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Quantifying the long-term impact of zoological education: a study of learning in a zoo and an aquarium

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ABSTRACT

There is increasing evidence that zoos and aquariums do, as intended, educate their visitors. However, even though most zoos offer a wide array of educational experiences, few studies have considered if the duration of an educational experience affects learning or whether learning lasts beyond the immediate visit. The current study used matched-pairs surveys to investigate children's knowledge, attitude and knowledge of positive behavior during both a five-day zoo camp and six months after an aquarium visit. The participants of the study included children aged 9–12 years some of whom had participated in a purposefully designed educational intervention. First, the impact of a five-day zoo camp experience on children's learning was investigated. Second, learning retention was investigated six months after a school tour at an aquarium. Results showed that during the camp learning was positively affected by participation in the educational intervention and by previous zoo experience. Girls were more likely than boys to have an increase in learning six months after an aquarium visit. The study demonstrates that learning persists, but that education can be enhanced with longer programs. Thus, zoos can play an increasingly important role in igniting pro-environmental behavior.

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Introduction

Zoos and aquariums define themselves as centers for education (Patrick et al. 2007; Roe, McConney, and Mansfield 2014). However, in addition to education, visitors may attend the zoo for a multitude of reasons including entertainment and socializing (Godinez and Fernandez 2019). Although many variables may affect visitor learning (Godinez and Fernandez 2019), recent research confirms that children do learn as a result of a trip to a zoo or aquarium (Jensen 2014; Collins et al. 2020), particularly when accompanied by an educational intervention (EI; Randler et al. 2007; Collins et al. 2020). Yet, few studies have investigated whether the duration of the educational experience affects learning or what the long-term impact of education is on learning.

Intuitively, it seems that a longer educational experience should produce more in-depth and perhaps longer lasting learning, but rarely has this been tested. Because of a lack of quantifiable

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data surrounding children's learning in the zoo, research from other environmental education experiences is relied on here. Briseño-Garzón (2014) cautions that learning experiences at zoos and aquariums may differ from those at other informal settings, but Bitgood (1992) states that researchers should neither be too cautious, nor too general, in applying interpretations from one type of setting in visitor research to another but must carefully apply generalities from one situation to the next. Bitgood's (1992) suggestion is followed in this manuscript, and research from environmental education literature is referred to when appropriate. While it is important to remember that zoos and aquariums are distinct from other settings because of the presence of live exotic animals living in captivity, often the conservation goals surrounding environmental education centers are similar.

Previous research has found that children in five-day environmental education programs had a more positive attitude towards the environment and specific species (Emmons 1997), and were more willing to take action to help the environment (Mittelstaedt, Sanker, and Vander Veer 1999) at the end of the program than at the beginning. Bexell, Jarrett, and Ping (2013) found that after a five-day long camp in China, children (8–12 years) showed significant increases in knowledge, inclination for action to help the environment and empathy towards animals. Additionally, the campers' negative behavior, such as littering, declined over the course of the camp (Bexell et al. 2013). The results of these studies were not compared to a shorter learning experience, so it is not possible to determine whether the duration of the education programs was one of the contributing factors in the changes that were discovered. Bogner (1998) did compare the success of one-day and five-day long ecology programs at increasing pro-environmental behavior. The results revealed that students in both of the programs had increases in knowledge, but the children in the five-day program developed positive shifts in actual and intended behavior, such as taking action to help the environment. The author concluded that if the program is of sufficient length, students' behavior towards the environment can be influenced by education.

Yet, program duration may not be relevant if learning after an environmental educational experience is not retained. Even though the demonstration of a lasting effect is potentially the most important goal for environmental educators (Leeming et al. 1993), learning retention after informal science experiences is an under-studied area. Limited research does indicate that learning in students persists months or even years after an educational experience. Farmer, Knapp, and Benton (2007) found that one year after an environmental education field-trip, students still remembered what they had learned, with some students describing experiments in detail; there was also evidence of retention of pro-environmental attitudes in several students. Additionally, knowledge was retained in students (aged 7–12 years) two years after attendance at an environmental education program for schools near the Kalinzu Forest Reserve, Uganda (Kuhar et al. 2010). Previously, Kuhar et al. (2007) determined that their program was successful at increasing short-term knowledge. Students were then retested one and two years later, and it was found that knowledge had increased above the initial pre-program level (Kuhar et al. 2010). Randler et al. (2007) also reported increases in students learning from pre-visit level to post-visit and in a retention test 8-9 weeks after students visited workstations in the zoo. Ballantyne, Packer, and Falk (2011) investigated the short- and long-term impact of wildlife tourism experiences on visitors' awareness, appreciation and commitment to actions on environmental issues. The authors report that visitors' pre-visit commitment to the environment and motivation to learn were the best predictors of long-term learning impact.

More recently, Moss, Jensen, and Gusset (2015) discovered that an understanding of biodiversity and knowledge of actions to help protect biodiversity significantly increased after a zoo or aquarium visit. A follow up study two years later revealed that respondents' biodiversity understanding remained unchanged, but knowledge of actions to help protect biodiversity had improved (Jensen, Moss, and Gusset 2017). The authors speculated that this could be due to the visitors' heightened awareness of biodiversity after their zoo visit. As a result of their zoo experience, visitors paid more attention to subsequent biodiversity messages that they encountered in

their daily lives (Jensen, Moss, and Gusset 2017). There is also evidence that it is not only knowledge but pro-conservation behavior that lasts beyond the zoo visit. Over a year after a visit to an aquarium approximately 50% of adult visitors, who made a promise (in the form of a written pledge) to penguins to become more environmentally responsible, were still carrying out their intended actions, such as not littering (Mann, Ballantyne, and Packer 2018).

