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Contributed Paper

Evaluating Children's Conservation Biology Learning at the Zoo

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Abstract: *Millions of children visit zoos every year with parents or schools to encounter wildlife firsthand. Public conservation education is a requirement for membership in professional zoo associations. However, in recent years zoos have been criticized for failing to educate the public on conservation issues and related biological concepts, such as animal adaptation to habitats. I used matched pre- and postvisit mixed methods questionnaires to investigate the educational value of zoo visits for children aged 7–15 years. The questionnaires gathered qualitative data from these individuals, including zoo-related thoughts and an annotated drawing of a habitat. A content analysis of these qualitative data produced the quantitative data reported in this article. I evaluated the relative learning outcomes of educator-guided and unguided zoo visits at London Zoo, both in terms of learning about conservation biology (measured by annotated drawings) and changing attitudes toward wildlife conservation (measured using thought-listing data). Forty-one percent of educator-guided visits and 34% of unguided visits resulted in conservation biology-related learning. Negative changes in children's understanding of animals and their habitats were more prevalent in unguided zoo visits. Overall, my results show the potential educational value of visiting zoos for children. However, they also suggest that zoos' standard unguided interpretive materials are insufficient for achieving the best outcomes for visiting children. These results support a theoretical model of conservation biology learning that frames conservation educators as toolmakers who develop conceptual resources to enhance children's understanding of science.*

Keywords: conservation education, environmental education, informal science learning, public engagement, public understanding of conservation biology, science education, zoo education

Evaluación del Aprendizaje de Biología de la Conservación por Niños en el Zoológico Jensen

Resumen: *Millones de niños visitan a los zoológicos cada año con sus padres o escuelas para conocer de primera mano a la fauna silvestre. La educación pública de la conservación es un requisito para pertenecer a las asociaciones profesionales de zoológicos. Sin embargo, en años recientes los zoológicos han sido criticados por fallar en educar al público en asuntos de conservación y conceptos biológicos relacionados, como la adaptación de los animales al hábitat. Utilicé cuestionarios pareados de métodos mixtos de pre- y pos-visita para investigar el valor educativo de las visitas a los zoológicos para niños entre 7 y 15 años. Los cuestionarios recopilaron datos cualitativos de estos individuos, incluyendo opiniones relacionadas con el zoológico y un dibujo de un hábitat con comentario. Evalué los resultados relativos del aprendizaje de visitas guiadas y no-guiadas por un educador en el zoológico de Londres, ambas en términos de aprendizaje sobre biología de la conservación (medida por los dibujos con comentario) y actitudes cambiantes hacia la conservación de la fauna silvestre (medidas con los datos de la lista de opiniones). El 41% de las visitas guiadas por un educador y el 34% de las visitas no guiadas resultaron tener aprendizaje relacionado con la biología de la conservación. Los cambios negativos en el entendimiento de los niños sobre los animales y sus hábitats fueron más prevalentes en las visitas sin guía. En general, mis resultados muestran el potencial del valor educativo de las visitas a zoológicos por los niños. Sin embargo, también sugieren que los materiales interpretativos estándar en las visitas sin guía no son suficientes para obtener los mejores resultados de los niños visitantes. Estos resultados apoyan un modelo teórico del aprendizaje de la biología de la conservación que enmarca a los educadores ambientales como los encargados de hacer herramientas que desarrollan recursos conceptuales para mejorar el entendimiento de la ciencia por los niños.*

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Palabras Clave: Aprendizaje informal de la ciencia, compromiso público, educación ambiental, educación de la ciencia, educación de la conservación, educación en zoológicos, entendimiento público de la biología de la conservación

Conservation science is a field deeply intertwined with social, cultural, and political factors. The fact that many of the most fundamental and intractable problems conservation biologists face have human interests, motivations, assumptions, and behavior as the central feature (Balmford & Cowling 2006) indicates the importance of developing and refining conservation education practice. Although conservation education has urgent problems to address among adult populations, improving the long-term outlook for species conservation requires effective engagement with children. Millions of children visit zoos every year with their schools, where many encounter educational messages relating to conservation biology alongside live animals. As such, zoos represent a major opportunity to engage children with live animals, biological science, and conservation. Indeed "keeping animals and presenting them for the education of the public" is one of the fundamental activities of the contemporary zoo and a requirement for membership in professional zoo associations such as the European Association of Zoos and Aquariums (Moss & Esson 2012). Moreover, the recent emphasis on public engagement with science by government and scientific institutions (e.g., Holliman et al. 2009; Holliman & Jensen 2009; Jensen & Wagoner 2009) offers zoos the opportunity to position themselves as a key venue for public engagement with both the sciences and wildlife conservation.

