.

In columns (a) and (b) we used as outcome variable SEK scores. In column (a) we included all the variables of Equation (1) and clustering by school-year. None of the two explanatory variables analyzed (comunero and professional interest) was associated in a statistically significant way to SEK. We ran the same regression without clustering by school-year (column (b)). We found that students having a comunero parent had 13.76% higher SEK score than students without a comunero parent ($p = 0.06$). Results also suggest that having professional interest in the environment was associated with students’ SEK, but...
Table 2. OLS regression of school and local environmental knowledge (outcome variables) against explanatory and control variables ($n=95$).

<table>
<thead>
<tr>
<th>Outcome variables</th>
<th>School environmental knowledge</th>
<th>Local environmental knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>Comunero</td>
<td>13.75 (6.81)</td>
<td>13.76 (7.27)*</td>
</tr>
<tr>
<td>Professional interest</td>
<td>-11.84 (7.09)</td>
<td>-11.84 (6.89)*</td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>13.01 (7.99)</td>
<td>13.01 (4.26)**</td>
</tr>
<tr>
<td>Age</td>
<td>-4.02 (1.21)*</td>
<td>-4.02 (6.89)</td>
</tr>
<tr>
<td>School-year 2</td>
<td>5.38 (0.18)***</td>
<td>5.39 (5.41)</td>
</tr>
<tr>
<td>R2</td>
<td>0.20</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Notes: (a) and (c) are core model clustering by school-year, and (b) and (d) without clustering. *, **, and *** are significant at the 10%, 5% and 1% level. ∧ variable intentionally excluded from the analysis. For definition of variables see Table 1.

Contrary to our expectations the sign of the association was negative. Students interested in working on environmental jobs had 11.84\% lower SEK score than students interested in having jobs not related to the environment ($p = 0.09$).

It is possible that the negative association between adolescents’ SEK scores and their environmental professional interest simply reflects the fact that the students with best qualifications were not interested in jobs related to the environment because they perceived them as low-status jobs. To test that possibility, we ran model (b) including the students’ school qualifications as control (not shown). We found that the variable that proxies professional interest lost its statistical significance which supports the intuition that the negative association between students’ environmental professional interest and their SEK scores is due to the lack of interest in environmental jobs by students with better overall academic qualifications.

Columns (c) and (d) resemble the models in columns (a) and (b) but using as dependent variable LEK. We did not find statistically significant associations between students’ LEK scores and the comunero and professional interest variables in any of the two models.

Results presented in Table 2 show statistically significant associations between the SEK and LEK scores and control variables. Boys had a 13.01\% higher SEK score than girls ($p = 0.00$), but a similar LEK score. Across models, we found a negative and statistically significant association between age and both environmental knowledge scores ($p = 0.1$). We also found statistically significant associations between students’ environmental knowledge and year of schooling. The coefficients of both school year variables were important in real terms. A student in the 1st year of the preparatory school had an 11.99\% lower SEK score than a student in the 3rd year ($p = 0.03$), whereas a student in the 2nd year had 5.38\% higher SEK score than a student in the 3rd year ($p = 0.00$). In contrast, a student in the 1st year had a 21.18\% lower LEK score than a student in the 3rd year ($p = 0.02$) and a student in the 2nd year had a 15.74\% lower LEK score than a student in the 3rd year ($p = 0.00$).

Discussion

We organize the discussion around the four major findings that emerge from this work. These include (a) a lack of correlation between school and local environmental knowledge; (b)
little association between parental occupation and adolescents’ environmental knowledge; (c) a weak association between students’ interest in environmental jobs and environmental knowledge; and finally (d) a strong but nonlinear association between the year of schooling and school environmental knowledge.

School and local environmental knowledge and their link

Results of this research suggest Ixtlan preparatory students’ environmental knowledge was low. We found that, on average, students obtained a school environmental knowledge score of 6.7 points over a total of 10. Since the annual average of students’ school qualifications was 7.6 over 10 points, students’ school environmental knowledge was lower than the average knowledge on subjects taught in the school.