In contrast, Adelman, Falk, and James (2000) and Ballantyne, Packer, and Falk (2011) reported a low level of long-term impact on visitors' learning, especially attitude and behavior, after participation in an aquarium and wildlife tourism experience. However, the relatively short time (6–8 weeks) between the initial visit and the follow-up interview in the Adelman, Falk, and James (2000) study suggests that it may take visitors longer to assimilate what they learned, perhaps in combination with other reinforcing experiences, such as facilitating emotional connections with animals and reflection during the visit (Ballantyne, Packer, and Sutherland 2011).

Zoos and aquariums aspire to and are expected to be leaders in environmental education (Ogden and Heimlich 2009; Roe, McConney, and Mansfield 2014). Recently, zoos have been called on to raise biodiversity awareness amongst their visitors by the World Association of Zoos and Aquariums (WAZA) in support of the United Nations Strategic Plan for Biodiversity 2011–2020 (Moss, Jensen, and Gusset 2015; World Association of Zoos and Aquariums [WAZA] 2015). Additionally, zoos should strive to inspire their visitors to engage with conservation related behaviors which support biodiversity conservation (WAZA 2015).

The current study was part of a larger zoological education research project which was interested in enhancing children's knowledge about certain species, attitude towards zoos and knowledge of positive behavior towards captive animals (Collins 2018). Since zoo-housed animals may suffer reduced welfare if visitors engage in negative behaviors, such as shouting and banging on glass (Choo, Todd, and Li 2011; Sherwen et al. 2014; Chiew et al. 2019), it is imperative to educate visitors about behaving in a positive way when viewing animals. Increased knowledge of positive behavior towards captive animals may be indicative of an emotional connection and empathy towards animals, a precursor for driving behavior change (Myers and Saunders 2002; Bexell, Jarrett, and Ping 2013). Therefore, Collins et al. (2019) developed and implemented an EI that was found to significantly improve children's behavior at the zoo as they viewed animals and increase their learning after a one-day school tour (Collins et al. 2020). The present study follows a similar procedure and uses the same EI as these previous studies, but the current research focuses on a longer duration educational program duration in a zoo and a follow-up study six-months after an aquarium visit. There is little understanding of how program duration affects learning or of the long-term impact of zoological education on visitors' learning. Furthermore, few studies have considered children as learners, even though they comprise many of the visitors to zoos each year. If the education that zoos and aquariums provide, even if successful in the short-term, does not have lasting benefits, then their goals of promoting positive pro-environmental behavior and actions may not be realized.

The specific aims of this research were (1) to evaluate the effect of a five-day long program on children's knowledge, attitude and knowledge of positive behavior at Fota Wildlife Park, while considering the effect of an EI on a longer duration program, and (2) to compare differences in learning between one day school tours (results reported in Collins et al. 2020) and five-day camps at Fota Wildlife Park, and (3) to investigate changes in children's knowledge, attitude and knowledge of positive behavior six months after a visit to Dingle Aquarium, including the effect of an EI on long-term learning.

Methodology

This study was ethically reviewed and had approval from University College Cork's (UCC) ethics committee for working with children. Furthermore, all procedures followed the strict ethical

guidelines for working with children outlined by Cohen, Manion, and Morrison (2007). Before the study began, teachers signed a consent form allowing children to participate in the study. Additionally, the children were verbally told at the beginning of the study that they did not have to participate in the study and that they could withdraw at any time. All data were anonymized and stored in accordance with UCC's data storage policy.

Study sites

The study took place at two institutions in Ireland between 2013 and 2016. The five-day camp occurred at Fota Wildlife Park (Fota) in County Cork, a 100-acre wildlife park where some of the animals are free-ranging and all are housed in naturalistic enclosures. The six-month follow-up study involved children who had been to visit Dingle Oceanworld Aquarium (Dingle) in County Kerry. Dingle Aquarium is a purpose-built facility with many different animal exhibits.

Fota Wildlife Park camps

Procedure

Fota Wildlife Park offers camps throughout the year as part of their educational programming. They are generally taught by the same staff who conduct the school tours. The camp cost €115 per child for five days (Fota Wildlife Park 2018), and included a tour of Fota, conservation-based art, sports and games, films and ecology activities. All camps followed the same standard curriculum; however, some variation of the program was unavoidable. For example, sometimes a science show occurred; this has been included as an independent variable in the statistical models. Groups ranged in size from 5 to 16 children and were generally comprised of both boys and girls. Age of participants ranged from 9- to 12-year old; age nine had previously been determined as the minimum age required to understand and complete the survey. At the start of the camp, all children within the correct age range were asked if they were willing to participate in the research, and there was almost complete agreement. Some non-English speakers were unable to complete the surveys and were excluded from the study.

