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Child-orientated environmental education influences adult knowledge and household behaviour

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Abstract
Environmental education is frequently undertaken as a conservation intervention designed to change the attitudes and behaviour of recipients. Much conservation education is aimed at children, with the rationale that children influence the attitudes of their parents, who will consequently change their behaviour. Empirical evidence to substantiate this suggestion is very limited, however. For the first time, we use a controlled trial to assess the influence of wetland-related environmental education on the knowledge of children and their parents and household behaviour. We demonstrate adults exhibiting greater knowledge of wetlands and improved reported household water management behaviour when their child has received wetland-based education at Seychelles wildlife clubs. We distinguish between 'folk' knowledge of wetland environments and knowledge obtained from formal education, with intergenerational transmission of each depending on different factors. Our study provides the first strong support for the suggestion that environmental education can be transferred between generations and indirectly induce targeted behavioural changes.

Keywords: environmental education, knowledge, behaviour, wildlife club, Seychelles

S Online supplementary data available from stacks.iop.org/ERL/8/015016/mmedia

1. Introduction

Environmental education (EE) is a key component of the conservationist's toolbox, which can increase knowledge (Vaughan *et al* 2003, Trewhella *et al* 2005) leading to improved attitudes (Bradley *et al* 1999, Aipanjiguly *et al* 2002), thus potentially changing behaviour. The effect of EE on behaviour is challenging to investigate as uncertainties proliferate concerning the psychological determinants of behaviour and the effect of socio-cultural factors on behavioural expression (Ajzen 1991). There are inherent difficulties in proving a causal relationship rather than an association between receiving EE and subsequent changes in knowledge levels, attitudes or behaviours (Bride 2006). Research on the topic has been biased towards qualitative analysis of 'perceptions' and 'opinions', limiting the ability to draw conclusions regarding the influence of knowledge acquisition on exhibited behaviour.

There are trade-offs in choosing the targets for environmental education. Children are a frequent target

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audience as attitudes towards the environment start developing at an early age (Bryant and Hungerford 1977) and once formed do not change easily (Asunta 2003). They are less likely to have well-established environmentally harmful behaviours to 'unlearn'; have a longer period to influence environmental quality and are possible effective agents promoting environmentally responsible behaviour in others (Leeming and Porter 1997).

Whilst these are robust reasons for targeting children with EE, many serious environmental issues require swift, decisive action (MEA 2005). EE should perhaps, therefore, target those with the capacity to implement rapid change through modification of their own behaviours and by demanding legislative change. Children rarely meet these criteria. However, the role of children as agents of change may point at a solution to the apparent trade-offs associated with focusing EE on a single generation.

The commonly held view is that parents teach their children, inculcating their knowledge, values and beliefs. However a growing body of literature provides evidence for bi-directional influence between parents and children (Ambert 1992, Kuczynski *et al* 1999, Knafo and Galansky 2008). Studies into the impact of children on parent's environmental knowledge, attitudes and behaviours however remain limited and inconclusive (Duvall and Zint 2007). For example Vaughan *et al* (2003) showed that following children's attendance at a month long educational course about scarlet macaws (*Ara macao*), their parents' scores on knowledge tests had improved by 38% on average; the control group showed no improvement. However the method of knowledge transfer in this study—shared homework activities—means that the extent of active child influence on parents is impossible to discern. Results of studies that have attempted to assess child influence on parent's ecological behaviours are less frequent still. Legault and Pelletier (2000) found no behavioural influence of a one year long education programme in Canada whilst Uzzell *et al* (1994) describes an increasing in parental 'action competence' the ability to identify a problem, evaluate it and undertake possible solutions. Leeming and Porter (1997) do identify elevated levels of self-reported 'communication behaviours' such as engaging in environmental discussions with friends and family and purchasing books about environmental problems. To date no link between a children's education programme directed at a specific environmental problem and an increased uptake of parental behaviours directly related to same environmental problem has been quantitatively demonstrated. Past studies have also had a narrow focus that is centred on short-term programmes within the formal education systems of developed countries (Duvall and Zint 2007).

