Data triangulation confirms learning in the zoo environment

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Abstract

Although zoos have an increasingly important role to play in educating the public about conservation and inspiring pro-conservation behaviour, they are not firmly established as leaders of conservation education. A multitude of logistical challenges and methodological limitations in zoological education research are contributory factors to this. However, certain research weaknesses can be minimized by collecting data from more than one source. The current research evaluated children's learning in a zoo and an aquarium using three different methodologies in one study: match pairs surveys, behavioural observation and conversational content analysis. The findings indicate that learning occurred in both the zoo and aquarium for most participants but was more profound for children who participated in an educational intervention. Importantly, the results of each methodology substantiate each other to definitively validate results and demonstrate the positive impact of a zoo or aquarium visit on children's learning. To produce more meaningful, reliable and valid research, zoological education studies should integrate mixed-methods and data triangulation into future research.

Key words: environmental education; data triangulation; mixed-method, educational intervention; zoo; aquarium

Introduction

The World Association of Zoos and Aquariums (WAZA) has called on zoos to raise biodiversity awareness and inspire conservation related behaviours amongst their visitors in support of the United Nations Strategic Plan for Biodiversity 2011-2020 (Moss et al., 2015; WAZA, 2015). One of the primary ways for zoos to inspire the public towards pro-conservation behaviour is through education. With over 700 million people visiting zoos and aquariums worldwide each year, zoos are in a leading position to be advocates of environmental education (Gusset and Dick, 2011; Moss et al., 2015). Yet, even though most zoos classify themselves as education centres, prioritise education over other activities and list education as one of their main objectives (Patrick et al., 2007; Roe et al., 2014), zoos are still not firmly established as leaders in conservation education (Moss et al., 2015).

In fact, the RSPCA (Royal Society for the Prevention of Cruelty to Animals, 2006) implied that since zoos have not demonstrated a substantial impact of their education programmes in peer-reviewed journals, that keeping animals in captivity for educational purposed is not justified. Jensen (2014) and Moss and Esson (2013) summarise that zoos are increasingly under pressure to demonstrate a positive educational impact as thus far, the literature on zoological education does not confirm the mission statements of zoos as education providers. Therefore, the last decade has seen a rapid increase in impact evaluations for zoological education programmes, as zoos strive to validate their claims to be educators.

However, the evaluation of zoological education has proven challenging for a multitude of reasons. The theories surrounding learning in informal settings, such as zoos, have largely evolved from the transmission absorption theory of learning to constructivism, meaning that visitors are active participates in their own acquisition of knowledge (Piaget, 1951; Vygotsky, 1978; Hein, 1998). Thus, the learning that occurs in informal settings is personal and is based

on prior experience as well as the socio-cultural environment and the physical surroundings (Falk and Dierking, 2000). Additionally, the goals of zoological education have evolved. It is no longer sufficient for zoos to communicate simple facts or cognitive knowledge to visitors, now zoos must aim to inspire their visitors towards pro-conservation action (Ogden and Heimlich, 2009). With this, educational messages have also transformed from basic signage focusing on facts, to sometimes elaborate educational experiences whose outcome aims to inspire pro-conservation behaviour change (Mellish et al., 2019). Each visitor will learn and experience the zoo differently and their behaviour or intended behaviour should be considered, which can make evaluation of learning challenging.

This already complex learning environment is further compounded by a range of methodological complexities. In fact, over 80% of zoological education studies analysed by Mellish et al. (2019) were rated as weak based on methodological design, data collection technique and data analysis. For example, zoological education research often suffers from poor methodological validity such as only surveying visitors as they exit the zoo or failure to randomly assign visitors to test groups (Mellish et al., 2019). This is also described by Marino et al. (2010) who criticized Falk et al. (2007) for the use of retrospective pre-surveys. Statistical analysis is often over simplified and fails to consider multiple variables that could affect learning, with only 4.2% of analysed studies considering multiple dependent variables in their analysis (Mellish et al., 2019). It is also difficult to attribute positive learning outcomes to a particular educational programme since there may be many influences present, especially if there is a delay between the educational experience and testing (Smith et al., 2008). For example, a global study on zoo and aquarium visitors found that knowledge of actions to help protect biodiversity improved from post-visit to the delayed post-visit two years later (Jensen et al., 2017). This suggests that it may take time for visitors to assimilate knowledge after a zoo visit or as suggested by Jensen et al. (2017) that visitors have been ‘primed’ to accept

environmental messages after a zoo or aquarium visit. Additionally, unlike the current study, few studies consider children as learners in the zoo setting even though they comprise a large percentage of zoo visitors (Jensen, 2014).

As outlined in the Tbilisi declaration (UNESCO, 1978), the goal of environmental education, including zoological education (Ogden and Heimlich, 2009), should be pro-conservation behaviour change, and yet according to Mellish et al. (2019) less than half of the studies they investigate contained a measurable conservation related behavioural outcome. Measuring changes in pro-conservation behaviour after an educational experience may be particularly challenging since it is often more feasible to ask visitors what their intended behaviour is than to actually observe it. Many pro-conservation behaviours, such as buying sustainable products or recycling, are likely to take place off-site (Smith et al., 2008). However, when a self-report method is used, visitors may be untruthful and report what they would like to do rather than their actual actions (Dierking et al., 2004). Although differences may also occur between zoo and aquarium visitors, only 14.6% of studies that Mellish et al. (2019) investigated collected data at both a zoo and an aquarium, which makes generalisability of data more difficult. The research in the current study included data collection at both a zoo and aquarium. However, zoo, wildlife park and aquarium are considered sufficiently similar in terms of the presence of visitors and live animals to be referred to collectively as 'zoo' hereafter when appropriate (Skibins and Powell, 2013; Mellish et al., 2019).

Common methods to evaluate the impact of education in the zoo include surveys and visitor interviews (Mellish et al., 2019). Surveys can be powerful tools for indicating that learning has occurred, especially when repeated measures testing at an individual level is conducted since this allows for changes in both positive and negative thinking to emerge as a result of an educational experience (Jensen, 2011; Moss et al., 2015). However, surveys do not allow for all aspects of learning, such as personal, social and emotional experiences, to be discovered,

even when mixed methods (quantitative and qualitative questions) are included. Interviewing, such as described by Tofield et al. (2003), can be logistically difficult, time consuming and costly, and challenging with children (Cohen et al., 2007). Alternative methods of assessing visitor learning and experiences in the zoo include observing visitor behaviour and attentiveness, monitoring exhibit stay time and engagement with educational material or animal training programmes, measuring noise level or querying intended actions after an educational experience (Swanagan, 2000; Anderson et at., 2003; Smith et al., 2008; Moss et al., 2010; Sherwen et al., 2014). The more innovative methods for assessing education include conversation content analysis where visitors' conversations are listened to as they view animals or exhibits (Tunnicliffe et al., 1997; Clayton et al., 2009) and annotated drawings of animal habitats (Jensen, 2014).

The above described methodologies are useful and appropriate for revealing learning in some situations, yet they all suffer from limitations. Although traditionally quantitative and qualitative research practices were not mixed, now it is more commonly recognised that drawing on both types of methodologies in one study can minimise research flaws and maximise results (Johnson and Onwuegbuzie, 2004). In fact, Jensen (2011; 2014) highlights the need for a mixed-method approach to data collection in zoo research to gain insight into learning from different sources and validate results. Yet, Mellish et al. (2019) report that only 25% of the zoo-based studies they investigated used data triangulation or two or more sources to gather data. The current study represents the aggregation of a series of integrated studies (previously published) that examine children's learning in a zoo and an aquarium using three different data collection techniques including 1) repeated-measures mixed-method surveys (Collins et al., 2020), 2) behavioural observation (Collins et al., 2019) and 3) conversational content analysis (Collins et al., 2021). The aim of the current manuscript is to validate learning in a zoo and aquarium by examining the efficacy of data triangulation.