During the Fota camp, children completed the pre-survey on Monday morning in a classroom-like setting after arriving at Fota but before any activities occurred. They completed the post-survey on Friday afternoon at lunchtime. Only the data from children who participated in the entire camp and completed both the pre- and the post-survey were included in the study. This yielded a study sample of 110 matched-pairs surveys over the course of the study between October 2013 and August 2016. Camp groups were randomly assigned as a treatment group, who participated in an EI, or a control group, who did not. Generally, every second camp was assigned as a treatment group and then the following year this was reversed. The EI for treatment groups was conducted mid-week and followed several of the recommendations described by Ballantyne and Uzzell (1994) for the enhancement of informal learning experiences. The EI consisted of an hour-long specially designed class, including a PowerPoint presentation on Ringtailed lemurs (*Lemur catta*) and Humboldt penguins (*Spheniscus humboldti*). These species were chosen because they are generally common in zoos and also popular with visitors (M. O'Shea, personal communication 2014; T. Power, personal communication 2016). This was followed by a hands-on activity, during which children made enrichment devices for two species of animal (see Appendix A). For the penguins, the children made bubble mixture and filled plastic bottles with shiny paper. For the lemurs, the children cut up fruit for a scatter feed. Children in the treatment group had an additional tour of Fota on Friday morning, when they saw the animals interacting with the enrichment that they had prepared.

The survey instrument used in this study has previously been described in detail by Collins et al. (2020). It was extensively trialed with several different groups of children and reviewed by

experts in the field before the final version was implemented. Unfamiliar terminology, such as 'enrichment', were explained to the children as they completed the survey. Throughout this study, pre- and post-surveys, divided into sections on knowledge, attitude and knowledge of positive behavior towards zoo-housed animals (shortened to behavior in tables and figures), were used to assess learning (see Appendix B). The knowledge section of the survey focused on children's basic knowledge of ring-tailed lemurs (Fota students only) and penguins. The section on attitude investigated children's attitude toward captive animals and learning in the zoo setting. This is a different approach from other environmental or zoological education studies which have tended to focus on visitor's attitude toward conservation (Lindemann-Matthies and Kamer 2006; Jensen 2014). Finally, the survey concluded with a section on children's knowledge of positive behavior towards captive animals. This was intended to uncover visitors' awareness of the correct way to treat zoo-housed animals and was considered an indicator of empathy towards animals, which could be a precursor for pro-conservation behavior (Myers and Saunders 2002; see Collins et al. (2019) for details of animal and children's actual on-site behavior).

Since the current study was part of a larger project, this provided a unique opportunity to compare the results of children attending the 5-day camp described here to the results of children who attended a 1-day school tour described by Collins et al. (2020). The two versions of the educational experiences offered at Fota Wildlife Park were similar in procedures, age of participants, location, staff and the EI. The curriculum and fees were also similar between the experiences, although the 1-day school tour was less expensive than the camp and offered a reduced, but comparable curriculum. One uncontrolled variable was the children's reason for participating in the educational experience. For example, children may choose to attend a five-day camp at Fota because of an active interest in conservation, while school tour children may have attended because their teacher chose it for them, though of course some of them may also have an interest in conservation. The current study attempted to address this potential variation by assessing learning before the activities began.

Data analysis

Data analysis was carried out with the use of R 3.1.2 (R Development Core Team 2017). The camp survey data were analyzed using general linear models, where the difference in pre- and post-scores was used as the dependent variable for each section of the survey: knowledge, attitude and knowledge of positive behavior to test whether a camp experience impacted children's learning. The full statistical model and all of the independent variables tested are presented in table format for each section where a GLM was used to analyze data (Tables 1 and 3). All of the assumptions of the models were met. The least significant parameters in the model were removed sequentially using the step function in R (which uses Akaike's Information Criterion to delete terms from the model; Crawley 2007). ANOVA was used to check the deviance and where it was not significantly increased by the removal of that parameter (at the $p < 0.05$ level), it was excluded from the final model. The final optimal model, the results of which are presented in the text, included all parameters that were significant at the $p < 0.05$ level. Where a statistically significant effect was detected, tables representing the proportion of students' scores to decrease, remain stable or increase for each response option of the statistically significant independent variable are shown (Table 2 and 4).

Since self-selected groups of visitors, such as camp children, may have higher than expected conservation knowledge before the visit (Mittelstaedt, Sanker, and Vander Veer 1999; Adelman, Falk, and James 2000), the study compared the results of a one-day school tour (results reported in Collins et al. 2020) versus camp children as a group. The Mann-Whitney *U* test was used (1) to determine if children began the camp and the school tour with the same level of knowledge, attitude and knowledge of positive behavior by analyzing their pre-survey group scores and (2)

Table 1. The complete statistical model for (A) knowledge, (B) attitude and (C) behavior for the Fota Wildlife Park camp before any of the variables were removed during analysis.

A. Knowledge-independent variables	Response options	Estimate	Standard error	*t* Value	*p* Value
Condition	Control/treatment	1.501	0.447	3.359	0.001*
Science show	No/yes	3.951	0.454	0.870	0.386
Gender	Male/female	0.428	0.423	1.011	0.314
Camp before	No/yes	0.002	0.205	0.096	0.924
Zoo before	No/yes	2.547	2.163	1.178	0.242
Nature shows TV	No/yes	−0.000	0.000	−0.508	0.613
B. Attitude-independent variables	Response options	Estimate	Standard error	*t* Value	*p* Value
Condition	Control/treatment	0.305	0.382	0.798	0.427
Science show	No/yes	−0.135	0.389	−0.348	0.729
Gender	Male/female	−0.092	0.362	−0.254	0.800
Camp before	No/yes	−0.386	0.176	−2.199	0.030*
Zoo before	No/yes	1.220	1.852	0.659	0.511
Nature shows TV	No/yes	−0.000	0.000	−0.709	0.480
C. Behavior-independent variables	Response options	Estimate	Standard error	*t* Value	*p* Value
Condition	Control/treatment	0.698	0.317	2.202	0.040*
Science show	No/yes	0.102	0.322	0.317	0.752
Gender	Male/female	0.148	0.300	0.491	0.625
Camp before	No/yes	−0.425	0.146	−2.915	0.004*
Zoo before	No/yes	−0.884	1.536	−0.576	0.566
Nature shows TV	No/yes	0.000	0.000	0.343	0.737

*Variables left in the model and presented within the manuscript are marked with an asterisk, after the non-significant variables are removed *p* values of remaining variables may change slightly, which corresponds to the value reported in the text.