However, in recent years there has been increasing criticism of zoos for failing to demonstrate their purported educational and conservation impacts. In particular, animal rights groups, such as the Royal Society for the Prevention of Cruelty to Animals (RSPCA), have leveled criticisms against zoos' educational claims on evidentiary grounds. The RSPCA contends, that because keeping animals in captivity has an animal welfare cost "it is not enough for zoos to *aim* to have an educational impact, they should *demonstrate* substantial impact" (emphasis added) and that "this does not yet appear to be the case" (RSPCA 2007: 97).

The RSPCA conducted a literature review in which they evaluated the level of peer-reviewed evidence supporting zoos' educational claims. They concluded that evidence on the educational value of zoos in the current peer-reviewed literature is thin.

> . . . [Z]oos are only just beginning to seriously evaluate . . . the impact their educational programs have on visitors and whether they are fulfilling their objectives. In this respect they are lagging well behind institutions such as museums and science centres (RSPCA 2007: 97).

Reacting to such assessments, Esson (2009: 1), Education Programmes Manager at Chester Zoo, describes the situation as follows:

> Zoos are increasingly finding themselves lodged between a rock and a hard place when it comes to substantiating claims to be education providers, and the zoo community is coming under increased pressure to evidence that learning has taken place as a result of a zoo visit.

When paired with ethical criticisms of holding animals in captivity (e.g., Jamieson 2006), the lack of evidence of learning has been used to call into question the legitimacy of the zoo as an institution. Antizoo activists have gone much further in arguing that only negative learning could result from a zoo visit (e.g., Captive Animals Protection Society 2010). Thus, evidence of educational impact is crucial if contemporary zoos are to empirically validate their role as charities promoting biology-related learning and conservation.

However, as noted in the RSPCA (2007) report, prior published research on zoos often eschews fundamental questions about zoos' abilities to deliver effective engagement of visitors with science and conservation and focuses instead on dependent (outcome) variables such as satisfaction, "stopping power," "implicit connectedness to nature," and visitor behavior within the zoo (Moss et al. 2010*a*, 2010*b*), which are assumed to provide some proxy information about educational impact. For example, previous studies have focused on independent (causal) variables such as viewing area size (e.g., Moss et al. 2008), visitor density (Moss et al. 2007), relative credibility of different zoo-based personnel (e.g., Fraser et al. 2008) and "identity-related motivations" (Falk et al. 2007). Among those previously published studies that do focus on zoo impacts, most use postvisit only or aggregate-only data (or both), thus making it impossible to identify patterns of learning that can be validly applied at the level of the individual (Molenaar 2004). A range of methodological shortcomings such as an overreliance on self-reported data further undermines the conclusions (both positive and negative) of most such studies of zoos' educational impact.

Prior Research on Zoo Visitor Impacts

Perhaps the most prominent prior study of zoos' educational impact was conducted by Falk et al. (2007) at 4 sites in the United States. This zoo visitor study was called the multi-institutional research program or MIRP

(Falk et al. 2007). In this multipart study, Falk et al. (2007) set out to evaluate adult zoo visitors' motivations for visiting a zoo and any changes in attitudes toward or learning about conservation. Falk defines this task in terms of identity-related motivations. The focus on these motivations is justified as a prerequisite for prediction of visitor outcomes: "we need to capture the essence of what motivates visitors so we could [*sic*] better predict what they might gain from their visit" (Falk et al. 2007: 6).

