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Children's conversation reveals in-depth learning at the zoo

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Abstract

Learning in the zoo is a complex process with many influences affecting outcomes, which traditional methods of evaluation may not consider. This study used conversational content analysis, an innovative and under-used technique, to investigate children's learning in the zoo setting during an educational experience. The children's conversations were observed at Fota Wildlife Park and Dingle Aquarium in Ireland at three different animal exhibits 1) free-ranging ring-tailed lemurs (*Lemur catta*) 2) Gentoo penguins (*Pygoscelis papua*) and 3) Humboldt penguins (*Spheniscus humboldti*). Some groups of children (the treatment group) participated in a purposefully designed educational intervention, while others (the control group) experienced the standard curriculum only. Descriptive statistics indicated that all children engaged in diverse topics of conversation indicative of learning as they viewed animals. However, further analysis using a GLM showed that participation in the treatment or control group ($p<0.001$) and species viewed ($p<0.001$) affected the proportion of positive comments made by children. Groups that viewed free-ranging ring-tailed lemurs and Gentoo penguins made more types of positive comments than those that viewed Humboldt penguins, and children who experienced the educational intervention made more types of positive comments than children in the control group. Conversely, children in the control group made more types of negative comments ($p<0.001$) than those in the treatment group. The results indicate that children do learn in the zoo setting; however, this was enhanced based on the type of educational activity the children experienced and the species they viewed. Overheard conversation offers a unique insight into the visitors' experience at the zoo, but further research is required to establish if conversation can reveal a propensity for pro-conservation behavior.

Key words: zoological education; informal science; conversational content analysis; zoo setting; school groups

Introduction

Zoos have largely transitioned from entertainment destinations to centers that now prioritise education and conservation, though this is an on-going process, which not all zoos have yet achieved or aspired to (Carr and Cohen, 2011; Godinez and Fernandez, 2019; Mellish Ryan, Pearson and Tuckey, 2019). Subsequently, most zoos' educational messages have also evolved from short-term factual information to campaigns that aim to inspire long-term pro-conservation behavior change (Mellish et al., 2019; Ogden and Heimlich, 2009). However, it has been difficult to establish the impact of a zoo visit on visitors' learning (Moss and Esson, 2013). Some studies have found that zoos do educate visitors both in the short- and long-term (Collins et al., 2020; Jensen, Moss and Gusset, 2017; Moss, Jensen and Gusset, 2015) others have reported limited knowledge gain as a result of a zoo visit (Balmford et al., 2007). Although the World Association of Zoos and Aquariums has called on zoos to inspire their visitors towards conservation related behaviors (WAZA, 2015), critics (e.g., Jamieson, 1985; Royal Society for the Prevention of Cruelty to Animals (RSPCA), 2006; Marino, Lilienfeld, Malamund, Nobis, and Broglio, 2010) have accused zoos of contributing little to conservation efforts and not showing enough educational evidence to justify keeping animals in captivity (Godinez and Fernandez, 2019; Moss and Esson, 2013).

Yet, it can be challenging to reliably evaluate educational impacts in the zoo setting (Jensen, 2014; Marino et al., 2010). Mellish et al. (2019) suggest that more robust educational research should be conducted in the zoo setting, but caution that a range of methodological problems exist that may limit outcomes. For example, over 83% of zoological education studies analyzed by Mellish et al. (2019) employed weak methodological evaluations and failed to, for example, triangulate data or include both zoos and aquariums in their study sample. One classic example of controversy surrounding educational methodology in the zoo setting is the Falk et al. (2007) study, which used surveys to evaluate the impact of visiting a zoo or aquarium on adult visitors'

learning. Falk et al. (2007) reported a positive association between the visit and conservation attitudes. However, the study was criticized by Marino et al. (2010) on the grounds of methodological validity, for example, the use of retrospective-pre-surveys, which may overestimate programme effect, calling into question the results of the study. Although Falk, Heimlich, Vernon and Bronnenkant (2010) retorted that Marino et al. (2010) misunderstood and misrepresented the study, the implied methodological flaws highlight the need for more robust educational research in zoos and aquariums. Yet, it is not just zoos that face these methodological complexities, and insights can be drawn from other sources of informal learning.