We also found that, on average, students were only able to report 2.51 plants in the free-listing exercise. The result is low in comparison with similar studies with indigenous populations throughout Latin American communities. For example, Lozada, Ladio, and Weigandt (2006) found that inhabitants from a rural population in Patagonia, Argentina, mentioned on average 31 species of useful wild plants. Although the previous study was conducted with adults, not with adolescents, the number of plants listed varies greatly from the plants listed in our study.

Results from this work also show that school and local environmental knowledge are not correlated among indigenous adolescents in a Mexican preparatory school. We have two possible explanations for the lack of correlation between the two proxies of environmental knowledge. First, it is possible that our proxies for SEK and LEK do not capture well students’ school and local environmental knowledge. To construct our proxies, we followed insights from previous research (see, e.g., Barraza & Pineda, 2003; Bradley et al., 1999; Hunn, 2002), but we cannot rule out the possibility that our measures are poor indicators of the types of environmental knowledge under consideration. A second, more plausible, explanation to the lack of correlation between the two measures is that the two types of environmental knowledge might just measure different domains of environmental knowledge that complement, rather than substitute, each other. SEK proxies adolescent’s knowledge about scientific concepts taught in the school whereas LEK proxies adolescent’s knowledge about local plants. Some adolescents might have acquired knowledge of their local environment, but might not have the academic interest to learn the environmental concepts taught at school and vice versa. The lack of association between both types of knowledge has implications for future research on environmental knowledge because it suggests that an accurate definition of individual environmental knowledge should include both school and local environmental knowledge. The finding also implies that environmental education programs might be more comprehensive if addressing both school environmental science concepts and local environmental issues.

Environmental knowledge and parental occupation

The second finding that deserves discussion is the weak association between parental occupation in the community forestry enterprise and adolescents’ environmental knowledge. We had hypothesized that students with comunero parents would be more familiarized with environmental issues than those students whose parents were not engaged in the community organization. Our data do not support the hypothesis.

Three reasons, one methodological and two theoretical, might explain the lack of association between having a comunero parent and student’s local environmental knowledge.
First, remember that only 9.50% of the students in our sample belonged to comunero families. The small sample size made our estimation more conservative.

Other than this methodological reason, two nonexclusionary theoretical reasons might explain the lack of association. Comunero parents and their adolescents enrolled in school might spend little time together and in contexts other than the forest. According to Sternberg et al. (2001), in some developing countries, time that children spend on learning school material is taken away from time they spend learning material relevant to adaptation to community life. In Ixtlan, before the opening of the preparatory school, adolescents used to help their parents in forest management activities, which might have enhanced their local environmental knowledge. For example, our key informant told us that he knew about plants more because his father worked in the forest than because of his schooling. However, nowadays, adolescents cannot go with their parents to the forest because they are at school from 7 a.m. to 3 p.m. In addition, ethnographic information suggests that adolescents spend most of their free time playing games or just walking in the streets, which probably decreases the number of conversations about forest issues at home. In a research on a similar context, Ruiz-Mallén and Barraza (2006) interviewed 32 adolescents and their father or mother about the conversations they usually had at home. Adolescents mentioned that in conversations with their parents local topics were often discussed and more so in comunero’s families, but no one said that they talked about managing forest resources. Furthermore, many parents responded they usually talked with their children about the social and economic topics regarding the community forest; they did not mention forestry issues.

The last explanation for the lack of association between students’ local environmental knowledge and having a comunero parent is that parental acculturation might affect students’ local environmental learning. Observations and informal conversations with key informants from Ixtlan revealed that parents do not teach their children Zapoteco because they do not want their children to learn “traditional” issues. Comunero parents might not transmit local environmental knowledge to their children for similar reasons.