Methodology and results

All three of the studies included here had full ethical approval from University Collect Cork's Social Research Ethics Committee for working with children. All procedures followed the ethical guidelines outlined by Cohen et al. (2007) for working with children. For example, before the study began, teachers signed a consent form allowing children to participate in the study and the children were verbally told at the beginning of the study that they did not have to participate in the study if they did not want to and that they could withdraw at any time. All data were anonymised and stored in accordance with the university's data storage policy.

Research sites

The studies described here occurred at both Fota Wildlife Park (Fota) in Carrigtwohill, County Cork, Ireland (51.889585º N, 8.311276º W) and Dingle Aquarium (Dingle) in County Kerry, Ireland (52.1399° N, 10.2783° W) between 2014 and 2016.

Participants

The animal species that were chosen as a focus for learning in this study were ring-tailed lemurs (*Lemur catta*) and Humboldt penguins (*Spheniscus humboldti*) at Fota Wildlife Park and Gentoo penguins (*Pygoscelis papua*) at Dingle Aquarium. These species are considered popular by visitors at the institutions involved with this research and have been listed by visitors as animals they would most like to see (Carr, 2016; M. O'Shea, personal communication, November 6, 2014; T. Power, personal communication, July 27, 2016).

The three integrated studies that comprise the current research involved children who were scheduled for either a school tour or camp at Fota or a school tour at Dingle (Table 1). For study one, children completed a pre- and post-survey approximately one-week before and one-week after their visit to the zoo or aquarium (see appendix one for surveys included in this study). Then, during their zoo or aquarium visit their behaviour (study two) and conversation

were observed (study three). It was logistically impossible to ensure one hundred percent participation in each study by each child. Therefore, although group composition is similar across the three studies, slight variations occurred. For example, if a younger child joined the tour group to be with their sibling or a viewing was cancelled because of logistical constraints, group composition may have varied.

After agreeing to participate in this research, all groups of children were randomly assigned as control or treatment groups. This allocation remained the same across the three studies. The control groups experienced the standard curriculum offered by Fota Wildlife Park or Dingle Aquarium. While treatment groups experienced the standard curriculum plus an educational intervention (EI) designed specifically for this research. Participants did not have prior knowledge as to the details of the research or the content of the educational intervention.

Table 1

The educational intervention

The educational intervention (EI) was a one-hour long programme, delivered in a classroom-like setting, which was purposefully developed for the treatment groups that participated in this research project (see Collins et al., 2020 for further of the EI). The focus of the EI was on increasing knowledge about the study species (lemurs and penguins), improving children's attitude towards zoos and learning in the zoo and changing behaviour towards captive animals by reducing negative behaviour. For example, feeding, touching, shouting and banging on glass by visitors are behaviours which are known to disturb some captive animals and may negatively affect their welfare (Morgan and Tromborg, 2007; Sherwen et al., 2014).

Specific elements of the EI included a PowerPoint presentation which described the biology of lemurs (Fota only) and penguins. Then, since emotionally engaging visitors can positively impact learning (Ballantyne et al., 2011), the EI aimed to connect with children emotionally by

showing appealing pictures of the study animals during the PowerPoint presentation. Furthermore, clearly stating the behaviours which were expected to change can increase the success of an environmental education programme (Smith et al., 2008; Mann et al., 2018). Therefore, the children were told not to feed zoo animals because it could make them sick. Finally, the children participated in a hands-on activity during which they made enrichment devices for the study species. This involved filling clear plastic bottles with shiny pieces of foil for the penguins (Clarke, 2003) and cutting up fruit for a scatter feed for the lemurs (M. Esson, personal communication, 2013). During their tour of the zoo, the children in the treatment groups had the opportunity to see the animals engaging with the devices they had made during the EI, which was comparable to an indirect animal-visitor interaction (Learmonth et al., 2020).

Procedure

The results from the three studies included here have been previously published. Thus, the methodology and results from Collins et al. (2019), Collins et al. (2020) and Collins et al. (2021) have informed the current study, but the data analysis has been modified to suit the present research, investigating data triangulation. Here, the primary objective was to evaluate children's learning in the zoo setting considering the combined effect of three methodologies during two conditions:

1) Control groups, children who had not participated in the EI;

2) Treatment groups, children who had participated in the EI.

Since procedure, data analysis and results for the three studies varied, the individual components of each study are described below and followed by a general discussion.

1) Surveys

Before visiting the zoo or aquarium, the primary researcher travelled to each school to administer the survey. If a group was designated as a treatment group, they participated in the EI immediately after completing the pre-survey. Post-surveys were administered by the school teacher (Ballantyne and Packer, 2002), after the children visited Fota or Dingle. Standardisation of timing was not possible, but all pre- and post-surveys were completed one week before or after the zoo visit, respectively. Children in camps at Fota Wildlife Park completed the survey at the beginning and end of the camp. To avoid some of the common methodological flaws identified by Mellish et al. (2019) in zoological education research, the survey employed both valid and reliable methods. For example, a repeated measures experimental design was employed, a mixed-method approach using both qualitative and quantitative questions was used, Cronbach's alpha was used to test for internal consistency, a controlled experimental approach was followed, the survey instrument went through six trial phases and was examined by experts in the field before the final version was accepted and data analysis was rigorous (Oppenheim, 1992; Cohen, Manion and Morrison, 2007; Wellington and Szczerbinski, 2007).

Previously unpublished qualitative survey items are included in the current analysis (Table 2). Qualitative questions required the students to provide their own response. However, to provide quantitative data for analysis, content analysis or the coding of the open-ended questions was used for all qualitative questions (Krippendorff, 2004; Moss et al., 2015) (Table 2). This was based on pre-existing categories derived from the hypothesis, but also on themes that emerged from the responses given during two preliminary trials (Oppenheim, 1992; Krippendorff, 2004; Cohen et al., 2007). The question 'how can you help zoo animals?' was based on a question posed by Moss et al. (2015) 'Can you think of an action to help save animal species?' It was intended to assess if students developed a sense of environmental empowerment or conservation self-efficacy (a belief in their own ability to help the environment) which has been

shown to be of paramount importance in environmental education studies (Hungerford and Volk, 1990; Jensen, 2014).

Table 2

The survey was designed in three separate sections: knowledge, attitude and knowledge of positive behaviour. However, since Collins et al. (2020) have already conducted a comprehensive analysis of these quantitative data with multiple independent variables tested and reported that condition (control or treatment) was the most significant and consistent predictor of knowledge, here a simplified investigation was conducted. The mean total post-survey score (combining the three sections) was used as the dependent variable in the analysis and condition was the only independent categorical variable tested.

Data analysis

For qualitative questions, preliminary results indicated little change from pre- to post-visit or influence from the other variables. Furthermore, while some responses were more favourable than others, there was not a correct or incorrect response for each question, so it was not possible to code the responses as scale data. Therefore, results for the qualitative questions are presented as descriptive data (Table 3).

The quantitative survey data were visually inspected with a plotted histogram and a quantile-quantile plot, which revealed that the data were approximately normally distributed. A general linear model (GLM) was conducted where the dependent variable, mean post-survey score, was tested against the covariate mean pre-survey score, which controlled for any effect of pre-survey score on post-survey score, and the independent categorical variable condition (control or treatment). Then, to show the magnitude of difference between the pre- and post-survey scores a paired t-test was used to calculate the effect size with Cohen's d. All of the assumptions of the models were met. Validation of the model was tested by plotting a histogram of residuals,

plotting the residuals against the fitted values and checking linearity of the model. Levene's test revealed homogeneity of variance across all groups. Data analysis was conducted using SPSS version 26. The accepted alpha level for these analyses was $p<0.05$.

Results

For the qualitative survey questions, the question 'how can you help zoo animals?' produced the largest variation in student responses between control and treatment groups and pre- and post-survey (Table 3) and therefore a figure is provided (Figure 1). On the post-survey, 20% of students responded with 'don't annoy animals' versus 9% on the pre-survey (Figure 1). However, on the post-survey taking condition into account, 24% of treatment respondents said 'don't annoy animals' versus 15% in the control group (Table 3). There was also a 7% decrease in children answering with food related responses and a 6% increase in enrichment related responses on the post-survey (Figure 1).