Many institutions, such as museums, offer informal science education experiences; in fact, science is a discipline that is conducive to free-choice learning or learning outside the classroom (Falk, 2001). Although most students consider learning outside the classroom an exciting and memorable way to learn, they may not be given much 'choice' about learning in an outdoor environment, depending on school requirements (Braund and Reiss, 2004). Yet, it is generally accepted that the public participate in informal science experiences for a combination of curiosity, entertainment and educational reasons (Falk, 2001), but the motivation for learning during an informal science experience is personal and varies considerably (Falk and Dierking, 2000; Hein, 1998; Phipps, 2010; Roschelle, 1995). The present theory on the framework surrounding informal science learning is based on constructivism or the belief that visitors 'build' knowledge based on the personal, physical and social context of the visit (Falk and Dierking, 2000; Vygotsky, 1978). Thus, learning science in an informal setting is a highly personal, cumulative process, based on multiple prior experiences, which together contribute to the construction of knowledge (Falk, 2001; Ham, 2009; Hein, 1998; Roschelle, 1995). This makes the assessment of learning in any free-choice setting challenging. Using interviews and observation, Tofield et al. (2003) specifically

examined the usefulness of zoos as free-choice learning centers. The authors concluded that although learning science at the zoo may be limited for the general public, primary school children developed an enhanced awareness of animal welfare and an understanding of exhibit design. It is most beneficial if the methodology used in the evaluation of informal educational experiences illuminates all aspects of the learning process, including cognitive, emotive and social. However, traditional evaluation methods, such as surveys, may fail to determine the true outcome of a zoo visit or to take into consideration the individual components of learning (Clayton et al., 2009), or they may be costly and time-consuming, such as interviews.

An under-used methodology in the evaluation of informal science education is conversational content analysis. Overheard conversation in the zoo can reveal how visitors view exhibits and about children's natural interests, which educators can then build upon to enhance learning (Tunnicliffe, Lucas and Osborne 1997). At a basic level, conversation indicates visitors' immediate level of interest and whether or not they are paying attention to an exhibit, which is a precursor for learning and the start of the cognitive process (Altman, 1998). A comprehensive analysis of conversation can also reveal visitors' curiosity and engagement at an exhibit, while considering personal, emotional and social experiences, which contributes to our understanding of visitor learning in the zoo setting.

A limited amount of research involving conversational content analysis has previously taken place in museums and zoos (e.g. Allen, 2002; Clayton et al., 2009; Pavitt and Moss, 2019; Tunnicliffe et al., 1997). In one of the few studies to focus on children, Tunnicliffe et al. (1997) discovered that when family and school groups' conversations at the zoo were compared, they were similar. The lack of conversation amongst school children about science, even though they were visiting the zoo as part of their school curriculum, led the authors to conclude that schools are not fully using the educational potential of the zoo visit (Tunnicliffe et al., 1997). Other research in the zoo setting used conversational content to assess visitors' response to