The Republic of Seychelles is a biodiverse archipelago in the Indian Ocean. Local management of scarce freshwater habitats collapsed with the creation of a Public Utilities Company. As a result litter, wetland reclamation and household wastewater are degrading freshwater habitats. A key conservation activity component in the Seychelles is EE within the school system, one component of which is provided by Wildlife Club Seychelles (WCS), an NGO overseeing extracurricular wildlife clubs in every school. WCS staff and Wildlife Club leaders collaborate to develop each club's activities around specific topics, including wetland conservation.

Determining the direction of influence is a key goal of any study on intergenerational knowledge transfer (Knafo and Galansky 2008). In this study, we utilize the WCS structure to assess the effectiveness of EE in influencing both the knowledge of children and their parents and related household behaviours. Because all schools had a Wildlife Club we were able to control for parental influences on wildlife club attendance, enabling us to compare children with otherwise very similar experiences, except for the receipt of specific education concerning wetlands. Wetlands were chosen as the topic because Seychelles were likely to have relatively low baseline awareness due to a historical emphasis towards species rather than habitat conservation (Norris and McCulloch 2003, Komdeur 1994) and because a wetlands module had been taught in some clubs over the past 12 months but not others. These other clubs had instead focused on alternative environmental subjects during their after school club activities. We aimed to quantify the effect of receiving education on wetland ecology and conservation on children's environmental knowledge; quantify differences in knowledge between parents whose children had or had not received wetland education; and assess whether reported water conservation behaviour differed between households with children who had or had not studied wetlands.

2. Methods

Data were collected on Mahé Island, Republic of Seychelles in May–June 2009. Fifteen wildlife clubs took part in the study. Seven (five primary and two secondary school-based) had undertaken activities on wetlands in the past 12 months; whilst the remaining eight (four primary and four secondary) had worked on alternative subjects. The design produced four population sub-samples; children who had received education on wetlands, a control group who had worked on alternative topics and the parents of each child group.

Self-administered questionnaires were used to collect paired data from parent and child. Response rates were maximized by following the 'total design method' (Dillman 1978, 1983, Salant and Dillman 1994). Questionnaires were handed out to all the students enrolled in each school's wildlife club within the age range 7–15, a total of 161 children. Two similar questionnaires were produced, one for students and a second for their parents. The students filled in their questionnaire in class, and were asked to take the second questionnaire home for their parents, with entry into a prize draw as the incentive for returning the questionnaire. Open-ended questions within both questionnaires gave an opportunity to confirm that forms had been completed by an adult within the household. English language questionnaires were used for adults and secondary school pupils and a Creole translation for primary school students. Back translations were used to confirm translation accuracy (Werner and Campbell 1970). The questionnaires measured multiple

aspects of wetland knowledge, behaviour and demographic characteristics and included closed and open-ended questions. A pilot study with 24 students at two wildlife clubs was undertaken to check survey design.

Five questions covering knowledge of wetland species composition, ecosystem service provision, wetland location, threats to wetlands and conservation organizations working to conserve wetlands were used to assess participant's wetland knowledge. Principal component analysis (PCA) was used to reduce the dimensionality of the knowledge measure (see supplementary material available at stacks.iop.org/ERL/8/015016/mmedia). Generalized linear models (GLMs) were used to analyse explanatory variables that best explained wetland knowledge. These included the frequency and duration of child attendance of WCS and socio-demographic variables including children's age. Explanatory variables highlighted as influential by tree models and their interactions were included in a saturated model with an appropriate error structure (Crawley 2007). Model residuals were examined for evidence of lack of fit. The models were then simplified to a minimal adequate model (MAM) by the stepwise deletion of the least significant variables (Crawley 2002).

The measure of reported behaviour addressed the issue of water shortages on the Seychelles (Payet and Agricole 2006). Families' choices were analysed between undertaking comparable behaviours with a high and low water cost, for example taking a bath or having a shower. The measure was adapted from a commonly used water budgeting project for school children which features as an exercise in the wetland topic's educational materials (Vel and Morel 2001). Behaviours were scored as +1: water conscious and −1: high water cost. Total scores were calculated based on parents' selections from 16 possible behaviours. Data analysis was conducted using Microsoft Excel, SPSS Ver. 17.0.2 and R Ver. 2.8.1 (R. Development Core Team 2009).