Responses from the other qualitative questions produced little variation, even in the treatment group (Table 3). Over 70% of children responded that animals were the first thing that they thought of when they thought of the zoo or aquarium (Table 3). There was little change in this response from pre- to post-test or between control and treatment groups. Similarly, most children said that animals were the best part of the visit; however, slightly more children in the treatment group than the control group mentioned learning (4% vs 1%), enrichment (1% vs 0%) or the penguins and lemurs (29% vs 22%) specifically as the best part (Table 3). Although, this research was part of a large project which considered the effectiveness of a zoo visit at increasing interest in STEM subject, almost no change occurred between control or treatment groups or pre- and post-survey for students' favourite subject at school (Table 3).

Figure 1

Table 3

For the quantitative survey questions, a GLM revealed that there was a significant difference in post-survey score for condition and pre-survey score (Table 4). The covariate (pre-survey score) explained a larger part of the variance η_p^2=0.397 than condition η_p^2=0.154. However, comparing the estimated marginal means (±SE) showed that students in the treatment group (0.833±0.004) scored higher on the post-survey than those in the control group (0.773±0.005), when the pre-survey score was controlled for (Figure 2A). The paired t-test for the difference between pre- and post-survey scores was statistically significant (t= -19.866, p <0.001) and Cohen's d (0.94) revealed a strong effect size between pre- and post-survey scores (Cohen, 1988).

Table 4

2) Behavioural observation of visitors

As the children toured Fota or Dingle, the primary researcher used behaviour sampling to observe and record every incidence of negative behaviour that the children engaged in at the three specified animal enclosures (Sattler, 1988; Bexell et al., 2013). Negative behaviours included in the study were behaviours that were not compliant with the rules of each institution and were also based on preliminary observation of behaviours that children engaged in and previous research (e.g. Sherwen et al., 2014; Orams and Hill, 1998). These behaviours differed between enclosures and institutions. Examples include chasing, feeding and touching at Fota and flash photography and banging on glass at Dingle.

Data analysis

The total number of negative visitor behaviours to occur per observation period were recorded at each enclosure. Since the length of each viewing session varied because of different group schedules, the rate of negative events per observation period was calculated based on the number of negative incidences per length of viewing session. The current analysis considers

the total mean rate of negative behaviour observed in the study since Collins et al. (2019) previously presented a comprehensive description of negative behaviour at the three individual enclosures. These data were tested for normality using the Kolmogorov-Smirnov test, and visually inspected with histograms and quantile-quantile plots and were found to be non-normal. Therefore, the Mann-Whitney U test was used to test the effect of condition on the rate of children's negative behaviour.

Results

Children in control groups were significantly more likely to engage in negative behaviour than those in treatment groups ($U=299.500$, $p>0.001$) (Figure 2B).

3) Children's conversation

The Tunnicliffe Conversation Observation Record (TCOR) (Tunnicliffe, 2005) was used to record children's conversation at the three animal exhibits. The TCOR was developed to determine if learning occurred during a zoo field trip (Patrick and Tunnicliffe, 2013). In the current study, a list of typical children's conversational comments was generated (based on the TCOR and preliminary investigation), then for each observation session, if a remark was made by any child in the group, a tick was made next to the corresponding pre-designated category on the checklist. Standard content analysis coding procedure was used in the analysis (Cohen, Manion and Morrison, 2007). Conversational remarks were categorised as negative or positive for the analysis. For example, positive comments included remarks relating to science, conservation, enrichment or the exhibit or remarks that gave or sought information or described or named the animal. Negative remarks included, for example, misinformation, anthropocentric comments or discussion of feeding or touching animals. This led to 15 positive and 4 negative types of comments (Collins et al., 2021, for further detail).

Data analysis

The dependent variables were the proportion of the types of positive and negative comments made during each viewing session and are referred to as the 'diversity' of positive or negative comments. For example, this was calculated by dividing the number of types of negative comments made per viewing session by the total possible types of negative remarks. Since positive comments were found to follow a nearly normal distribution, a one-way analysis of variance (ANOVA) was used to test the diversity of positive comments against the independent variable condition. All assumptions of the test were met. The diversity of negative comments was not normally distributed, and a Mann-Whitney U test was conducted to test for differences in negative comments for condition.

Results

Condition affected the diversity of positive comments ($F(1,72) = 29.159$, $p<0.001$). For the diversity of negative comments, a statistically significant difference was found between treatment and control groups ($U=292.00$, $p<0.001$) [Authors, C]. Children in the treatment group expressed a more diverse range of positive comments and fewer types of negative comments than those in the control group while viewing animals (Figure 2C).

Figure 2

Discussion

Although one of the primary goals of zoos is education of the public (Roe et al., 2014), for a variety of reasons zoos have struggled to establish themselves as leaders in this area. The current study has shown using three different, but complementary, methodologies that zoos make a positive contribution to visitor learning. However, learning was enhanced for children who participated in the specially designed educational intervention, which confirms the results reported in a global study on zoo and aquarium visitors who saw educational campaign materials and experienced improvements in learning (Moss et al., 2017a).

The first part of this research assessed children's learning using a repeated-measures, mixed method survey, which included both quantitative and qualitative questions (Jensen, 2014). Quantitative survey questions can provide valuable insight into learning, while qualitive questions can reveal more complex learning, combining both methodologies validates results (Johnson and Onwuegbuzie, 2004). Yet few zoological education studies have used mixed method surveys to assess visitor learning (Jensen, 2014). However, in the current study responses from the qualitative questions on the survey produced limited variation in response. This may indicate that the questions did not allow for the students to amply express their thoughts or they did not have the time or motivation to do so since preliminary results from this study indicated that children were reluctant to answer open-ended questions. Overall, responses to qualitative questions revealed a slight indication of more in depth learning from children in the treatment group, but further research is required to fully understand these results.

Visitors who remembered specific actions after a zoo visit, were more likely to take pro-environmental action than those that only remembered a general action (Mann et al., 2018). Therefore, for the question, 'how can you help zoo animals?' the aim was to have specific, self-oriented responses like 'adopt an animal' or 'don't frighten them,' and fewer responses like 'give them enough food' and 'care for them.' There was a noticeable decrease in students responding with a food related response from pre- to post- visit, but little variation occurred between control and treatment groups. However, on the post-survey an increase occurred in the response 'don't annoy animals' and this was most prevalent in the treatment group. This suggests that children in treatment groups understood the importance of respectful behaviour while visiting zoo animals, which could be an indicator of compassionate conservation (Learmonth, 2020). The increase of children answering 'give animals enrichment' in the post-survey treatment group was not the child-centred action that was aimed for. Yet, this response shows an increase in understanding from children in the treatment group that enrichment is

beneficial for captive animal welfare and demonstrates an understanding of the needs of caring for animals, indicative of empathy and deeper learning (Bexell et al., 2013). However, it should be noted that since children in the treatment group were exposed to the term 'enrichment' during the EI, it is possible that this may have caused an increase in that response from some children, and it does not necessarily mean that these children fully understood the benefits of enrichment. Furthermore, it would have been beneficial to allow children to answer this question with multiple responses; however, time constraints and children's reluctance to answer open-ended questions made this difficult.