varying enrichment conditions in a chimpanzee (*Pan troglodytes*) enclosure (Wood, 1998). Broadly, it was found that visitors made more positive comments, indicative of intellectual curiosity, when new enrichment was present, and the animals were active, and, conversely, visitors made more negative comments when enrichment was one-day old and animals were less active (Wood, 1998). Another study compared adult visitors' conversations at tamarins in cages versus a free-ranging environment (Price, Ashmore and McGivern, 1994). Both environments led to a variety of comments, but the authors concluded that overall the free-ranging animals instigated more insightful conversation, indicative of interest and curiosity (Price et al., 1994). Similarly, Pavitt and Moss (2019) discovered that visitor engagement, evidenced through conversation, was most indicative of learning at walk-through exhibits. Visitors made more 'deeper-level' comments at walk though exhibits compared to traditional enclosures, suggesting that the close proximity with animals resulted in more in-depth learning and visitor engagement (Moss and Pavitt, 2019). Importantly, in another study, a combination surveys and overheard conversation revealed emotional connections between humans and animals (Clayton et al., 2009). The authors stated that visitors' concern for the well-being of animals increased after a zoo visit, which might lead to visitors' support of conservation programmes (Clayton et al., 2009). However, ultimately the authors concluded that even though visitors are open to learning at the zoo, education must fit into visitors' leisure pursuits and it is the responsibility of the zoo to stimulate learning, possibly through social interaction (Clayton et al., 2009). Yet, Clayton et al. (2009) did not specifically concentrate on school groups who often follow a particular curriculum during a zoo visit (Collins et al., 2020; Jensen, 2014; Tunnicliffe et al., 1997).

Children visiting a zoo inevitably have a lot to talk about, much of it is social conversation, but some of their dialogue will also include learning discourse (Patrick and Tunnicliffe, 2012). Yet, children are generally an under-studied group of zoo visitors (Jensen, 2014). The current

research was part of a larger project to investigate children's learning in the zoo setting. Although it uses the same educational intervention, sites and animal exhibits, as Collins et al. (2019) and Collins et al. (2020), it offers new insights into learning based on children's conversation as they view animals and substantiates the findings of the previous studies. The aims of the current research were to 1) reveal the types of comments made as children view animals in the zoo setting; 2) consider which variables influence the diversity of positive and negative comments in the zoo setting and 3) evaluate if overheard conversation reveals evidence of learning in the zoo setting.

Methodology

Study sites and participants

This research received full ethical approval from the University College Cork ethics committee. The research was carried out at Fota Wildlife Park (Fota), Carrigtwohill, County Cork, Ireland and Dingle Oceanworld Aquarium (Dingle), County Kerry, Ireland between May 2014 and August 2016. Animal exhibits where data were gathered included: ring-tailed lemurs (*Lemur catta*) and Humboldt penguins (*Spheniscus humboldti*) at Fota Wildlife Park and Gentoo penguins (*Pygoscelis papua*) at Dingle Aquarium.

These animals were included in this research because lemurs and penguins were listed by zoo visitors as animals they would most like to see (Carr, 2016). At both institutions in this study, they are considered popular by visitors, who may be drawn to their charismatic behavior and bold colour patterns (pers. comm. M. O'Shea and T. Power). Furthermore, penguins have been described as having high educational potential, since visitors are attracted to them and generally these penguins do not give an adverse behavioral reaction to visitors (Collins et al., 2016). At Fota Wildlife Park, the ring-tailed lemurs are completely free-ranging, which also adds interest to the study, and the Humboldt penguins are kept in a large outdoor naturalistic display with a

125 seawater fed pond. At Dingle Aquarium, the gentoo penguins are kept in a purposefully built
126 indoor enclosure with a pool, and a land surface area where a snow machine produces half a
127 ton of snow and ice throughout the day.

128 The children included in this research were aware that they were participating in a research
129 project; however, they did not know the purpose of the study or that their conversation would
130 be listened to. In total, 49 groups of children, on either a scheduled school tour of the
131 institutions or participating in a five-day camp at Fota Wildlife Park, participated in this study.
132 The number of children per group ranged from 7-40 (mean=23) and the age ranged from 6-12
133 years. Almost all groups were of mixed gender, though there were some all girls' groups. The
134 variation in demographics was out of the control of the researcher since groups participated
135 voluntarily; however, where possible variations are included as independent variables is the
136 statistical analysis (Table 2). All groups participating in this research experienced a guided tour
137 of the facility, conducted by trained zoo and aquarium staff, who followed the standard
138 curriculum. School tours and camp tours were similar. At Fota Wildlife Park, some groups
139 viewed both the ring-tailed lemurs and the Humboldt penguins, when this occurred each
140 viewing was recorded as a separate conversation. Camp groups observed the animals twice,
141 and their pre- and post-viewing conversations were also recorded separately. This yielded a
142 sample size of 74 observed conversations between Fota Wildlife Park and Dingle Aquarium.