Falk et al.'s (2007: 9) thesis is that visitors arrive at museums or zoos with "specific identity-related-motivations and these motivations directly impact how they conduct their visit and what meaning they make from the experience." He develops this thesis with an audience segmentation approach that defines visitors as belonging to one of his 5 categories: facilitators ("desire a social experience aimed at the satisfaction of someone else," such as parents), explorers ("visit for personal interests," such as learning), experience seekers ("visit as tourists [. . . and] value the zoo [. . .] as part of the community"), professionals or hobbyists ("tuned into institutional goals and activities"), spiritual pilgrims (attend zoos as "areas for reflection") Falk et al. (2007: 13). This identity-related motivations approach has been called into question by Dawson and Jensen (2011). Dawson and Jensen (2011) also challenge the methodological approaches employed in the MIRP study for a range of fundamental errors in assumptions and measurement biases. Complementary critiques have also been published highlighting flaws in Falk's approach (e.g., Bickford 2010) and Falk et al.'s (2007) questionable survey methods (Marino et al. 2010).

The segmentation-based research conducted by Falk, Fraser, and other zoo researchers—and most other zoo visitor research in the literature—is almost universally focused on adult visitors only. There is a surprising paucity of evaluation research focused on children visiting zoos (Fraser 2009). Published studies of zoo impacts routinely exclude children from their samples. One example of this is Fraser's (2009) research on parents' perspectives on the value of zoo visits conducted at Bronx Zoo in New York City. Interviews and observations of zoo visits were undertaken with 8 families (14 adults). Fraser (2009: 357) concluded, "parents conceive of the zoo as a useful tool . . . to promote an altruistic sense of self, and to transfer their environmental values. [. . .] They could use these visits to actively support their children's self-directed learning." However, the study only discusses parents' assumptions of the impact of zoos on their children—or what Fraser calls "anticipated utility." The actual utility of zoo visits was not investigated, leaving this issue still unaddressed in the literature.

This lack of direct evidence of the value of zoo-based education for children prompted the present study. The case I examined was groups of pupils, accompanied by teachers and sometimes parents, visiting the Zoological Society of London's (ZSL) London Zoo. Visits by students from state schools, funded by the Greater London Authority, either had an educational presentation that supplemented the mostly unguided (i.e., teacher-led) visit or were unguided for their entire zoo visit. Independent, privately funded schools were able to access the same educational experiences on a subsidized per school group fee basis. This arrangement predated the present research, but it was identified as a unique opportunity to test whether additional educational provision results in increases or decreases in learning or enjoyment. Because the decision about whether to receive an additional educational presentation is made at the school or classroom level and the outcomes are measured at the level of the individual pupil, differences in pupils' outcomes can be attributed to the zoo experience. That is, I took advantage of a naturally occurring setting in which additional educational content was introduced to pupils on a non-self-selecting basis. This study therefore provides insights into the impacts of zoo visits through a comparison of 2 common formats for such visits (zoo educator supplemented and unguided). The percentages of pupils evincing positive, negative, or no change in the annotated drawing data collected for this study provide the basis for assessing the potential learning value of zoo visits.

This manuscript reports on a large-scale ($n = 2839$) study designed to address the lacuna in the literature identified above through an assessment of whether zoos' educational programs deliver positive conservation biology learning outcomes. I used data collected from June to August 2009 on pupils at schools in the Greater London area. I evaluated and compared educational impact for zoo visits accompanied by an educational presentation conducted by zoo educators and for unguided zoo visits. This comparison addresses the most relevant question for conservation biology educators: What can one achieve with pupils who are visiting one's institution? I used data from a sample of pupils visiting one zoo to address this question. I focused on the cumulative impact of zoo visits, rather than the specific individual elements of such visits (cf. Marino et al. 2010).

Methods

I directly measured stability or change in pupils' attitudes and understanding of conservation biology concepts to examine whether a zoo visit facilitates conservation biology learning among school pupils. I also attempted to determine the extent to which unguided school zoo visits lead to conservation biology learning and whether educator-guided school zoo visits lead to greater learning than unguided zoo visits.