'When you think of the zoo, what is the first thing that comes to mind,' showed little change from pre- to post-survey or between conditions. Most children in both groups answered 'animals' on the pre-survey. In the control group this decreased by 4% on the post-survey and 'fun' increased by 3%. Conversely, for the treatment group 'animals' increased by 6% in the post-survey and 'fun' decreased by 5%. It is positive indication of learning that children associate their visit with animals (Patrick and Tunnicliffe, 2013); however, many visitors report their reason for visiting a zoo is for entertainment (Reade and Warran, 1996). This is an area that would benefit from further research since it remains essential for zoos to balance visitor learning with visitor 'fun' in order to achieve all of their goals (Fernandez et al., 2009). Jensen (2014), who asked for five things you think of when you think of the zoo, reported a 34% increase in conservation-related thoughts from pre- to post visit. In contrast, the current study detected a minor decrease (2%) in conservation related responses from pre- to post-survey. This may be due to differences in the content of the curriculum. For example, the current study included traditional conservation curriculum, but also focused on the welfare of specific animals and components of compassionate conservation (Learmonth, 2020) and the development of cognitive empathy (Bexell et al., 2013).

Outdoor learning has been shown to promote positive attitudes toward environmental education (Bennett, 2001), yet little change took place from pre- to post-survey regarding the question about favourite subject at school. It was predicted that an outdoor, science-based excursion, such as a trip to the zoo, may increase interest in science, and that subject interest at school was an objective way to measure it. However, the only change that occurred in STEM subject choice was a decrease in the treatment group listing STEM subjects as their favourite after the visit. While the EI was intended to be a fun activity, it is possible that some children were put off science by the use of words like hypothesis, experiment and enrichment. [Author] reported that more children in the treatment group of this study (35%) responded that they 'strongly agreed' to enjoying learning about science after the visit than any other group, which suggests children may not be equating the science that they do in school, with the science that they experience outside the classroom. This should certainly be an area for further study. However, even if the children in the treatment group associated the visit with learning rather than entertainment, the last question 'what was the best part' indicated that children in the treatment group enjoyed the educational intervention. In the treatment group, 29% of children indicated that 'lemurs or penguins' were the best part of the visit, and generally animals (56%) and learning (4%). The control group followed a similar pattern but had fewer responses for lemurs and penguins (22%) and more for animals (67%) and learning was negligible (1%).

The results from the quantitative section of the survey complement those of (Collins et al., 2020) who reported that learning increased after the zoo and aquarium visit for many children but was greater in treatment groups and at Fota Wildlife Park. A different, but complementary analysis here revealed that, unsurprisingly, the pre-survey score was a significant predictor of post-survey score (Oppenheim, 1992) and condition affected post-survey score. When the pre-survey score was adjusted for, a difference in post score of approximately 6% occurred between control (77%) and treatment (83%) groups, which was found to be statistically significant.

Similarly, Moss et al. (2015) reported approximately a 5% increase from pre-survey to post survey surrounding visitor understanding of biodiversity. In fact, several studies following similar research designs to the one described here reported evidence of increased learning from pre- to post-survey (Lindemann-Matthies and Kamer, 2005; Randler et al., 2007; Moss et al., 2015), even if the education programme took place in a school rather than a zoo (Counsell et al., 2020). However, it may be premature to make generalisations about the impact of zoo visits and specific interventions on visitor learning since some studies have reported no increases in learning as a result of a zoo visit (Adelman et al., 2000; Balmford et al., 2007). Many variables such as previous experience and learner motivation together with physical surroundings may affect learning outcomes in informal settings (Falk and Dierking, 2000). These inconsistencies illuminate the need to consider learning outcomes from more than one perspective.

Moss et al. (2015) stated that an increased understanding of animals or conservation issues does not necessarily translate to new conservation behaviour or actions, which was confirmed in a later study (Moss et al., 2017b). For example, zoos might inspire visitors to make a donation, keep a conservation-themed promise to an animal, pick up road kill, buy sustainably sourced products or as in the case of the current study behave in a respectful way while observing animals (Swanagan, 2000; Mann et al., 2008; Smith et al., 2008), but visitors may not follow through with these intended actions. Although few studies have been able to observe conservation related behaviour on-site (Smith et al., 2008), the current research was able to assess if participation in an EI lead to positive observable on-site behaviour change.

The second study included here found an effect between negative behaviour and participation in a control or treatment group, which concurs with the results of (Collins et al., 2019). While generally incidences of negative behaviour were low, children in the treatment group were less likely than those in the control group to engage in negative behaviour as they viewed animals. This reduction in negative behaviour could be equated to a gain in cognitive empathy (Bexell

et al., 2013). Increased empathy towards animals and meaningful engagement with them can lead to pro-conservation behaviour (Myers and Saunders, 2002; Bexell et al., 2013; Learmonth, 2020). Bexell et al. (2013) also used a mixed-method approach to evaluate students' care for animals and behaviour towards nature by using surveys, vignettes, journals and behavioural observation. While this approach was comprehensive, the sample size (n= 60 children) was relatively small and the study topic highly specific which makes generalisability and extrapolation of results difficult. In the present study, when the decrease in negative behaviour observed in the treatment groups is considered together with the increase in learning on the survey, including knowledge of positive behaviour towards animals, for treatment groups, there is greater confidence in the EI and the results.

Finally, the third study employed an under-utilised methodology to assess learning based on visitors' conversations as they viewed animals. The results from the current study support previous studies that have used visitor conversation to show evidence of learning in the zoo (Tunnicliffe et al.,1997; Clayton et al., 2009; Pavitt and Moss, 2019; Collins et al., 2021). The current findings showed that all groups engaged in positive conversations, but the treatment groups engaged in more types of positive comments and fewer types of negative comments. Listening to visitors' conversations may be simple to implement and important for discovering indirect learning, yet there are certain limitations. It can be difficult to decipher which visitors are speaking, making detection of individual learning near impossible (Collins et al., 2021), conversations can be missed as visitors move out of range (Allen, 2002), it is time consuming to record and code entire conversations, yet pre-determined categories of conversation may not reveal the depth of learning that has occurred. When the results using this methodology are considered together with other methods, findings are strengthened. Clayton et al. (2009) draws on results from visitor surveys and overheard conversation to conclude that people visit zoos for the entertainment and social interaction purposes, but this is not incompatible with learning

if learning fits with visitors' social agenda. Zoos also facilitate emotional connections to animals for visitors, but these incidental learning outcomes are best detected using detailed and multiple methodologies (Clayton et al., 2009; Mellish et al., 2019)

In the current study, the three different but compatible methodologies converge to inspire confidence in results and substantiate the findings of each study. All three studies revealed evidence of learning in the zoo, but they also showed that learning was more impactful when children participated in the educational intervention. Zoological education research is fraught with methodological difficulties and a reader may be wary of accepting the results of any given study. However, when results from the same study are amalgamated and the findings concur, the research is more convincing (Johnson and Onwuegbuzie, 2004; Mellish et al., 2019). Additionally, data triangulation can provide different insights into learning (Wellington and Szczerbinki, 2007), such as emotional engagement. For example, in the current study a mixed method design survey revealed that children in the treatment groups scored higher on the post-survey than children in the control group and open-ended questions indicated slightly more in-depth learning for treatment groups. Additionally, treatment groups were less likely to engage in negative behaviour than control groups and finally treatment groups engaged in more types of positive conversation and fewer types of negative conversation than control groups. The survey offers evidence of cognitive gain (Jensen 2014), while behavioural observation gives evidence of positive behaviour change and compassionate conservation (Learmonth, 2020) and finally the conversation shows that more in-depth learning and social learning has occurred (Clayton et al., 2009). When considered together, these different methodologies enhance results and a convincing image of the positive influence of a zoo visit, and the EI in particular, on children's learning emerges.

Zoo research represents a meeting point of traditional scientific research and the social sciences (WAZA, 2015). While this may make research more challenging, it also presents an

opportunity for blended research methods, such as those reported here, which can ultimately produce more robust results. The collective findings from the studies examined here will be useful to researchers and those interested in comprehensively evaluating the impact of informal science education programmes, such as zoo educators, to advance understanding of visitor learning. By considering multiple methodologies together in one study to evaluate the impact of zoological education on visitors' learning, the impact of a zoo visit is definitely validated for the institutions involved in this study. This research progresses zoos' claims to be educators which has the potential to drive the conservation movement forward.