143 Before the study began each group was randomly assigned as a treatment group or a control
144 group, using the Excel random number generator. The treatment groups experienced a
145 purposefully designed educational intervention (EI) (see the next paragraph for details of the
146 EI) plus the standard zoo curriculum, while the control groups only experienced the standard
147 zoo curriculum. If a school brought more than one class to the zoo or aquarium, each class
148 within one school could be randomly assigned as a control or treatment group. Control and
149 treatment groups were similar in nature, in that they consisted of children who were already

150 enrolled in an educational activity at Fota Wildlife Park or Dingle Aquarium. Collins et al.
151 (2020) found that many of the demographic variables naturally occurring between these groups,
152 such as the socio-economic status of the school, did not affect learning outcomes. Thus, in the
153 current study children's conversations were listened to during two conditions: control (n=47,
154 no EI, standard zoo curriculum only) and treatment (n=27, with the EI, plus the standard zoo
155 curriculum).

156 The educational intervention (EI) was an hour-long class that was purposefully designed for
157 the treatment groups participating in this research project (see Collins et al., 2019, for complete
158 details of the EI). It was conducted between 2-7 days before the children toured the zoo or
159 aquarium. It aimed to enhance students' knowledge, attitude and behavior towards zoo-housed
160 animals, specifically penguins and lemurs. The EI consisted of a power-point presentation, and
161 a hands-on activity during which children made environmental enrichment devices for lemurs
162 and/or penguins. For the lemurs, the children cut up fruit for a randomised scatter feed (pers.
163 comm. M. Esson) and for the penguins they made bubble mix and filled plastic bottles with
164 shiny bits of paper (Clarke, 2003), which can mimic natural foraging opportunities. Then,
165 during their tour of the park or aquarium, students in the treatment group were able to see the
166 animals interacting with the enrichment devices that they had made.

167 *Procedure and data collection*

168 Conversation data were collected using an adapted form of the Tunnicliffe Conversation
169 Observation Record (TCOR) (Tunnicliffe, 2005). This checklist was developed to determine if
170 learning occurs during a zoo field trip, and includes pre-designated categories of conversation
171 (Patrick, Mathews and Tunnicliffe, 2013). Using standard content analysis procedure (Cohen,
172 Manion and Morrison, 2007), both pre-existing categories of conversation based on the TCOR
173 (Patrick and Tunnicliffe, 2012), and themes that emerged from preliminary research conducted

174 at Dingle Aquarium and Fota Wildlife Park were used to generate a list of typical children's
175 conversational comments (Table 1). For each group observation session, if a comment was
176 made by any child in the research group, a tick was made next to the corresponding category
177 on the checklist. Similar to Clayton et al. (2009) it was considered more important to know
178 how many types of comments were made, than to record the frequency of each comment,
179 therefore the occurrence, not the frequency of comments, is represented (Tunnicliffe et al.,
180 1997). Each comment was counted in only one category, where overlap occurred between
181 categories the most appropriate choice was made. Most children stood in a group around the
182 viewing area of the enclosure and the researcher stood amongst the children, moving with them
183 if necessary (Tunnicliffe, 1998). It is possible that some conversations were missed, if children
184 whispered or wandered from the main group, and at times acoustics and ambient noise made
185 listening difficult (Allen, 2002). This was out of the control of the researcher. Furthermore, it
186 was not possible to determine which child made the comment so that the data represent the
187 group rather than individual children. At times when other visitors were present during
188 observation sessions, their conversation was never purposefully recorded.