Table 2. The proportion of camp children whose (A) knowledge, (B) attitude and (C) behavior scores decreased, remained stable or increased between pre- and post-survey for the statistically significant independent variables.

Survey section	Response option	Decrease	Stable	Increase
A. Knowledge				
Condition	Control (no EI)	0.12	0.40	0.48
	Treatment (EI)	0.02	0.22	0.76
B. Attitude				
Previously attended a camp	No	0.12	0.27	0.61
	Yes	0.29	0.26	0.45
C. Behavior				
Condition	Control (no EI)	0.15	0.21	0.63
	Treatment (EI)	0.00	0.33	0.67
Previously attended a camp	No	0.06	0.14	0.80
	Yes	0.09	0.40	0.51

to identify any differences in school and camp children's knowledge, attitude and knowledge of positive behavior scores between pre- and post-survey for those that received the EI.

Dingle aquarium six-month follow-up study

Procedure

One school consisting of two classes participated in the follow-up study two years in a row, yielding a sample size of 91 students comprising two treatment and two control groups. For the follow-up study, the first author returned to the school six months after the Dingle Aquarium visit to administer the survey for a third time (see Collins 2018, for detailed results of the pre- and post-survey at this school). The children did not know that they would be tested for a third time. Only data from participants who completed all three surveys were included.

Surveys were designated as:

1. Pre-survey, the survey which was administered before the visit to Dingle Aquarium;
2. Post-survey, the survey which was administered directly after the visit to Dingle Aquarium;

Table 3. The complete statistical model for (A) knowledge, (B) attitude and (C) behavior for the Dingle Aquarium follow-up study before any of the variables were removed during analysis.

A. Knowledge-independent variables	Response options	Estimate	Standard error	*t* Value	*p* Value
Condition	Control/treatment	−1.367	0.370	−3.697	<0.001*
Gender	Male/female	0.170	0.370	0.460	0.646
Aquarium before	No/yes	0.328	0.286	1.150	0.253
Nature shows TV	No/yes	−0.059	0.225	−0.261	0.795
B. Attitude-independent variables	Response options	Estimate	Standard error	*t* Value	*p* Value
Condition	Control/treatment	0.466	0.515	0.905	0.368
Gender	Male/female	0.524	0.513	1.021	0.310
Aquarium before	No/yes	0.327	0.397	0.823	0.413
Nature shows TV	No/yes	−0.492	0.314	−1.570	0.120
C. Behavior-independent variables	Response options	Estimate	Standard error	*t* Value	*p* Value
Condition	Control/treatment	−0.681	0.315	−2.158	0.034*
Gender	Male/female	0.708	0.315	2.252	0.027*
Aquarium before	No/yes	−0.105	0.243	−0.431	0.668
Nature shows TV	No/yes	0.074	0.192	0.385	0.701

*Variables left in the model and presented within the manuscript are marked with an asterisk, after the non-significant variables are removed *p* values of remaining variables may change slightly, which corresponds to the value reported in the text.

3. Post-2-survey, the survey which was administered six months after the visit to Dingle Aquarium.

Data analysis

For the data collected at Dingle Aquarium, first a Friedman test was used to evaluate differences in mean test scores (pre-, post- and post-2) for both control and treatment groups, using combined knowledge, attitude and knowledge of positive behavior scores. Then, general linear models (following the same technique described above) were used to test which variables might impact long-term learning (see Table 3). The difference in total score for each section: knowledge, attitude and knowledge of positive behavior, between post-survey and post-2-survey was used to evaluate changes in learning over six months.

Results

Fota Wildlife Park camp data – general linear models for knowledge, attitude and knowledge of positive behavior

The EI was the only variable to have a significant effect on knowledge score ($p = 0.001$; Table 1A). Children in the treatment group (76%) were significantly more likely than those in the control group (48%) to have an increase in knowledge at the end of the camp (Table 2A). Previous attendance at a camp had a significant effect on pre- to post-survey attitude score ($p = 0.034$; Table 1B). Children who had not previously attended a camp were more likely to have an increase in attitude score (61%) compared to those who had previously been to a camp (45%). Conversely, more children who had attended a camp previously had a decrease in their attitude score (29%) compared to those who had not (12%; Table 2B). For knowledge of positive behavior, both participation in the EI ($p = 0.027$) and attending a camp before ($p = 0.002$) had a significant effect on the pre- to post-survey score (Table 1C). None of the respondents in the treatment group showed a decrease in their knowledge or positive behavior score compared to 15% in the control group (Table 2C). Children who had never attended a camp at Fota Wildlife Park before showed an 80% increase in knowledge of positive behavior score compared to only 51% of those who had attended a camp before (Table 2C).

Table 4. The proportion of students whose (A) knowledge and (B) behavior scores decreased, remained stable or increased between post- and post-2-surveys for the statistically significant the independent variables.