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References

Adelman, L. S., Falk, J. H. & James, S. (2000). Assessing the National Aquarium in Baltimore's impact on visitors' conservation knowledge, attitude and behaviour. *Curator,* 43(1), 33-61.

Allen, S. (2002). Looking for learning in visitor talk: A methodological exploration. In *Learning Conversations in Museums*. (Eds.) G. Leinhardt, K. Crowley & K. Knutson. Mahwah, Lawrence Erlbaum Associates: 259-303.

Anderson, U. S., Kelling, A. S., Pressley-Keough, R., Bloomsmith, M. A. & Maple, T. L. (2003). Enhancing the zoo visitor's experience by public animal training and oral interpretation at an otter exhibit. *Environment and Behavior,* 35(6), 826-841.

1 Ballantyne, R. & Packer, J. (2002). Nature-based excursions: School students' perceptions of
2 learning in natural environments. *International Research in Geographical and Environmental*
3 *Education*, 11(3), 218–236.

4 Ballantyne, R., Packer, J. & Sutherland, L. A. (2011). Visitors' memories of wildlife tourism:
5 Implications for the design of powerful interpretive experiences. *Tourism Management*, *32*(4),
6 770-779.

7 Balmford, A., Leader-Williams, N., Mace, G., Manica, A., Walter, O., West, C. &
8 Zimmermand, A. (2007). Message received? Quantifying the impact of informal conservation
9 education on adults visiting UK Zoos. *Catalysts for Conservation: a direction for zoos in the*
10 *21st Century*. In: Zimmermann A, Hatchwell M, Dickie L, West C. (Eds). *Zoos in the 21st*
11 *century: catalysts for conservation?* Cambridge: Cambridge University Press. 120-136.

12 Bennett, J. (2001). Science with attitude: the perennial issue of pupils' responses to science.
13 *School Science Review*. 82(300), 59-66.

14 Bexell, S. M., Jarrett, O. S. & Ping, X. (2013). The effects of a summer camp program in
15 China on children's knowledge, attitudes, and behaviors toward animals: A model for
16 conservation education. *Visitor Studies*, 16(1), 59-81.

17 Carr, N. (2016). Ideal animals and animal traits for zoos: General public perspectives.
18 *Tourism Management*, 57, 37-44.

19 Clayton, S., Fraser, J. & Saunders, C. D. (2009). Zoo experiences: Conversations,
20 connections, and concern for animals. *Zoo Biology*, 28(5), 377-397.

21 Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. 2nd Edition. New
22 York, Academic press. p.20-27.

Cohen, L. M. & Manion, L. l. & Morrison, K. (2007). *Research methods in education*, *6*. Routledge: London and New York.

Collins, C. K. (2018). Education in the zoo: A study of the relationship between education, zoo visitors and animal behaviour. PhD thesis. University College Cork, Ireland.

Collins, C., Quirke, T., McKeown, S., Flannery, K., Kennedy, D. & O'Riordan, R. (2019). Zoological education: Can it change behaviour? *Applied Animal Behaviour Science*, 220, 104857.

Collins, C., Corkery, I., McKeown, S., McSweeney, L., Flannery, K., Kennedy, D. & O'Riordan, R. (2020). An educational intervention maximises children's learning during a zoo or aquarium visit. *The Journal of Environmental Education,* DOI: 10.1080/00958964.2020.1719022.

Collins, C., McKeown, S., McSweeney, L., Flannery, K., Kennedy, D. & O'Riordan, R. (2021) Children's conversation reveals in-depth learning at the zoo. *Anthrozoös*, 34(1), 17-32

Conde, D. A., Flesness, N., Colchero, F., Jones, O. R., & Scheuerlein, A. (2011). An emerging role of zoos to conserve biodiversity. *Science*, 331(6023), 1390-1391.

Counsell, G., Moon, A., Littlehales, C., Brooks, H., Bridges, E., & Moss, A. (2020). Evaluating an in-school zoo education programme: an analysis of attitudes and learning. *Journal of Zoo and Aquarium Research*, *8*(2), 99-106.

Dierking, L. D., Adelman, L. M., Ogden, J., Lehnhardt, K., Miller, L. & Mellen, J. D. (2004). Using a behavior change model to document the impact of visits to Disney's Animal Kingdom: A study investigating intended conservation action. *Curator: The Museum Journal*, 47(3), 322-343.

Falk, J. H. & Dierking, L. D. (2000). Learning from Museums: visitor experiences and the making of meaning. Walnut Creek, CA. Alta Mira Press.

Falk, J. H., Reinhard, E. M., Vernon, C. L., Bronnenkant, K., Deans, N. L. & Heimlich, J. E. (2007). *Why zoos & aquariums matter: Assessing the impact of a visit to a zoo or aquarium*. Silver Spring, MD: Association of Zoos & Aquariums.

Fernandez, E.J., Tamborski, M.A., Pickens, S.R. & Timberlake, W. (2009). Animal-visitor interaction in the modern zoo: conflicts and interventions. *Applied Animal Behaviour Science*, 120, 1-8.

Gusset, M. & Dick, G. (2011). The global reach of zoos and aquariums in visitor numbers and conservation expenditures. *Zoo Biology*, 30(5), 566-569.

Hein, G. E. (1998). *Learning in the Museum*. Routledge.

Hungerford, H. R. & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8-22.

Jensen, E. (2011). *Learning about Animals, Science and Conservation at the Zoo: Large-scale survey-based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme*. A report to The Zoological Society of London.

Jensen, E. (2014). Evaluating children's conservation biology learning at the zoo. *Conservation Biology*, 28(4), 1004-1011.

Jensen, E. A., Moss, A. & Gusset, M. (2017). Quantifying long-term impact of zoo and aquarium visits on biodiversity-related learning outcomes. *Zoo Biology*, 36(4), 294-297.

Johnson, R. B. & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, 33(7), 14-26.

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology*. Sage: Thousand Oaks, CA.

Learmonth, M. J. (2020). Human–Animal Interactions in Zoos: What Can Compassionate Conservation, Conservation Welfare and Duty of Care Tell Us about the Ethics of Interacting, and Avoiding Unintended Consequences? *Animals*, 10(11), 2037.

Lindemann-Matthies, P. & Kamer, T. (2006). The influence of an interactive educational approach on visitors' learning in a Swiss zoo. *Science Education*, 90(2), 296-315.

Mann, J. B., Ballantyne, R. & Packer, J. (2018). Penguin Promises: encouraging aquarium visitors to take conservation action. *Environmental Education Research*, 24(6), 859-874.

Marino, L., Lilienfeld, S. O., Malamund, R., Nobis, N. & Broglio, R. (2010). Do zoos and aquariums promote attitude change in visitors? A critical evaluation of the American zoo and aquarium study. *Society & Animals*, 18, 126-138.

Mellish, S., Ryan, J. C., Pearson, E. L. & Tuckey, M. R. (2019). Research methods and reporting practices in zoo and aquarium conservation-education evaluation. *Conservation Biology*, 33(1), 40-52.

Morgan, K. N. & Tromborg, C. T. (2007). Sources of stress in captivity. *Applied Animal Behaviour Science*, 102(3), 262-302.

Moss, A., Esson, M., & Bazley, S. (2010). Applied research and zoo education: The evolution and evaluation of a public talks program using unobtrusive video recording of visitor behavior. *Visitor Studies*, 13(1), 23-40.

Moss, A. & Esson, M. (2013). The Educational Claims of Zoos: Where Do We Go from Here? *Zoo Biology*, 32(1), 13-18.

Moss, A., Jensen, E. & Gusset, M. (2015). Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1. *Conservation Biology*, 29(2), 537-544.

Moss, A., Jensen, E. & Gusset, M. (2017a). Impact of a global biodiversity education campaign on zoo and aquarium visitors. *Frontiers in Ecology and the Environment*, 15(5), 243-247.