One of my methodological aims was to overcome limitations associated with prior research on educational impact in informal learning settings. In particular, I did not rely exclusively on self-reporting measures for learning as previous researchers have (e.g., Marino et al. 2010). Instead a mixture of quantitative and qualitative data were collected, with the present manuscript reporting on quantitative analyses conducted on this mix of data genres, which includes thought listing, annotated drawings, and Likert scales, designed to allow for the valid collection of relevant and reliable data, which could be robustly analyzed to identify different possible forms of impact from children's zoo visits.

Survey Instrument

It is clear from both national and international zoo perspectives that a key emphasis for zoo-based education is promoting understanding of conservation biology. Thus, I tailored my methods to explore this domain of pupils' thinking. To accurately elicit pupils' understandings of habitats and animals, I designed a survey instrument that asked children to draw their favorite animal where it lives in the wild both before and after their visit or educational presentation. A drawing task, such as this, provides an opportunity for children to express their understanding in a medium that is less reliant on formal linguistic capabilities; thus, it is more accessible to young pupils and those for whom English is not their first language.

In a 1-week pilot study, I used 2 versions of the pupil questionnaire with different formats and phrasing. These were assessed for the extensiveness and relevance of pupils' responses. The version that elicited the most extensive responses was then used exclusively (Supporting Information).

The mixed methods (quantitative and qualitative) survey instruments developed for this study included a previsit form and a postvisit form. Different age-appropriate variations on these forms were used for primary school pupils and for secondary school pupils on zoo visits. The previsit form for primary school pupils visiting the zoo included the following elements: demographic details (name, age, and gender); a thought-listing item with 5 numbered lines and the question "What do you think of when you think of the zoo?"; space to complete an annotated drawing, with the instruction, "Please draw your favorite wildlife habitat and all the plants and animals that live there. (Please put names or labels on everything.)" Below the drawing space was a question, "What did you draw above?" I asked this question to elicit further linguistic clues to their level of understanding.

This pre-zoo visit form was expanded somewhat for the secondary school pupils in line with their increased linguistic capabilities. Specifically, the following items were added (which were carried on into the postvisit survey form). I operationalized the concept of conservation self-efficacy by asking pupils' pre- and postvisit (secondary school version of survey only), "Do you feel there is anything you can do about animal extinction?" This is admittedly a modest first attempt to operationalize this complicated idea of conservation self-efficacy. I assessed the pupil's level of concern about wildlife conservation by asking, "Do you feel personally concerned about species going extinct?" (response options were yes, no, not sure).

The postvisit survey forms retained thought listing and annotated drawing items in exactly the same form as in the previsit in order to allow for direct comparisons. In addition, there were items measuring pupils' satisfaction and enjoyment. The question measuring satisfaction was, "How was the London Zoo lesson?" For primary school pupils, a 5-point response scale using face drawings from smiling to frowning was provided; for secondary school pupils, a 5-point response scale from very good to very poor was provided for this item. Enjoyment was measured for the primary school pupils with the question, "Have you had fun at the zoo today?" (response options: yes, no, or not sure). For secondary school pupils the question was, "Overall, did you enjoy your time at London Zoo?" (response options: yes, no, or not sure). In the secondary school version of the postvisit survey form, conservation self-efficacy and conservation concern items exactly matching the previsit survey form were also included. Data from other items in the pre- and postvisit survey forms were not used.

Sampling

The Greater London Authority funding pupils' attendance at the zoo offered a unique opportunity to study patterns of zoo-based educational impact without the potential selection bias of ability to pay that would normally apply. Moreover, the fact that there was a split in the population of visiting pupils between those whose visits were supplemented by an educational presentation tailored to the zoo context and those whose attendance was unguided offered the opportunity to assess whether such additional zoo education made any difference and whether pupils visiting without such supplementary education still learned anything of value.

I surveyed mostly pupils whose zoo visits were supplemented by an educational presentation ($n = 1742$) or were unguided visits with their school ($n = 1097$). There were 890 boys and 834 girls in the education-officer-guided zoo visit sample (18 respondents did not specify their gender), making a total sample size for this category of 1742 pupils for whom paired (before and after) survey data were available. The age range for the education-officer-guided respondents was 7–15 years (mean 10 years). In the unguided zoo visit sample, there were 470 boys and 607 girls (20 respondents did not specify their gender), making a total sample size for this respondent type of 1097 pupils who completed both pre- and postvisit survey forms. The age range for unguided respondents was 7–14 years (mean 9.9 years).