Survey section	Response option	Decrease	Stable	Increase
A. Knowledge				
Condition	Control (no EI)	0.15	0.44	0.41
	Treatment (EI)	0.41	0.52	0.07
B. Behavior				
Condition	Control (no EI)	0.22	0.39	0.39
	Treatment (EI)	0.35	0.43	0.22
Gender	Male	0.35	0.44	0.21
	Female	0.20	0.39	0.41

Educational impact at Fota Wildlife Park – school tour versus camp

Pre-survey

Children attending camps had a higher mean test score than children attending a one-day school tour on the pre-survey for knowledge (9.31 vs. 13.53), attitude (14.56 vs. 14.91) and knowledge of positive behavior (9.56 vs. 10.84), with statistically significant differences occurring for knowledge ($W = 14{,}826$, $p < 0.001$) and knowledge of positive behavior ($W = 10{,}720$, $p < 0.001$)

Post-survey

There was a statistically significant difference in level of knowledge gained between school and camp treatment groups ($W = 5971.5$, $p = 0.001$). More children on a school tour (88%) had an increase in knowledge compared to children attending a camp (76%; Figure 1(A)). There was no difference in attitude scores detected between school tour students and camp children ($W = 9163$, $p = 0.22$). Knowledge of positive behavior scores were significantly different between camp children and school groups ($W = 10{,}303$, $p = 0.003$). A higher number of children in the camp group (67%) had an increase in their knowledge of positive behavior score compared to school tour students (51%), and camp children showed no decrease in knowledge of positive behavior score, but school children showed a large decrease (17%) in knowledge of positive behavior score between pre- and post-test (Figure 1(B)).

Dingle aquarium – six-month follow-up study

Throughout the study, students in the treatment group scored higher than those in the control group (Figure 2). For both the control group ($\chi^2 = 7.721$, $p = 0.021$) and the treatment group ($\chi^2 = 22.503$, $p < 0.001$) statistically significant differences were detected between pre- (before school tour), post- (directly after the school tour) and post-2- (six months after the school tour) test scores. In both cases, children scored higher in the post- and post-2-test than the pre-test (Figure 2).

General linear models: knowledge, attitude and knowledge of positive behavior

Only participation in the EI had a significant effect on knowledge from post- to post-2-survey scores ($p = 0.001$) (Table 3A). Students in the control groups (41%) were more likely than those in the treatment group (7%) to have an increase in their knowledge scores between post-survey and post-2-survey. In fact, in the treatment group, 41% of students experienced a decrease in knowledge between post- and post-2-survey compared to only 15% in the control group (Table 4A). None of the variables that were tested affected attitude score from post- to post-2-survey (Table 3B). The model for knowledge of positive behavior revealed that participation in the EI ($p = 0.03$) and gender ($p = 0.022$) had a significant effect from post- to post-2-survey (Table 3C). Students in the control group (39%) were more likely than those in the treatment group (22%)

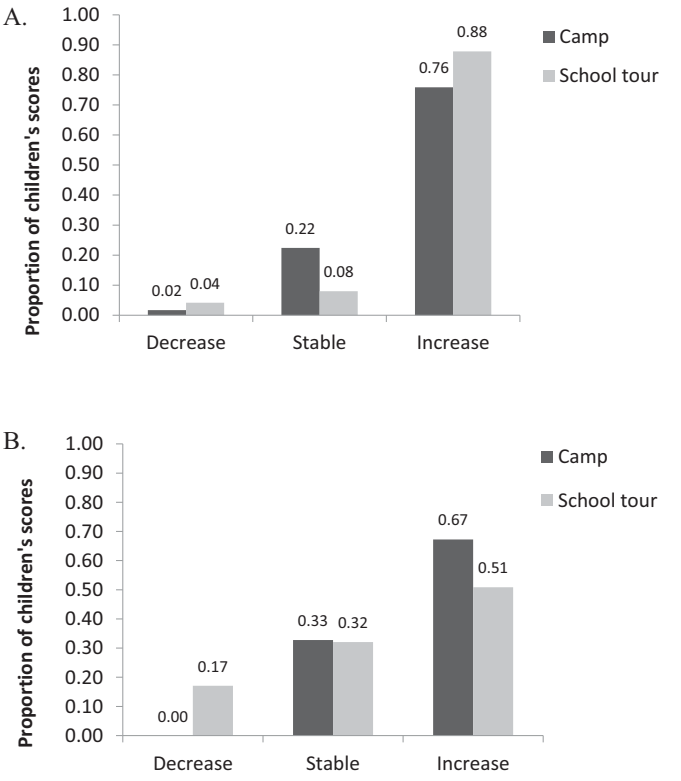

Figure 1. The proportion of camp versus school tour children in treatment groups whose (A) knowledge and (B) behavior scores decreased, remained stable or increased between pre- and post-survey.

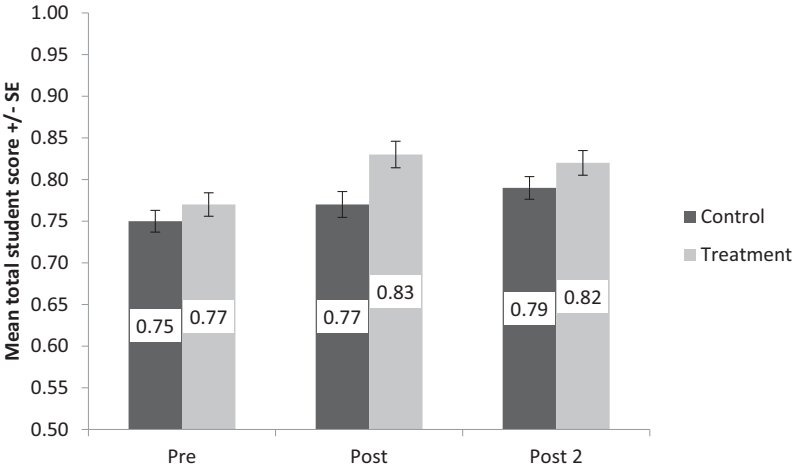

Figure 2. The mean total survey scores (knowledge, attitude and behavior combined) ± SE for control and treatment groups in the pre-, post- and post-2-survey at Dingle Aquarium.

to have an increase in knowledge of positive behavior score and least likely (22%) to have a decrease compared to 35% in the treatment group from post- to post-2-survey (Table 4B). Gender also affected the knowledge of positive behavior score, with 41% of girls showing an increase in their knowledge of positive behavior scores compared to only 21% of boys between post- and post-2-survey (Table 4B).