3. Results

85% of the questionnaires were returned with sufficient information to generate directly comparable knowledge scores for both parents and students ($n = 137$, 60 wetland subjects, 77 alternative subjects). PCA analysis of knowledge measures followed the same pattern for all sub-samples (see supplementary materials available at stacks.iop.org/ERL/8/015016/mmedia). Principal component (PC) 1, incorporated four of the five questions designed to measure wetland knowledge, PC2 was principally a measure of a single explanatory variable 'Awareness of Local River'; the respondent's ability to describe the location of the nearest river or stream to their home. The single variable nature of PC2 and the satisfactory explanation of remaining components by PC1 made it possible to discard PC2 and instead use the original question as a variable in the model. PC1 scores are subsequently referred to as the 'knowledge score'. The awareness of a rivers location is not related to scientific and ecological factual recall and can be more accurately associated with 'folk knowledge' of the local environment. Similar loadings for the knowledge score measure enabled direct comparison between parent and student knowledge scores.

Children who had carried out wetland work had higher knowledge scores than those who had not ($t = 4.144$, $df = 134.7$, $P < 0.001$), but there was no difference between the two sub-samples in their awareness of their local rivers location ($X^2 = 0.595$, $df = 1$, $P = 0.440$). Parents of children who had undertaken wetland work had higher knowledge scores ($W = 2905.5$, $n = 137$, $P = 0.0049$); again there was no significant difference in river awareness between sub-samples ($X^2 = 0.1947$, $df = 1$, $P = 0.6591$).

Parents who reported that their children talked about their environmental education had significantly higher knowledge scores than those who did not ($W = 2055.5$, $n = 137$, $P = 0.0024$). However there was no significant difference between knowledge scores of adults that reported acquiring environmental information from their children and those that did not ($t = 1.208$, $df = 89.18$, $P = 0.230$).

The minimum adequate model for student knowledge score contained four significant explanatory variables and two significant interactions (table 1(a)). Being aware of a local river's location, undertaking wetland work and attending WCS for longer periods all increased knowledge scores, while having a larger number of siblings had small but significant negative influence on student knowledge score as a main effect, but a positive interaction with having undertaken wetland work. Students were more likely to be aware of their local river if they had good wetland knowledge and parents who were aware of their local river's location (table 1(b)).

Student knowledge scores were a highly significant explanatory variable for adult knowledge score, along with increased adult age (table 2(a)). Child knowledge score explains half of the observed variance in parental knowledge score (partial correlation coefficient = 0.523). A second GLM was produced for parental knowledge score which excluded the explanatory variable 'student knowledge score', as it was felt that the strong influence of this variable might be masking the expression of variables which could provide further evidence for or against the occurrence of directional intergenerational knowledge transfer (table 2(b)). In this model a significant positive effect is seen when the focal child has undertaken wetland work at WCS and for parents who reported learning about the environment from their children. Additional predictors of higher wetland knowledge included parents educational level and long-term residence in the area. Predictors of parental awareness of their local river were very different; in this case student knowledge had a negative effect, while parental knowledge score was positively related to local river awareness (table 2(c)).

The model for household water conservation behaviour had high deviance suggestive of a poor overall fit. However diagnostic plots suggested there were no problems with model specification, enabling preliminary conclusions about the factors that influence family water use behaviour to be drawn (table 3). The most significant variable affecting water use behaviour was whether the focal child had undertaken wetland education; studying wetland topics had a highly significant positive influence on water use behaviour. Households where

Table 1. Student wetland knowledge. The minimum adequate generalized linear models for: (a) Student 'wetland knowledge score', Gaussian error structure. (b) Whether the student was aware of their local river, binomial error structure.