Procedure

Survey forms were administered before and after pupils' experience with London Zoo formal learning activities. The purpose of these questionnaires was to capture any changes in pupils' thinking about animals and their habitats as they participated in different zoo-related activities. The use of pre- and postvisit questionnaires was intended to measure the cumulative impact of the zoo visit on pupils' developing understanding of animals, habitats, and zoos.

The use of a before–after (repeated measures) survey design in this manner can result in false negatives because of inflated pretest responses to self-reported items. However, I used open-ended direct outcome measures (viz. annotated drawings of animals in habitats) rather than relying on closed-ended self-reported items, thereby mitigating the methodological risk typically involved in a repeated-measures design. The selection of this repeated-measures design was also weighted against highly fraught alternatives such as a retrospective pre- and post-test (i.e., both administered postvisit), which clearly increases the risk of a false positive result along with a high risk of response bias.

Data Analyses

Questionnaire data were entered into a spreadsheet by research assistants, where it was organized prior to import into the Statistical Package for the Social Sciences (IBM SPSS) for analysis. All data except for the annotated drawings could be straightforwardly entered without analytic judgment required. The nondrawing data were analyzed with the assistance of relevant software. The thought-listing item provided open-ended responses that were compared from pre- to postvisit to assess aggregate changes in associations between the zoo and conservation-related concepts.

For the pupils' annotated drawings (the learning impact measure), the analysis was idiographic (within each case). A content analysis was conducted using a simple coding scheme. On the first measure, drawings were coded as having undergone positive development in learning (coded as 3), no development (2), or negative development (1) from previsit form to postvisit form. Positive development was defined in terms of increased evidence of elaboration of physiological characteristics of animals, increased conceptual sophistication in terms of the use of more scientific ideas, such as shifting from describing a habitat as sand to desert, or improved accuracy in the placement of animals within their correct wild habitats. Training in conducting this analysis was provided to the 2 undergraduate research assistants working on this project. To show how this coding determination worked, an example of positive development is provided in Fig. 1. In this case, there was a substantial improvement over the course of the pupil's zoo visit and educational presentation in the labeling of the woodland habitat represented.

The previsit drawing in Fig. 1 shows 2 animals, whereas the postvisit drawing includes a dragonfly; butterflies; a generic insect; a pond with a frog, fish, and duck; and a bird's nest in a tree. In the postvisit drawing, the addition of grass, the more detailed selection of an apple tree, and the representation of a hole in the tree "for squirrels" were evidence of a more sophisticated understanding of the environment in which these animals live. Thus, there was evidence of a substantial expansion of this 9-year-old pupil's understanding over the course of her visit to the zoo, which included an educational presentation on teeth and diets.

I blind coded a randomly selected sample ($n = 350$) for quality assurance purposes. A widely accepted statistic for measuring intercoder agreement was employed (Cohen's kappa). The kappa value was 0.885, which is considered a good level of intercoder agreement in content analysis, particularly for latent content as in the present case. Differences uncovered through this quality assurance exercise were resolved through discussion. Once quantified, the data were analyzed to compare sample means for education-officer-led and unguided visits on the drawing-based measure of learning.

Results

Beyond reporting the percentages of positive and negative change in pupils' representations of animals in their wild habitats, the present analysis focuses on the distinction between zoo educator-led versus unguided visits to see whether the addition of a presentation from a zoo educator affected zoo visit outcomes. The dependent (outcome) variables analyzed in this manuscript include actual learning (as measured by annotated drawings), personal concern about species extinction, and conservation self-efficacy (the feeling that one is capable of making a difference in terms of saving animals from extinction).