189 During the preliminary research, children were overheard to make anthropocentric (humans as
190 superior to animals) and anthropomorphic (attributing human characteristics to animals)
191 comments. While it is common for children to take an anthropocentric attitude towards animals,
192 education, especially when it includes viewing animals in nature, can shift anthropocentricism
193 to a more biocentric attitude (Almeida, Vasconcelos, Strecht-Ribeiro and Torres, 2013).
194 Therefore, anthropocentric remarks were classified here as negative because it was reasoned
195 by the authors that they did not represent a pro-conservation attitude. For example, if children
196 exclaimed 'We rule them!' this does not demonstrate an understanding of nature and
197 conservation and indicates a more negative than positive attitude towards animals. However,
198 anthropomorphic remarks, also common in children, were classified as positive because even

199 though they can represent an unfair judgement of animals (Almeida et al., 2013) more often
200 they are representative of an emotional connection (Clayton et al., 2009) or a general valuing
201 of animals (Myers, Saunders and Garrett, 2003). This yielded 15 positive and 4 negative types
202 of comments (Table 1).

203 *Table 1*

204 *Data analysis*

205 Only the primary researcher recorded conversation data; however, for the purposes of
206 reliability and quality assurance a research assistant simultaneously recorded children's
207 conversation during two sessions and inter-observer reliability testing was carried out between
208 the primary researcher and the research assistant using Cohen's kappa (Jensen, 2014). A mean
209 of 0.745 (a positive association on a scale from -1 to +1) was achieved for inter-observer
210 reliability testing during this part of the study.

211 First, using descriptive statistics, data collected at each exhibit are presented in table format,
212 where the proportion of control or treatment groups to make each type of comment is shown.
213 Since categories of conversation are not mutually exclusive, the total of the categories is over
214 1.00 (Tunnicliffe et al., 1997). For inferential statistical analysis, comments were categorized
215 as either positive or negative. In this case, the dependent variables were the proportion of
216 positive and negative comments made per viewing session and are referred to as the 'diversity'
217 of positive or negative comments. Plotted histograms and the Kolmogorov-Smirnov test
218 revealed that comments observed during children's conversation were non-normally
219 distributed (positive comments $p=0.038$; negative comments $p<0.001$). However, positive
220 comments were approaching normal and a visual inspection of the histogram revealed a nearly
221 normal curve. Therefore, a GLM was used to model the diversity of positive comments against
222 the independent variables described (Table 2). Independent variables were tested for

multicollinearity and were found to be below the variance inflation factor (VIF) tolerance level of 2.5 in all cases. Graphs of standardised residuals were inspected throughout the analysis to ensure that the assumptions of normality were maintained. The diversity of negative comments was not normally distributed. Therefore, the Mann-Whitney U test was used to test for differences in negative comments between treatment and control groups, which was considered the most important independent variable.

Table 2

Results

Descriptive statistics

Diverse conversations took place as both control and treatment groups viewed the animals included in this study at each exhibit. However, a pattern emerged which indicated that generally more types of positive comments occurred in treatment groups and more types of negative comments occurred in control groups (Table 3).

Fota Wildlife Park – Ring-tailed lemurs

At the ring-tailed lemur exhibit, for almost every category of positive conversation, treatment groups were equally or more likely than control to make comments, including naming (83% vs 63%), describing (67% vs 50%), mentioning behavior (100% vs 69%) giving or seeking information (100% vs 88%) visitor effects (67% vs 19%) and affective comments (83% vs 56%) (Table 3). Conversely, control groups visiting the lemurs were more likely than treatment groups to make negative comments in every category except anthropocentric (Table 3). For both control and treatment groups, location and visitor effects were generally mentioned more by groups viewing lemurs than the groups viewing either penguin species (Table 3). Children made the most comments about touching/feeding at the free-range exhibit, yet the fewest generally negative comments occurred at the lemur exhibit (Table 3).