Discussion

Fota Wildlife Park camp

In the absence of the EI, less than half of the children who attended camp for five days and experienced a broad conservation curriculum demonstrated an increase in knowledge. In contrast, just over three quarters of children in the treatment group showed an increase in knowledge at the end of the week. This is unsurprising since Collins et al. (2020) reported similar results regarding knowledge when this EI was used during a one-day educational experience. Importantly, none of the camp children in the treatment group experience a decrease in their knowledge of positive behavior, compared to 15% of children in the control group. The EI may have been most beneficial at reinforcing learning for the treatment groups since knowledge of positive behavior was likely to remain stable or increase in these groups. These results confirm those of previous studies that reported significant increases in knowledge and behavior in children enrolled in long-term environmental education programs (Bogner 1998; Bexell, Jarrett, and Ping 2013; Borchers et al. 2014).

In the current study, previous camp attendance appeared to negatively affect attitude and knowledge of positive behavior score. Children who had attended a camp before were less likely to have an increase in attitude and knowledge of positive behavior and more likely to have a decrease in attitude at the end of the educational experience compared to those who had not been to a camp before. This is unexpected given that reinforcing experiences are thought to enhance learning (Mittelstaedt, Sanker, and Vander Veer 1999; Adelman, Falk, and James 2000). It is possible that the children who had previously attended a camp had higher expectations for the activities, which might lead to disappointment and a decrease in attitude, if what they experienced did not equal what they expected. Or perhaps these children had previously been introduced to concepts like conservation, biodiversity and animal welfare, and they thought more critically about the questions that were asked on the survey, which could also have resulted in lower attitude scores. Yet, if an educational program is successful at eliciting long-term learning, having attended a camp before should result in higher levels of learning (Lukas and Ross 2005; Ballantyne, Packer, and Falk 2011). Children in the pilot study at Fota were disinclined to answer open-ended questions; however, these results indicate that it would be appropriate for future studies to follow-up the attitudinal questions with 'why', which would facilitate disentangling the results.

School tour versus camp

Visitors who choose to attend a specific education program may already have a high level of knowledge (Adelman, Falk, and James 2000), and the results found here confirm that. Since camp children had a high level of knowledge to begin with, increasing knowledge might be difficult. Indeed, the results found here show that knowledge was more likely to increase for school tour children than camp children. Similar to Bogner (1998), findings showed that children in the five-day camp were more likely to have increases in their knowledge of positive behavior scores than children on the one-day school tour. This increase was most likely to occur in children who experienced the EI. Since the ultimate goal of environmental education is pro-conservation behavior change (Hungerford and Volk 1990; Ogden and Heimlich 2009), these results are encouraging and suggest that a longer duration program is most beneficial for influencing knowledge of positive behavior. The current study assessed children's knowledge of positive behavior, and not the actual behavior; still, an increase in understanding the correct way to behave towards animals in captivity may inspire children to protect animals in their natural habitat (Bexell, Jarrett, and Ping 2013). Developing these connections more fully should be a focus of future research.

Dingle aquarium six-month follow up study

The results from the six-month follow-up study confirm those of Kuhar et al. (2010) and Jensen, Moss, and Gusset (2017), who found significant increases in scores from pre-visit to post-visit, followed by an increase or a stable score on the delayed post-visit. In the present study results from different sections of the survey vary, and surprisingly it was found that children in the control groups were more likely than those in the treatment group to have an increase in their knowledge and behavior scores. This result is similar to the findings of Randler et al. (2007), who suggested that follow-up scores may have been influenced by post-activity discussions between control and treatment groups and repeated testing may increase scores (Ebbinghaus 1964; Karpicke and Roediger 2007). Or, perhaps it is more difficult to build on the already high knowledge scores of the treatment group in the post-test (Bogner 1998). Results found here support the latter theory since the treatment group, with the benefit of the EI, scored higher than the control group in the initial post-test. The EI probably helped the treatment group assimilate knowledge faster than the control group. Conversely, the control group may have benefited from more time and intervening experiences to score better on the survey six-months after the educational experience.

Randler et al. (2007) and Borchers et al. (2014) suggest that in local cultures different genders may benefit from the opportunity to discuss the experience after the post-test, which may influence learning and post-2-test scores. At the school attending Dingle Aquarium, it was not apparent that the girls discussed the experience more than the boys; yet, more girls than boys had an increase in their knowledge of positive behavior score between the post- and post-2-surveys. Gender differences in learning should be investigated further and environmental educators should be aware that post-experience discussions are vital to assimilate learning. Although Ballantyne, Packer, and Falk (2011) found that first-time visitors reported greater long-term learning than repeat visitors, having previously visited an aquarium did not affect learning in the current study. It is possible that other variables such as the media and subsequent zoo visits may contribute to the retention test scores, but this is almost impossible to control (Jensen, Moss, and Gusset 2017).