Cumulative Positive Change

The area which most frequently benefited from positive change following the zoo visit was the learning evidenced by pupils' annotated drawings of an animal in its habitat. In total, 1075 pupils (38%) showed such a positive change in their drawings in the postvisit questionnaire compared with the previsit drawing (41% of education-officer-led visits and 34% of unguided visits). Such positive changes incorporated a range of incremental developments observed across the annotated drawing data, including the addition of accurate labeling (e.g., "canopy," "understory," "rainforest floor"), accurate positioning of

Figure 1. Drawings before and after a zoo visit in response to the instruction to draw a wildlife habitat and the plants and animals that live there (female, age 9).

animals within specific habitats, and greater elaboration of physiological characteristics of animals represented in pupils' drawings. As with the other results presented below, this finding of a quantitative shift from pre- to the postvisit is based on idiographic (within case) analysis and therefore represents the actual proportion of unique individuals undergoing this kind of change.

Respondents were more likely to switch from not indicating previsit personal concern with species extinction to expressing such concern postvisit (18%), rather than the other way around (3%).

The relationship between perceived ability to do something about extinction (i.e., conservation self-efficacy) as measured in the secondary school pupils' survey forms in the pre- and postvisit surveys was weak. Pupils were marginally more likely to switch from having indicated an inability to do something about extinction previsit to having indicated an ability to do something about extinction postvisit (13%), rather than the other way around (9%). The data suggested that existing zoo educational provision may be better at promoting scientific learning and concern about wildlife conservation than empowering pupils to believe they can take effective ameliorative action.

Seven conservation-related ideas were identified in pupils' pre- and postvisit response for comparison. The total previsit frequency count for these conservation-related ideas was 170 (extinct—18; extinction—43; endangered—24; save—15; saved—0; saving—66; conservation—4). The postvisit total was 259 (extinct—16; extinction—76; endangered—27; save—10; saved—7; saving = 118; conservation—5). Therefore, on this measure there was a 34% increase in aggregate conservation-related thoughts from pre- to postvisit.

Comparison of Zoo Educator Guided and Unguided Visits

Pupils on education-officer-led visits showed consistently more positive outcomes (41%) on the annotated drawing measure of learning compared with unguided visits (34%). Those on education-officer-led visits were also significantly less likely to have an overall negative change in their drawings (11%) than those on unguided visits (16%).

Although education-officer-led and unguided visits both evinced significant gains in learning (no impact would be a mean of 2), education-officer-led visits yielded greater aggregate learning on this measure (mean [SD] = 2.297 [0.659]) compared with unguided visits (mean = 2.180 [0.686]).

Discussion

My impact evaluation study focused on the overall effectiveness of zoo education aimed at enhancing understanding of conservation biology for children visiting with their schools. The first headline finding in this study was that 34% of pupils in the study on unguided visits showed positive learning, whereas 16% showed negative learning. This is a net positive for unguided zoo visits but indicated poorer educational impact when compared with the education-officer-led visits, where the ratio of positive to negative learning was 41–11%. The 7% differential in positive learning impacts and 5% differential in negative learning impacts between guided and unguided visits may seem modest. Yet, given the millions of children who visit zoos and similar institutions every year, the prospect of increasing the level of positive learning impacts (while reducing negative impacts) by this proportion is important. It also establishes the principle that zoo education interventions may be able to make a positive difference in children's conservation-related learning outcomes. Although such learning outcomes may not fundamentally change conservation-related behavior, conservation biology learning may establish the basis for further engagement targeted at fostering proconservation social change.

Zoos' claims to serve a vital educational and engagement role in persuading publics of the importance of biodiversity conservation and involving them in this cause cannot be simply accepted at face value. As Moss and Esson (2012: 8) argue,

> for many years, they have confidently promoted themselves as education providers particularly with regard to the conservation of biodiversity; perhaps even used this educational function as part justification for their existence. Because of this, the burden of evidencing educational impact falls squarely on the shoulders of zoos. Yet the research undertaken thus far (and there is a substantial amount) has clearly not been universally accepted as an effective demonstration of zoos' positive impact.

My study was designed to assess whether and to what extent zoo visits can help to develop such positive impacts by employing rigorous social scientific impact evaluation (also see Wagoner & Jensen 2010; Jensen 2011).