Coefficients:	Estimate	Std. error	T value	Pr ($>\|t\|$)
	(a)			
(Intercept)	−1.7317	0.3791	−4.568	<0.001
Undertaken wetland work	0.7986	0.3846	2.076	0.0399
Student aware of local river	0.5490	0.1448	3.792	<0.001
Adults years in community	0.0240	0.0138	1.734	0.0852
Time attending WCS	1.1296	0.2513	4.494	<0.001
Number of siblings	−0.1583	0.0586	−2.700	0.0079
Undertaken wetland work: time attending WCS	−0.4271	0.2163	−1.974	0.0505
Undertaken wetland work: number of siblings	0.1883	0.0794	2.371	0.0192
Adults years in community: time attending WCS	−0.0200	0.0090	−2.234	0.0272
Null deviance: 135.158 on 136 degrees of freedom, residual deviance: 83.377 on 128 degrees of freedom				
	(b)			
(Intercept)	−0.9871	0.2855	3.457	<0.001
Parent aware of local river	1.3805	0.3898	3.542	<0.001
Student knowledge score	0.7887	0.2170	3.634	<0.001
Null deviance: 187.81 on 136 degrees of freedom, residual deviance: 157.12 on 134 degrees of freedom				

Table 2. Parent wetland knowledge. The minimum adequate generalized linear models for (a) Parental 'wetland knowledge scores', Gaussian error structure. (b) Parental 'wetland knowledge scores' excluding the explanatory variable 'Student wetland knowledge score', Gaussian error structure. (c) Parental awareness of their local river, Binomial error structure.

Coefficients:	Estimate	Std. error	T value	Pr ($>\|t\|$)
	(a)			
(Intercept)	−0.4734	0.3249	−1.457	0.1475
Student knowledge score	0.7417	0.0960	7.723	<0.001
Parent aware of local river	−0.0168	0.2931	−0.057	0.9543
Parent age	0.1931	0.0935	2.065	0.0409
Additive child club attendance	−0.2928	0.0907	−3.228	0.0016
Student knowledge score: parent aware of local river	−0.3425	0.1305	−2.625	0.009
Parent aware of local river: additive club attendance	0.4806	0.1284	3.742	<0.001
Null deviance: 157.198 on 136 degrees of freedom, residual deviance: 69.828 on 130 degrees of freedom				
	(b)			
Coefficients:	Estimate	Std. error	T value	Pr ($>\|t\|$)
(Intercept)	−2.2305	0.3171	−7.035	<0.001
Parent aware of local river	1.3196	0.1908	6.917	<0.001
Undertaken wetland work	1.5908	0.3136	5.073	<0.001
Adult education	0.3651	0.1188	3.073	0.0026
Adults years in community	0.0161	0.0077	2.095	0.0381
Parents get environmental info from kids	0.2920	0.1478	1.976	0.0503
Parent aware of local river: undertaken wetland work	−0.7382	0.2922	−2.526	0.0127
Undertaken wetland work: adults years in community	−0.0288	0.0119	−2.425	0.0167
Null deviance: 157.20 on 136 degrees of freedom, residual deviance: 89.64 on 129 degrees of freedom				
	(c)			
Coefficients:	Estimate	Std. error	Z value	Pr ($>\|z\|$)
(Intercept)	−0.698	0.2881	−2.422	0.0155
Parent knowledge score	1.848	0.3774	4.898	<0.001
Student aware of local river	1.609	0.4578	3.514	<0.001
Student knowledge score	−1.003	0.3105	−3.229	0.001 25
Null deviance: 189.92 on 136 degrees of freedom, residual deviance: 130.81 on 133 degrees of freedom				

all offspring had a higher combined WCS attendance also showed more conservative water use. Water conservation was also more reported in households where parents had higher knowledge of freshwater systems and had been actively engaged in freshwater conservation activities such as community conservation days.

Table 3. The minimum adequate model for family water use behaviour, using a generalized linear model with a Gaussian error structure.