Environmental knowledge and professional interests

Findings of this study suggest students’ professional interests in environmental issues are weakly associated with their school environmental knowledge but not with their local environmental knowledge. As we have discussed before, it is possible that students are not acquiring an environmental culture from their parents who encourage them to learn about their environment. Current pedagogic practices in Ixtlan preparatory school might also help explain the finding.

According to Reinfried (2004), teaching methods that allow action-oriented and autonomous learning in local settings promote students’ interest for real-world encounters and enhance long-term knowledge retention. However, our ethnographic information suggests that school environmental science concepts are taught basically by using textbooks and that science classroom teaching is focused on general rather than local specific issues. Since students are not able to apply the theoretical science concepts they read in textbooks to their local reality, it is possible that they do not see a direct connection between the environmental knowledge taught in school and the knowledge necessary to work on the local forest. In a lecture on the forest ecosystem of the Sierra Juarez addressed to preparatory school students, the lecturer, an Ixtleca biologist, similarly identified the lack of local ecosystem-specific information as a specific problem at the management level. Thus, both pedagogic style and pedagogic content might play an influential role in the creation of this gap.
Environmental knowledge and schooling

One more unexpected finding deserves discussion. The variable that captures the student’s level of schooling was associated in a positive way to school and local environmental knowledge. The finding meshes with results from previous research suggesting that the school system has a greater impact than parents in student’s environmental learning (Barraza & Pineda, 2003; Dimopoulos & Pantis, 2003).

Our data also suggest that school environmental knowledge does not increase linearly with years of schooling. We found that students in the 2nd year of preparatory school knew more about environmental science concepts than students in 1st and 3rd years. In Ixtlan’s preparatory school, environmental topics are not included in the curriculum of the 3rd year, but only in 1st- and 2nd-year curriculum. Our results then suggest that students in the 3rd year might not remember environmental concepts taught in previous years.

We also found that student’s familiarity with local plants increases with schooling, even after controlling for the student’s age. The different types of association between school and local environmental knowledge and schooling might relate with the different pedagogic methods used for teaching them. As explained, school science concepts are taught using traditional methods, which do not promote students’ enduring interest in school environmental learning (Reinfried, 2004). Contrarily, knowledge of local plants is acquired by practical methods, as observations, which is supposed to promote environmental learning of plant species (DiEnno & Hilton, 2005). It is understood that learning will inevitably be more successful if teachers can relate to and build upon students’ existing understandings of whatever concept or phenomenon is being addressed (Palmer, 1998). During informal conversations and interviews we noticed that several Ixtlan preparatory school students were consistent in asserting that they prefer practical to classroom learning in terms of feeling they “get in.” The ethnobotanical garden might have influenced the environmental knowledge of 2nd-year students because it is used as a didactic method for teaching both several school environmental science concepts and local plants.

Conclusions

There is an on-going need for environmental education research to pay more attention to the definition and measurement of the concept of environmental knowledge. Our research shows that school and household settings relate to school and local environmental knowledge in different ways. Research on children and adolescents’ environmental learning should analyze and evaluate knowledge acquisition and transmission in both formal and nonformal contexts and should measure separately school and local environmental knowledge. The distinction between both types of knowledge becomes more relevant when dealing with indigenous communities where researchers have historically focused on studying local environmental knowledge and put relatively little emphasis on considering what was taught in the schools. Ethnobiologists and environmental education researchers should work together in understanding how indigenous adolescents learn about their environment both within and beyond their schools in order to identify opportunities for designing environmental education programs.

Future research on environmental education should focus on improving environmental education at school and home in Mexican indigenous communities. In formal settings, efforts should focus on looking for novel participatory teaching techniques that substitute current traditional pedagogical practices. In nonformal settings, it is necessary to study what factors affect the transmission of environmental knowledge from parents to children.
Concretely in Ixtlan, further research on these issues will be helpful for promoting adolescents’ interest and participation in activities that can either support or be part of communal forest management.

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