My study is the first large-scale effort to quantify the potential educational impacts of zoos for children, and my findings broadly support the idea that zoo visits can deliver proconservation learning and attitudinal impacts. However, there are some important limitations inherent in my study. The most significant limitation, given the study does not employ an experimental design, is the uncontrolled risk of confounding variables, the most obvious of which is the role of the teacher (and accompanying parents). Although the results of this study are consistent with the explanation that the zoo visit yielded aggregate positive learning outcomes, it is possible that the teacher or some other unidentified factor was the key to the positive and negative impacts identified in this study, rather than the zoo. For example, one alternative explanation for the educational impacts I observed is that teachers used the zoo experience as a platform for delivering conservation biology learning. This research also leaves unanswered the broader policy question of whether zoos are worthwhile conservation education institutions compared with other public engagement sites such as botanical gardens and natural history museums. This broader policy question may be addressed by future research, which would most likely need to employ a quasi-experimental or microgenetic evaluation (Wagoner & Jensen, 2014) approach to better control for confounding variables.

My results indicated that pupils visiting the zoo were significantly more likely to evince positive conservation biology learning impacts when they attended an education-officer-led presentation than when they visited the zoo unguided by teachers. This finding is consistent with a Vygotskian theoretical explanation: Zoo educators may be assisting pupils' learning within a "zone of proximal development" as theorized by influential developmental psychologist Lev Vygotsky. On the basis of his research, Vygotsky argued that there is a zone of potential assisted learning that can occur above and beyond the autonomous learning potential of a pupil.

My results suggest the zoo is a setting in which this distinction between a proximal zone of potential assisted learning and a zone of autonomous learning (i.e., unguided) is applicable. Vygotsky's social development theory proposes that learning is inherently connected to social relationships and communication. Most relevant in the present context is his argument that learning can be assisted by a "more knowledgeable other," who can provide support or guidance through the learning process. In this case, the more knowledgeable others were education officers who helped pupils develop their scientific and conservation learning. The provision of conceptual tools relevant to the zoo context yielded enhanced learning outcomes, beyond the level that could be achieved autonomously or by nonspecialist teachers.

A further direction for theorizing the present research results connects to the work of another influential developmental psychologist and learning theorist, Jean Piaget. Piaget's (1957) classic theory proposes that learning takes place when children face new situations that existing mental schema are not set up to process, thereby leading to cognitive disequilibrium. To reequalize, children must extend their existing schema. Thus, in the present context, children are confronted with new stimuli at the zoo animals they have never seen before. These stimuli may cause disequilibrium in pupils' existing mental schema relating to animals. If facilitated effectively by zoo interpretation and education, the reequalizing process may extend pupils' thinking about animals. However, at this point in the zoo learning process, my data support the Vygotskian explanation regarding a zone of proximal development. That is, on the basis of the present data I argue that viewing new animals in a zoo may result in a form of cognitive disequilibrium as theorized by Piaget. However, the assimilation of new ideas into a pupil's existing mental schema for understanding animals and habitats can be significantly enhanced through assistance from a more knowledgeable other (in this case a zoo educator).

Thus, my results support (but do not confirm) a theoretical model in which new stimuli (viewing live animals) create the potential for the assimilation of new information about conservation biology into existing mental schema, as predicted by Piaget. However, this assimilation process is more likely to occur and likely to be better elaborated with guidance from a more knowledgeable other (i.e., a conservation educator or tailored educational materials). In sum, regardless of the precise nature of the learning facilitator, my results support Vygotsky's (1987; Vygotsky & Luria 1994) argument that the facilitator plays a vital role in drawing children's attention in useful directions and providing conceptual tools that allow children to develop their conservation biology learning. In other words, this theoretical model places conservation educators in the role of toolmakers, seeking to develop the most effective explanations possible to provision children for the process of developing a higher level of conservation biology-related understanding.

Supporting Information

Pre- and post-test questionnaires for primary and secondary school students (Appendices S1–S4) are available on-line. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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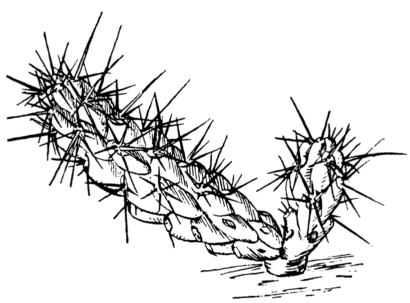

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