Coefficients:	Estimate	Std. error	*T* value	Pr (>|*t*|)
(Intercept)	−1.669 54	0.974 77	−1.713	0.0892
Adult knowledge score	0.181 71	0.236 79	0.767	0.4442
Undertaken wetland work	1.316 30	0.472 59	2.785	0.0062
Adults years in community	0.073 78	0.040 16	1.837	0.0685
Adult undertaken wetland activities	−0.025 20	0.633 59	−0.040	0.9683
Additive club attendance	0.951 18	0.451 45	2.107	0.0371
Adult knowledge score: adult undertaken activities	1.504 24	0.688 89	2.184	0.0308
Adults years in community: additive club attendance	−0.045 0	0.018 72	−2.409	0.0174
Null deviance: 1051.45 on 136 degrees of freedom, residual deviance: 854.92 on 133 degrees of freedom				

4. Discussion

The two measures of knowledge about wetland systems have very different connotations. Wetland knowledge score was a measure of taught knowledge whilst awareness of the local river was more akin to 'folk knowledge'. This enabled us to compare the factors that contributed to wetland knowledge scores with those that predicted river awareness and draw firmer conclusions about the role of EE in knowledge acquisition and transfer. Feedback between becoming aware of a habitat and acquiring factual information is likely, rather than there being a direct causal relationship, so wetland knowledge score and awareness of a local river's location are expected to be associated throughout the analysis.

This study provides evidence to suggest that the environmental knowledge of learners is positively influenced by EE. Higher wetland knowledge scores are found for pupils who have undertaken wetland work, having taken other explanatory variables into account. We also find that attending WCS for progressively longer time periods has a significant impact on knowledge scores. Longer attendance increases the chance a child has studied wetland subjects before the 12 months considered in this study. The final factor found to significantly predict higher student knowledge scores is student awareness of rivers. The predicted endogenous relationship between variables is likely to be enhanced in this analysis because the teaching of wetland topics frequently involves visits to local wetlands (pers. obs.). An additional interpretation is that practical hands-on interactions outside of the school environment enhance learning (Kusmawan *et al* 2006, Crater and Megs 1981, Aird and Tomera 1977). Awareness of a local river's location, in contrast to knowledge score, shows no significant difference between student sub-samples. This shows that children who have not undertaken specific work on wetland habitats are not devoid of wetland awareness or experience, but only by undertaking EE have they acquired and retained specific factual information. This result agrees with findings by Blum (1987); that education is a major source of environmental knowledge for children.

We also demonstrate transfer of environmental knowledge from child to parent. Parents with children that had studied wetland subjects had significantly higher wetland knowledge scores. Interestingly, however, it seems that parents did not perceive that they were gaining knowledge from their children; those who reported that children discussed their environmental work with them had higher scores, but there was no difference between the parental knowledge scores of adults who reported learning about environmental issues from their children and those that did not. Many studies that investigate child influence on parents rely on adult reporting of the phenomenon (Dillon 2002, Hagestad 1984, Peters 1985). If adults are unaware of knowledge transfer from children then the accuracy of investigations reliant on parental reporting of child–parent influence must be questioned. By providing evidence of child to parent transfer of education-dependent knowledge, this study suggests that children can be 'effective agents' for the environment, as suggested by Leeming and Porter (1997), to immediate family at least.

Parents were also shown to have higher wetland knowledge when older (table 2(a)), had resided in the same community for longer and had higher education levels (table 2(b)). Both increased age and longer community residence increase the chance that they experienced the tradition of community managed freshwater resources subsequently replaced by the Public Utilities Company. Greater education levels amongst adults are a recognized predictor of higher environmental knowledge and eco-centric behaviour (Godoy *et al* 1998).

The lack of a difference between the adult groups in their awareness of their local river, as for the children, suggests that, unlike specific wetland knowledge, parental awareness of their local environment is not due to EE undertaken at WCS. Indeed an unexpected small negative influence of increased child knowledge on adult awareness of their local rivers location is observed. This may be due to increasing uncertainty amongst adults about which river is geographically closest to them as their children are exposed to more of the Seychelles many small wetland areas through WCS activities. Parental knowledge score, itself influenced heavily by child knowledge (table 2(a)), has a positive impact on parental awareness of local river location, as a result it is difficult to determine the true direction of influence of factual education on parental folk knowledge. Further study of the factors that contribute to high levels of informal acquired knowledge of the natural world would be needed to determine the true direction of influence. It is likely that awareness of the local environment is reciprocal in nature, with parents and children sharing activities and conversation (Musser and Diamond 1999).