General discussion

Throughout this study, attitudinal change was limited. Similar results were reported by Lukas and Ross (2005) in their study on visitor attitude towards great apes, but in contrast to other studies that have reported significant attitude change after an environmental educational experience (Bogner 1998; Borchers et al. 2014). This difference may be because the latter studies focused on environmental issues, but both the current study and Lukas and Ross (2005) focused specifically on captive animals. For example, a child with a propensity to care for animals and the environment may have strongly agreed that zoo animals are bored, if they did not learn about typical animal behavior and zoo conservation during their visit. But if that same child had been asked an attitudinal question about an environmental issue such as recycling, they may have given a positive response, since some children may already be familiar with the importance of recycling. These findings are important for the zoo community, where there is little understanding of children's attitudes towards zoos and captive animals. The results indicate that the reasons for keeping animals in captivity, how to behave towards them and the conservation value of captive animals should be introduced into the curriculum of zoological education programs to enhance learning.

Although no educator wants to consider the possibility that a student might exhibit a decrease in learning after an educational experience, to present an accurate account of learning all outcomes should be considered (Moss and Esson 2013; Jensen 2014). The present study is one of only a few zoological education studies to evaluate if education could lead to a decrease

in learning or a negative outcome. The data suggest that the control groups were more likely than treatment groups to show a decrease in learning. It is probable that the advanced and hands-on curriculum the treatment groups experienced engaged the students more, which led to learning either stabilizing or increasing. Conversely, the decrease in learning more often seen in the control groups may indicate disinterest or boredom with the curriculum. The exception to this was the six-month follow-up study at Dingle Aquarium, where students in treatment groups were more likely to show a decrease in learning than those in control groups. It may have been difficult for students in treatment groups to maintain their already high scores, perhaps indicating that the initially advanced learning of the students who experienced the EI did not last six-months after the visit. Future research should consider using follow-up activities to reinforce learning. The reason for these findings is not entirely clear; negative learning outcomes after educational experiences should continue to be considered in zoological education research.

Additionally, previous attendance at a Fota camp was associated with a decrease in attitude and knowledge of positive behavior scores, and children in school tour and camp groups arrived with varying levels of knowledge. Therefore, zoos and aquariums should consider the impact of previous experiences and potential differences in children's understanding at the start of their educational activity (Dierking et al. 2004; Lukas and Ross 2005; Ballantyne, Packer, and Falk 2011). For example, it could be beneficial for children with a greater understanding, if the curriculum was more advanced to suit their higher level of knowledge or experience. Introducing more complex ecological concepts such as biodiversity, extinction and actions to help the environment might engage these children more and promote in-depth learning. Furthermore, the camp curriculum should progress from year to year, to benefit repeat campers by reinforcing and building on already existing knowledge and a pre-existing propensity to care for the environment (Bexell, Jarrett, and Ping 2013). The introduction of hands-on activities like the ones completed during the EI may help to achieve this by introducing a more complex curriculum in a fun and interactive way.

Certain limitations occurred with this study. For example, the use of a quantitative survey to measure learning only allows for a limited, self-reported evaluation of learning. Open-ended questions or even interviews would allow for a more comprehensive analysis of learning to occur. Furthermore, these findings are limited to the institutions involved in this study, further investigation should be carried out to ascertain generalizability of these data. Future research should also consider retention testing after a long-term educational experience, such as the five-day camp described in this study. In addition to this, future research should consider if an inclination to care for captive animals leads children to take conservation action outside of the zoo. Still, the findings from this research are encouraging and suggest that longer educational experiences together with the EI may lead to a greater depth of understanding and knowledge of positive ways to behave towards animals, and that learning does last beyond the immediate educational experience.

Conclusions

1. During the Fota Wildlife Park camp, participation in the EI was the most significant predictor of knowledge gain. This type of in-depth, hands-on program should be considered by zoological institutions to enhance learning.
2. Both attitude and knowledge of positive behavior were influenced by previous attendance at a camp at Fota Wildlife Park. Children who had never attended a camp before were more likely than those who had to have increases in attitude and behavior scores between pre- and post-survey. Zoological education curriculum should be tailored to suit repeat visitors and visitors of varying previous experiences with wildlife.

3. Camp children showed higher knowledge scores than school tour children on the pre-survey. For treatment groups, school tour children were more likely to gain in knowledge and camp children were more like to experience increases in knowledge of positive behavior score between pre- and post-survey. Learning resulting in knowledge of positive behavior may be enhanced with a longer duration program.
4. Treatment groups scored consistently higher than control groups on the pre-, post- and post-2-survey at Dingle Aquarium. However, control groups were more likely than treatment groups to experience gains in knowledge between post- and post-2-survey than treatment groups. Girls were also more likely to have increases in knowledge of positive behavior score between the post- and post-2-test than boys. It may take time for some visitor groups to assimilate knowledge after an educational experience, reinforcing learning after an educational experience should continue to be evaluated.