Moss, A., Jensen, E. & Gusset, M. (2017b). Probing the link between biodiversity-related knowledge and self-reported proconservation behavior in a global survey of zoo visitors. *Conservation Letters*, 10(1), 33-40.

Myers Jr, O. E. & Saunders, C. D. (2002). Animals as links toward developing caring relationships with the natural world. *Children and nature: Psychological, sociocultural, and evolutionary investigations*, 153-178.

Ogden, J. & Heimlich, J. E. (2009). Why focus on zoo and aquarium education? *Zoo Biology*, 28(5), 357–60.

Oppenheim, A. N. (1992). *Questionnaire design, interviewing and attitude measurement*. Pinter Publishers: London, UK.

Orams, M. B. & Hill, G. J. (1998). Controlling the ecotourist in a wild dolphin feeding program: is education the answer? *The Journal of Environmental Education*, 29(3), 33-38.

Patrick, P. G., Matthews, C. E., Ayers, D. F. & Tunnicliffe, S. D. (2007). Conservation and Education: Prominent Themes in Zoo Mission Statements. *The Journal of Environmental Education*, 38(3), 53–59.

Patrick, P. G. & Tunnicliffe, S. D. (2013). *Zoo talk*. Springer Science & Business Media.

Pavitt, B. & Moss, A. (2019). Assessing the effect of zoo exhibit design on visitor engagement and attitudes towards conservation. *Journal of Zoo and Aquarium Research*, 7(4), 186-194.

Piaget, J. (1951). *The child's conception of the world* (No. 213). (A. Tomlinson & J. Tomlinson, Trans.) Lanham, Maryland: Rowman & Littlefield.

Randler, C., Baumgärtner, S., Eisele, H. & Kienzle, W. (2007). Learning at workstations in the zoo: A controlled evaluation of cognitive and affective outcomes. *Visitor Studies*, 10(2), 205-216.

Reade, L. S. & Waran N. K. (1996). The modern zoo: how do people perceive zoo animals? *Applied Animal Behaviour Science*, 47(1), 109-118.

Roe, K., McConney, A. & Mansfield, C. F. (2014). The role of zoos in modern society: A comparison of zoos' reported priorities and what visitors believe they should be. *Anthrozoös*, 27(4), 529-541.

Royal Society for the Prevention of Cruelty to Animals (RSPCA). (2006). Evaluation of the effectiveness of zoos in meeting conservation and education objectives. *The Welfare State: Measuring Animal Welfare in the UK 2006*, Horsham, UK, 95-98.

Sattler, J. M. (1988). *Assessment of children*. pp. 472-529. San Diego, CA.

Sherwen, S. L., Magrath, M. J., Butler, K. L., Phillips, C. J. & Hemsworth, P. H. (2014). A multi-enclosure study investigating the behavioural response of meerkats to zoo visitors. *Applied Animal Behaviour Science*, 156, 70-77.

Skibins, J. C. & Powell, R. B. (2013). Conservation caring: Measuring the influence of zoo visitors' connection to wildlife on pro-conservation behaviors. *Zoo Biology*, 32(5), 528-540.

Smith, L., Broad, S. & Weiler, B. (2008). A closer examination of the impact of zoo visits on visitor behaviour. *Journal of Sustainable Tourism*, 16(5), 544-562.

Swanagan, J. S. (2000). Factors influencing zoo visitors' conservation attitudes and behaviour. *Journal of Environmental Education*, 31(4), 26-31.

Tofield, S., Coll, R. K., Vyle, B. & Bolstad, R. (2003). Zoos as a source of free choice learning. *Research in Science & Technological Education*, 21(1), 67-99.

Tunnicliffe, S. D. (2005, January). Do your visitors talk about your exhibits? What do they say? Presentation given at Visitor Studies Day: Victoria and Albert Museum, London, UK. http://www.leeds.ac.uk/educol/documents/168630.htm Date last accessed January 5, 2021.

Tunnicliffe, S. D., Lucas, A. M. & Osborne, J. (1997). School visits to zoos and museums: a missed educational opportunity? *International Journal of Science Education*, 19(9), 1039–1056.

UNESCO. 1978. Final report: *Intergovernmental Conference on Environmental Education*, Organized by UNESCO in Cooperation with UNEP, Tbilisi, USSR, October 14–26, 1977, Paris: UNESCO ED/MD/49.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press. 79-91.

Wellington, J. & Szczerbinski, M. (2007). *Research methods for the social sciences*. Continuum International Publishing Group: London and New York.

World Association of Zoos and Aquariums (WAZA) (2015). Committing to conservation: The world zoo and aquarium conservation strategy. https://www.waza.org/wp-content/uploads/2019/03/WAZA-Conservation-Strategy-2015_Landscape.pdf Last accessed January 5, 2021.

Appendix I – surveys (previously published in Collins et al., 2020)

1. The pre-survey administered before visiting FWP.

First Name:_____ Second Name:_____

Age: **Gender – Please circle**: Boy Girl

* * *

1. Have you ever visited a zoo before today?

Yes No I'm not sure

2. Do you like to watch nature shows on TV?

Yes No I'm not sure

3. What is your favourite subject at school?

4. How can you help animals living in zoos? Please answer with ONE idea in the box.

* * *

Please read each sentence below. Circle the answer that most closely matches how you feel.

5. Zoo animals are HAPPY.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

6. Zoo animals are BORED.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. During my visit to Fota, I am looking forward to LEARNING ABOUT ANIMALS.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Fota, I am looking forward to LEARNING SCIENCE.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

9. When you think of Fota Wildlife Park, what is the first thing that comes to mind? One word

In this section, if you don't know the answer, just take a guess. Choose one answer only.

***10. Ring-tailed lemurs come from...?**

Africa South America Madagascar New Zealand Sri Lanka

***11. Ring-tailed lemurs are endangered because of...?**

Drought Deforestation Global Warming Fire Hunting

***12. What do you think is the most important part of a Ring-tailed Lemur's diet?**

Fruit Flowers Leaves Food from visitors Meat

* * *

13. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

14. Do you think penguins can fly?

Yes I'm not sure No

15. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

16. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some animals at Fota live in enclosures and some are free-ranging, which means they can walk around the park. Some zoo animals have enrichment (toys), which promotes more natural behavior.

Please read each statement below and circle the answer that most closely matches how you feel.

17. I think visitors should be allowed to feed free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

18. I think visitors should be allowed to touch the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

19. I like to see zoo animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

*Note: After 2015 the lemur questions were excluded from the survey, the EI and the children did not view them while on tour at Fota.

2. The post-survey administered after visiting FWP.

First Name:_____ Second Name:_____

* * *

1. Did you enjoy the day at Fota?

Yes No I'm not sure

2. What was the best part?

3. What is your favourite subject at school?

4. How can you help animals living in zoos? Please answer with one idea in the box.

* * *

Please read each sentence below. Circle the answer that most closely matches how you feel.

5. Zoo animals are HAPPY.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

6. Zoo animals are BORED.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. During my visit to Fota, I enjoyed LEARNING ABOUT ANIMALS.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Fota, I enjoyed LEARNING SCIENCE.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

* * *

9. When you think of Fota Wildlife Park, what is the first thing that comes to mind? One word.

In this section, if you don't know the answer, just take a guess.

***10. Ring-tailed lemurs come from...?**

Africa South America Madagascar New Zealand Sri Lanka

***11. Ring-tailed lemurs are endangered because of...?**

Drought Deforestation Global Warming Fire Hunting

***12. What do you think is the most important part of a Ring-tailed Lemur's diet?**

Fruit Flowers Leaves Food from visitors Meat

* * *

13. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

14. Do you think penguins can fly?

Yes I'm not sure No

15. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

16. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some animals at Fota live in enclosures and some are free-ranging, which means they can walk around the park. Some zoo animals have enrichment (toys), which promotes more natural behavior.

Please read each statement below and circle the answer that most closely matches how you feel.