Fota Wildlife Park – Humboldt penguins

Children's conversation followed a similar pattern at the penguin exhibits. Treatment groups were more likely than control groups to describe the animals (40% vs 13%), discuss enrichment (100% vs 0%), science (60% vs 0%) the animals' behavior (100% vs 30%) and make anthropomorphic (53% vs 13%) and affective (67% vs 46%) comments (Table 3). Control groups made more negative comments than treatment groups, misinformation (63% vs 7%), feeding or touching (25% vs 7%) and generally negative remarks (25% vs 0%) (Table 3). More control groups (8%) than treatment groups (0%) discussed conservation, though this unexplained result may be an anomaly of the data (Table 3). Both groups discussed the Humboldt penguins' location more than the Gentoo penguins' location (Table 3). Additionally, children visiting the Humboldt penguins were generally less likely to make affective or anthropomorphic comments than groups at the other exhibits included in this study (Table 3).

Dingle Aquarium – Gentoo penguins

At the Gentoo penguin exhibit at Dingle Aquarium, treatment groups were more likely than control groups to describe the animals (100% vs 14%), discuss enrichment (100% vs 14%) and science (50% vs 0%), mention conservation (17% vs 0%) and the media (17% vs 0%), make anthropomorphic remarks (100% vs 71%) or give and seek information (100% vs 71%) (Table 3). However, more control groups than treatment groups named the animals (100% vs 83%) and made comments about the exhibit (71% vs 33%), and approximately equal numbers of control (14%) and treatment groups (17%) mentioned visitor effects (Table 3). Control groups at Dingle Aquarium were more likely to engage in negative conversations than treatment groups, which mostly involved giving misinformation or making anthropocentric comments (Table 3). None of the treatment groups, compared to 14% of control groups, made negative comments such as 'this is stupid' or 'I don't like them' as they viewed the birds (Table 3).

Table 3

Inferential statistics

The general linear model indicated that condition (control vs treatment) ($p<0.001$) and species ($p<0.001$) affected the proportion of positive comments (expressed as mean proportion$\pm$SE). Children in the treatment group expressed a more diverse range of positive comments (0.59 ± 0.03) than those in the control group (0.41 ± 0.02) as they viewed the animals. Additionally, conversations that took place at the Gentoo penguins (0.54 ± 0.04) and ring-tailed lemurs (0.58 ± 0.03) were more diverse than those that occurred at the Humboldt penguins (0.39 ± 0.02). No significant interactions occurred between any of the independent variables tested (Table 2).

The Mann-Whitney U test revealed a statistically significant difference for the diversity of negative conversation between treatment and control groups ($U=292.00$, $p<0.001$) (expressed as mean proportion$\pm$SE). Children in the control groups (0.28 ± 0.03) made more types of negative comments while viewing animals than those in the treatment groups (0.08 ± 0.03).

Discussion

The results found here support the findings of other studies that visitors make comments indicative of curiosity, cognitive engagement, emotional connections and deeper level learning as they view animals (Clayton et al., 2009; Pavitt and Moss, 2019; Price et al., 1994). A pattern emerged which showed that irrespective of the location or species, treatment groups made more types of positive comments, and control groups made more types of negative comments. In fact, participation in the control or treatment groups was one of the variables found to significantly influence the proportion of positive comments that groups made. This suggests that children in the treatment group had a more insightful and emotionally rich experience (Bexell, Jarrett and Ping, 2013; Clayton et al., 2009; Tunnicliffe et al., 1997), likely due to the