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Appendix A - Details of the EI used during this study

Previously described by Collins (2018, 125–126); Collins et al. (2019); Collins et al. (2020)

The EI was purposefully designed to enhance students' learning in the zoo setting. It focused on knowledge about ring-tailed lemurs and penguins, children's attitude towards captive animals and learning in the zoo, and behavior towards captive animals. Specific elements of the EI included a PowerPoint presentation which described the biology of penguins (and lemurs at Fota Wildlife Park only), threats to their existence in the wild and what life might be like for them in the zoo versus the wild. Smith, Broad, and Weiler (2008) and Mann, Ballantyne, and Packer (2018) state that for environmental education to successfully impact a specific behavior, messages about that behavior should be clearly communicated to visitors. Therefore, visitor behaviors that were intended to change were described and discussed (e.g. 'you should not feed the lemurs because it could make them sick' or 'you should not bang on the penguins' glass wall because you could disturb or frighten them'). Additionally, emotionally engaging visitors with environmental issues and animals has a positive impact on learning and behavior

(Ballantyne, Fien, and Packer 2001; Myers, Saunders, and Birjulin 2004; Ballantyne, Packer, and Sutherland 2011; Mann, Ballantyne, and Packer 2018), and infant animals elicit emotional responses (Ballantyne et al. 2007). Therefore, the PowerPoint presentation included emotionally appealing pictures, including infants, of the species studied.

Part of the EI was dedicated to a hands-on activity during which children made enrichment devices for the animals included in the study (Dewey 1998). The purpose of this was multi-functional. First, it was intended to improve animal welfare by encouraging the penguins to swim and the lemurs to be more active by providing a non-scheduled feeding/foraging opportunity (Collins et al. 2019). Second, the presence of the enrichment, and more specifically the animals' interest in the enrichment device and potential increased activity, was intended to stimulate children's learning. McPhee et al. (1998) reported that an enrichment device itself had little effect on visitors, but others assert it is the animal behavior that the device elicits that is interesting to visitors (Wood 1998; Davey, Henzi, and Higgins 2005). It was expected that because the children made the enrichment device themselves, and then observed the reaction of the animals that general interest and thus learning would be enhanced (Collins et al. 2020).

Appendix B – the three surveys used during this study. Not all of the survey items included on this survey were analyzed in this manuscript, those that were not analyzed are marked with an asterisk

Previously described by Collins (2018)

1. The pre-survey administered before the Fota Wildlife Park camp.

First Name:_____ **Second Name:**_____

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

* * *

1. Have you ever visited a zoo before today?

Yes No I am not sure

2. Have you ever been to a camp at Fota before?

Yes No I am not sure

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

Yes No I am not sure

***4. What is your favorite subject at school?** [ ]

***5. 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.

6. Zoo animals are HAPPY.

Strongly Agree Agree I am not sure Disagree Strongly Disagree

7. Zoo animals are BORED.

Strongly Agree Agree I am not sure Disagree Strongly Disagree

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

Strongly Agree Agree I am not sure Disagree Strongly Disagree

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

Strongly Agree Agree I am not sure Disagree Strongly Disagree

* * *

***10. When you think of Fota Wildlife Park, what is the first thing that comes to mind?**

One Word [ ]

In this section, if you do not know the answer, just take a guess.

11. Ring-tailed lemurs come from..?

Africa South America Madagascar New Zealand Sri Lanka

12. Ring-tailed lemurs are endangered because of..?

Drought Deforestation Global Warming Fire Hunting

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

Fruit Flowers Leaves Food from visitors Meat

14. Do you think penguins are?
Marine mammals Birds Fish I am not sure
15. Do you think penguins can fly?
Yes I am not sure No
16. Where do you think penguins live (mostly)?
The Northern Hemisphere The Southern Hemisphere Both I am not sure
17. Do you think penguins live in .
Warm places Cold places Both I am 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.
18. I think visitors should be allowed to feed free-ranging animals.
Strongly Agree Agree I am not sure Disagree Strongly Disagree
19. I think visitors should be allowed to touch the free-ranging animals.
Strongly Agree Agree I am not sure Disagree Strongly Disagree
20. I like to see zoo animals that have enrichment.
Strongly Agree Agree I am not sure Disagree Strongly Disagree

Thank you!

2. The post-survey administered after the FWP camp.
First Name:_____ Second Name:_____

* * *

1. Have you enjoyed the camp at Fota?
Yes No I am not sure

2. What was the best part?

***3. What is your favorite 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 am not sure Disagree Strongly Disagree
6. Zoo animals are BORED.
Strongly Agree Agree I am not sure Disagree Strongly Disagree
7. During my visit to Fota, I enjoyed LEARNING ABOUT ANIMALS.
Strongly Agree Agree I am not sure Disagree Strongly Disagree
8. During my visit to Fota, I enjoyed LEARNING SCIENCE.
Strongly Agree Agree I am 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 do not 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 am not sure

14. Do you think penguins can fly?

Yes I am not sure No

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

The Northern Hemisphere The Southern Hemisphere Both I I am not sure

16. Do you think penguins live in .

Warm places Cold places Both I am 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 am not sure Disagree Strongly Disagree

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

Strongly Agree Agree I am not sure Disagree Strongly Disagree

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

Strongly Agree Agree I am not sure Disagree Strongly Disagree

Thank you!

3. The post-2-survey administered six months after visiting DA.

First Name:_____ Second Name:_____

1. Do you remember your visit to Dingle Aquarium?

Yes No I am not sure

***2. What was the best part?**

***3. What is your favorite 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 am not sure Disagree Strongly Disagree

6. Aquarium animals are BORED

Strongly Agree Agree I am not sure Disagree Strongly Disagree

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

Strongly Agree Agree I am not sure Disagree Strongly Disagree

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

Strongly Agree Agree I am 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 do not know the answer, just take a guess.

10. Do you think penguins are?

Marine mammals Birds Fish I am not sure

11. Do you think penguins can fly?

Yes No I am not sure

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

The Northern Hemisphere The Southern Hemisphere Both I am not sure

13. Do you think penguins live in .

Warm places Cold places Both I am 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 am 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 am not sure Disagree Strongly Disagree

Thank you!