17. I think visitors should be allowed to feed the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

18. I think visitors should be allowed to touch the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

19. I like to see zoo animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

*Note: After 2015 the lemur questions were excluded from the survey, the EI and the children did not view them while on tour at Fota.

3. The pre-survey administered before visiting Dingle Aquarium.

First Name:_____ Second Name:_____

Age: _____ Boy/Girl

1. Have you ever visited an aquarium before today?

Yes No I'm not sure

2. Have you ever been to Dingle Aquarium before?

Yes No I'm not sure

3. Do you like to watch nature shows on TV?

Yes No I'm not sure

4. What is your favourite subject at school?

5. How can you help animals that live in aquariums? Please answer with one idea in the box.

Please read each sentence below. Circle the answer that most closely matches how you feel.

6. Aquarium animals are HAPPY

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. Aquarium animals are BORED

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Dingle Aquarium, I am looking forward to LEARNING ABOUT ANIMALS

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

9. During my visit to Dingle Aquarium, I am looking forward to LEARNING SCIENCE

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

10. When you think of Dingle Aquarium, what is the first thing that comes to mind?

One Word

In this section, if you don't know the answer, just take a guess.

11. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

12. Do you think penguins can fly?

Yes No I'm not sure

13. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

14. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some aquarium animals have enrichment (toys), which helps to promotes more natural behavior. Please read each statement below and circle the answer that most closely matches how you feel.

15. I prefer to see aquarium animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

16. I think it is okay to bang on the glass at the aquarium to get the animals' attention.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

4. The post-survey administered after visiting Dingle Aquarium.

First Name:_____ Second Name:_____

1. Did you enjoy the day at Dingle Aquarium?

Yes No I'm not sure

2. What was the best part?

3. What is your favourite subject at school?

4. How can you help animals that live in aquariums? Please answer with one idea in the box.

Please read each sentence below. Circle the answer that most closely matches how you feel.

5. Aquarium animals are HAPPY

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

6. Aquarium animals are BORED

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. During my visit to Dingle Aquarium, I enjoyed LEARNING ABOUT ANIMALS

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Dingle Aquarium, I enjoyed LEARNING SCIENCE

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

9. When you think of Dingle Aquarium, what is the first thing that comes to mind?

ONE Word

In this section, if you don't know the answer, just take a guess.

10. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

11. Do you think penguins can fly?

Yes No I'm not sure

12. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

13. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some aquarium animals have enrichment (toys), which helps to promotes more natural behavior. Please read each statement below and circle the answer that most closely matches how you feel.

14. I prefer to see aquarium animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

15. I think it is okay to bang on the glass at the aquarium to get the animals' attention.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Tables

Table 1. The details of each previously published research project 1). surveys 2). behavioural observation and 3). children's conversation included in the current study.

Published study	**1). Study one - surveys**	**2). Study two – behavioural observation**	**3). Study three- children's conversation**
Paper Title	An educational intervention maximizes children's learning during a zoo or aquarium visit	Zoological education: Can it change behaviour?	Children's Conversations Reveal In-Depth Learning at the Zoo
Primary methodology	Surveys	Behavioural observation	Conversational content analysis
Sample size	n=501	n=74	n=74
Grouping	Individual response	Group observation	Group observation
Study site	Fota (n=242); Dingle (n=259)	Fota (n=61); Dingle (n=13)	Fota (n=61); Dingle (n=13)
Condition*	Control (n=214) Treatment groups (n=287)	Control (n=47) Treatment groups (n=27)	Control (n=47) Treatment groups (n=27)
Age**	9-12 years	6-12 years	6-12 years
Gender	Mixed groups; all girls groups	Mixed groups; all girls groups	Mixed groups; all girls groups
Educational experience	1-day school tours; 5-day camps	1-day school tours; 5-day camps	1-day school tours; 5-day camps
Statistical analysis	Descriptive statistics and ANCOVA	Mann-Whitney U test	ANOVA and Mann-Whitney U test

*Condition; control groups = standard zoo or aquarium curriculum, treatment groups = standard curriculum plus the purposely designed EI.

** Most children (approximately 85%) included in the study were between 9-12 years.

1 **Table 2. Qualitative questions and descriptions of response categories on the survey.**

Question 1.	**'How can you help zoo animals?'**	
Code	**Response**	**Example**
0	Something negative	They can't be helped; Let them go
1	Other; not related to any of the other categories; I don't know	Become a zoo keeper
2	A vague answer involving taking care of animals	Take good care of them; make them comfortable; love them; give them friends
3	Food related*	Feed them the right food; make sure they have enough to eat
4	Related to enclosures, cages, space or space restrictions	Give them enough space; make bigger enclosures/cages
5	Broad conservation idea	Stop extinction; stop deforestation
6	Child centered positive action	Donate money; pick up litter; adopt an animal
7	Don't tease/annoy/feed zoo animals	Don't touch them; don't laugh at them
8	Enrichment	Give them enrichment or toys to play with
Question 2.	**'When you think of a zoo/ aquarium, what is the first thing that comes to mind?'**	
Code	**Response**	**Example**
0	Something negative	Confined; cages, poor animals, sad
1	Other	Blue
2	Positive, non-zoo related response; food	Ice cream, fun, friends
3	Any response naming a specific animal or something having to do with animals; including 'water' for the aquarium	Cheetah, fish, animals
4	Conservation type response	Conservation, saving wildlife
5	Learning type response	science; learning
6	A specific mention of the enrichment activity	Toys

2

Table 2. Continued

Question 3.	**'What is your favorite subject at school?'**	
Code	**Response**	**Example**
0	Something negative	I hate all subjects
1	Other	Friends
2	Activity based	Art, dancing, music, sports
3	Arts	Irish, reading, history, religion
4	STEM subjects	Maths, science, computers
Question 4.	**'What was the best part?'** Post-survey only	
Code	**Response**	**Example**
0	Something negative	Nothing; I hated it
1	Other; I don't know; everything	I loved everything
2	Positive, non-zoo related response; food	Pizza, the bus ride, the gift shop
3	Animals; any response naming a specific animal or something having to do with animals or the zoo/aquarium in general	Animals, touch tank, touring park/aquarium
4	Learning science/conservation	Science was fun; learning conservation/biology
5	A specific mention of the enrichment activity	Making the bottles; making toys, cutting up fruit
6	Specifically mentioning lemurs or penguins	Seeing the penguins; watching the lemurs eat fruit

*This response was based on the assumption that children did not intend to feed the animals themselves. Many children responded with this and it was thought to be a generic type of response referring to animal care in general (e.g. if you have a pet you must ensure that it is fed). If the student clearly indicated that they intended to personally feed zoo animals, this was counted as a negative response. This table is a copy of a table first produced in (Collins, 2018).

Table 3. Results from the qualitative questions on the survey administered to groups visiting [zoo] and [aquarium] presented as control and treatment groups. Responses are expressed as the percent of the group that chose a given answer.

1) How can you help zoo animals?									
Control group	Responses:	Neg.	Other	Care	Food	Space	Cons.	Child	Don't Annoy	Enrich
PRE		0.01	0.04	0.19	0.27	0.19	0.03	0.12	0.11	0.05
POST		0.01	0.05	0.21	0.18	0.17	0.02	0.15	0.15	0.06
Treatment group	Responses:	Neg.	Other	Care	Food	Space	Cons.	Child	Don't Annoy	Enrich
PRE		0.00	0.04	0.21	0.24	0.20	0.05	0.16	0.09	0.01
POST		0.00	0.06	0.15	0.17	0.16	0.01	0.13	0.24	0.09
2) When you think of a zoo/ aquarium, what is the first thing that comes to mind?										
Control group	Responses:	Neg.	Other	Fun	Animals	Cons.	Learning	Enrich.		
PRE		0.01	0.03	0.11	0.77	0.05	0.02	0.02		
POST		0.02	0.03	0.14	0.73	0.03	0.02	0.03		
Treatment group	Responses:	Neg.	Other	Fun	Animals	Cons.	Learning	Enrich.		
PRE		0.01	0.04	0.15	0.72	0.04	0.01	0.02		
POST		0.02	0.05	0.10	0.78	0.01	0.01	0.03		

Table 3. Continued

3) What is your favorite subject at school?							
Control group	Responses:	Neg.	Other	Activity	Arts	STEM	
PRE		0.00	0.00	0.48	0.19	0.32	
POST		0.00	0.01	0.49	0.18	.032	
Treatment group	Responses:	Neg.	Other	Activity	Arts	STEM	
PRE		0.00	0.01	0.52	0.19	0.29	
POST		0.00	0.02	0.55	0.16	0.27	
4) What was the best part?							
Control group	Responses:	Neg.	Other	Pos. non-zoo	Animals	Learning	Enrich	Lemurs Penguins
PRE		0.01	0.08	0.01	0.67	0.01	0.00	0.22
Treatment group	Responses:	Neg.	Other	Pos. non-zoo	Animals	Learning	Enrich	Lemurs Penguins
PRE		0.00	0.06	0.03	0.56	0.04	0.01	0.29

Questions and responses correspond to those presented in Table 2 but have been abbreviated to fit the table.