Two unexpected negative interactions were also observed. In the model for students wetland knowledge having undertaken wetland work at WCS and longer times of attending WCS interact to have a slight negative influence (table 1(a)). Parents being aware of their local rivers locality and having a child that has undertaken wetland work interact to have a negative impact on parental wetland knowledge (table 2(b)). For both of these interactions the individual variables are observed to have a positive impact within the same model. As a result interpreting these interactions is difficult. Their presence should not distract from the key findings within the models but may indicate that further study is necessary to highlight further nuances of the impact EE has on children and parents uptake of factual knowledge.

The fact that students undertaking wetland work is a significant predictor of their family's water use supports the prediction of Leeming and Porter (1997); that children may be able to influence behaviours of those not directly receiving EE. Additionally a higher combined attendance at WCS, which increases the chance of at least one child experiencing some freshwater education, also has a positive effect on family water use behaviour. This evidence that EE can have a significant effect on family behaviour related to the taught subject disagrees with the findings of Hungerford and Volk (1990), Palmer (1995) and Palmer and Birch (2005), who all demonstrate that environmental knowledge alone is insufficient to generate favourable environmental behaviours. It also disagrees with Legault and Pelletier (2000) who found that intergenerational knowledge transfer did not increase ecological behaviours in recipients parents. Eco-centric household water use is also seen when adults show higher knowledge of freshwater systems and have themselves been actively involved in freshwater-based environmental activities within their communities. As adult knowledge itself is influenced by child participation in freshwater lessons at WCS, this suggests that positive reinforcement of intergenerational influences is being achieved.

This study suggests that the EE being conducted on the Seychelles is working. Children are learning about their environment and are passing this information on to their parents, influencing household behaviours. Practical and integrated environmental activities that take place outside the classroom can enhance student learning (Kusmawan *et al* 2006, Crater and Megs 1981, Aird and Tomera 1977) and are more effective at instilling an intrinsic valuation of nature (Van den Born *et al* 2001). Club visits that enable children to have direct experiences of nature are integral features of WCS activities and act as a major draw for children joining WCS (club leaders, personal communications). Van den Born *et al* (2001) show that intense and direct experience of natural environments as a child are important in shaping future attitudes towards the natural world. In this study, time spent in the formal school system (proxied by age) does not affect students' wetland knowledge. It is only by attending the more dynamic WCS that this knowledge is acquired. Parent knowledge may benefit from children undertaking interactive activities as they are more likely to discuss exciting EE with parents than written tasks.

Higher attendance of WCS, over time or by multiple children, may be confounded with innate enthusiasm, hence complicating the inference of causality. The fact that water use behaviour is self-reported rather than observed also means that the inference of causality is weaker, as those with more knowledge may be more aware of the answers expected by the researcher. An ideal experimental scenario would follow Vaughan *et al* (2003) who used a longitudinal experimental design in which data from children and adults were collected at three points in time. Crucially a baseline measure of knowledge, attitudes and behaviour prior to delivering an education programme facilitates the identification of causality (Taris 2000, Legault and Pelletier 2000). Undertaking a longitudinal study in this manner not only requires an extended data collection period; it also requires a positive decision to analyse EE effectiveness to be made prior to the education programme taking place.

This study is unique in the EE literature in that it uses quantitative data to demonstrate a causal link from EE-induced knowledge acquisition in children through to a desired, conservation linked, behavioural change at the household level. By illustrating the capacity of EE directed at children to modify parental knowledge and behaviour this analysis also provides evidence that the decision to educate children or adults need not be mutually exclusive. Further studies assessing the potential of EE and evaluating its implementation should build on the findings in this study.

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