Table 4. Statistical paraments for the variables included in the GLM

Variables included in the model	Estimate	Standard error	t-value	P-value	F	Error, df
1). Pre-survey score	0.574	0.039	14.661	<0.001	289.262	440,1
2). Condition	-0.060	0.007	-8.162	<0.001	80.228	440,1

Figures

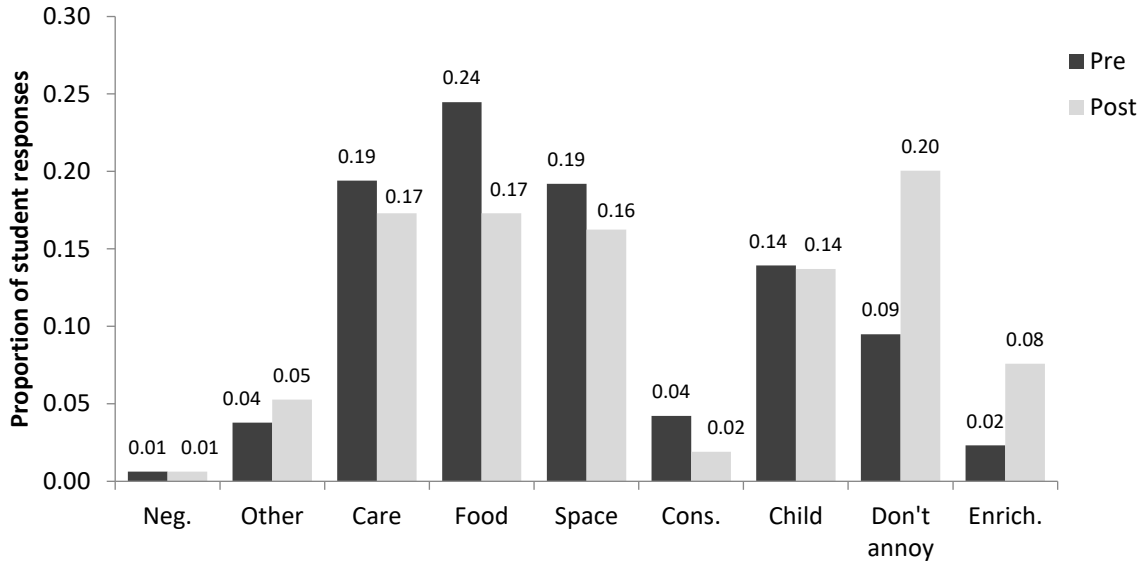

Figure 1. Student responses given to the question 'how can you help zoo animals?' on the pre- and post-survey.

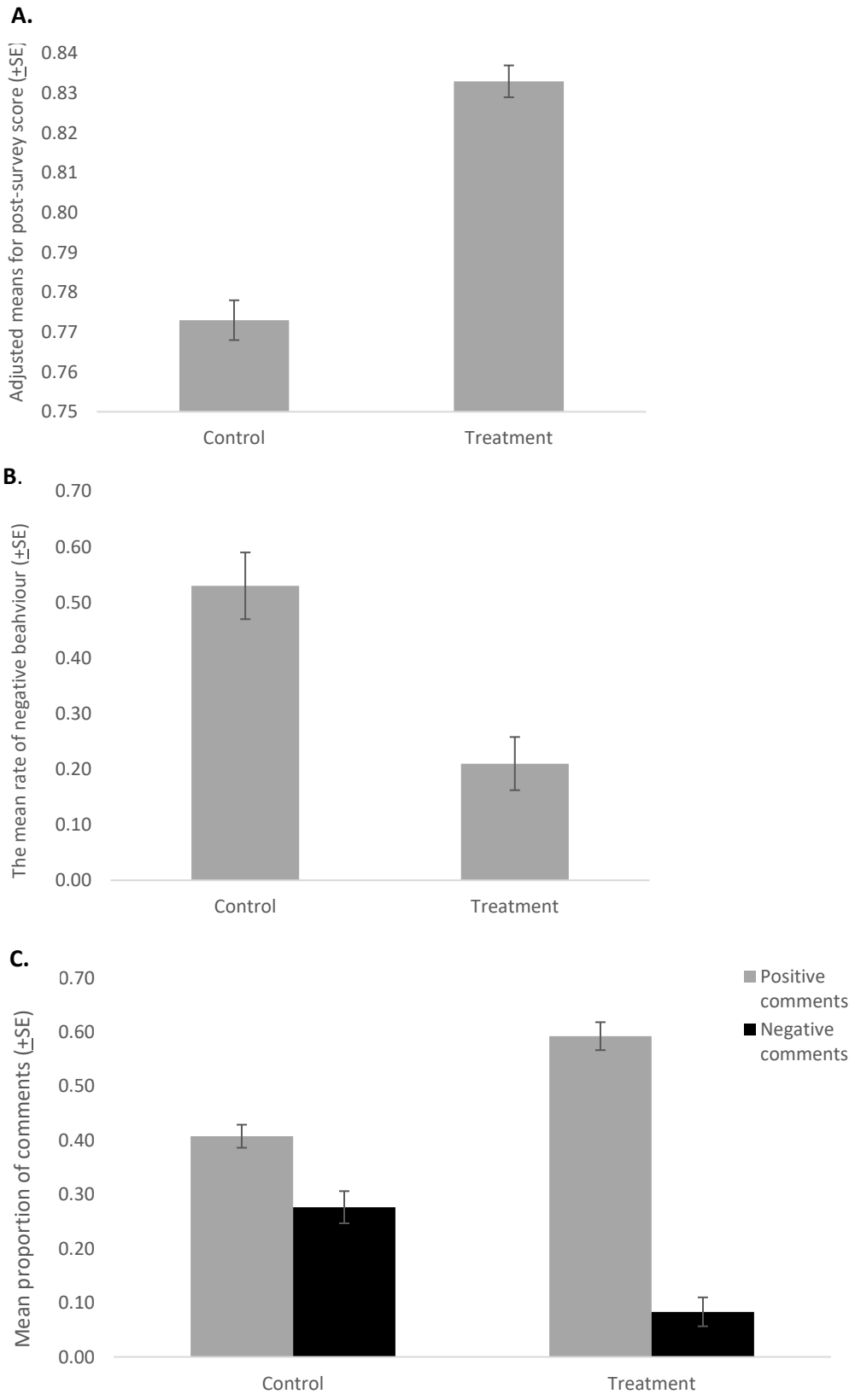

Figure 2. The mean (±SE) for A) the post-survey score, showing the means adjusted for the covariate B) the rate of negative behaviour and C) the proportion of positive and negative comments made per viewing session for control and treatment groups at each animal exhibit and institution in the study. *note the different y-axis scale on figure 2A.

Figure captions

Figure 1. Student responses given to the question 'how can you help zoo animals?' on the pre- and post-survey.

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