295 hands-on learning activity and the closer engagement with the animals. A detailed inspection
296 of the comments revealed that in general the treatment groups made more comments indicative
297 of learning (naming, describing and commenting on behavior), curiosity about the animals on
298 display (giving and seeking information) and emotional connection to the animals (affective
299 and anthropomorphic) than control groups. Giving and seeking information, suggests students
300 are engaging socially (Clayton et al., 2009) and explaining their observations based on previous
301 experience (Patrick and Tunnicliffe, 2012) which is a precursor for learning (Tunnicliffe et al.,
302 1997). Furthermore, the treatment groups commented on topics (enrichment, conservation,
303 science and visitor effects) that they learned about during the educational intervention.
304 Tunnicliffe et al. (1997) expressed concern that children did not engage in conversation
305 evidencing scientific learning. Here, none of the control groups mentioned science, but many
306 of the treatment groups did. Pavitt and Moss (2019) report that only 2.3% of the comments
307 they observed were related to conservation. Although 93% of those occurred at walk-through
308 exhibits, the authors still caution that this does not help zoos to define themselves as
309 conservation educators (Pavitt and Moss, 2019). In the current study, 33% of the treatment
310 groups that visited the free-ranging lemurs made conservation-type comments, supporting the
311 finding that the educational intervention together with the free-range exhibit lead to greater
312 learning.
313 Display species also affected the diversity of positive comments, which could be due to
314 environmental factors such as enclosure design and animal activity (Clayton et al., 2009; Pavitt
315 and Moss, 2019) or the animals' general popularity with visitors. Free-ranging species or those
316 housed in walk-through exhibits are reported to receive more comments than traditionally
317 caged ones (Clayton et al., 2009; Pavitt and Moss, 2019; Price et al., 1994). Indeed, in the
318 current study the free-ranging ring-tailed lemurs received the most diverse range of positive
319 comments from both control and treatment groups. It is likely that the opportunity to observe

these animals in a natural habitat without restrictions inspired respect, awe and an emotional connection. This finding supports Pavitt and Moss (2019) in their conclusion that visitors are more engaged with and potentially learn more from a free-ranging species. The Gentoo penguins received more positive comments than the Humboldt penguins and the most comments relating to behavior of any species, possibly because of the Gentoo penguins' charismatic nature, including their large stature, distinctive pattern, easy visibility and the ability of visitors to observe them swimming underwater. Also, at Fota, the penguins received negative remarks about their 'bad smell.' Jensen (2011) states that 'smell' can be a prominent and memorable feature of a zoo visit for children. However, at Dingle, the penguins were behind a glass wall, so no smell was apparent. Further research should be conducted to tease out how an animals' perceived 'charisma' or likeability affects conversation and learning.

In the current study many of the independent variables tested did not affect diversity of positive comments. This concurs with previous studies in the zoo setting that reported little difference in the content of conversation between children of different ages (Tunnicliffe, 1996b) or genders (Tunnicliffe, 1998). Gender was not evaluated in the current study because most groups were of mixed gender and it was difficult to determine if a boy or girl made the comment and the age range was restricted to 6-12 years. Future research should consider the effects of these demographic variables in greater detail. Neither was the diversity of positive comments affected by participation in a camp or a tour, the number of children present in the group or the length of their stay at the exhibit. Previous research has equated longer visitor stay time at exhibits with visitor interest and perhaps enhanced learning (Clayton et al., 2009; Moss and Esson, 2010). Interestingly, in the current study longer stay time was not associated with more types of positive comments; however, the length of the viewing session was generally controlled by the zoo staff and school teacher's schedule and did not necessarily reflect the students' level of interest. The lack of a significant effect of some of these variables could be

345 useful information to future researchers, since it can be challenging to control visitor variables
346 in the dynamic zoo setting.

347 Similar to Clayton et al. (2009), it was discovered that children in the current study generally
348 made fewer negative than positive remarks. However, negative remarks were more common
349 in control groups. Many of the negative comments centered around misinformation. For
350 example, at the Fota Wildlife Park penguin exhibit, a child exclaimed 'they're too hot'. The
351 child is likely basing this misinformation on previous experience and understanding
352 (Tunnicliffe et al., 1997) perhaps influenced by the media (Wagoner and Jensen, 2010), where
353 penguins are often portrayed living in the snow. Presumably, the child did not encounter
354 anything during the visit to adjust their prior understanding (Patrick and Tunnicliffe, 2012) or
355 realize that Humboldt penguins do not live in snowy climates. Ideally, a teacher or parent
356 should correct this misinformation. However, recording adult remarks was out of the scope of
357 this study, and Patrick and Tunnicliffe (2012) report that many teachers or parents are not able
358 to give the correct information. Children who experienced the EI were specifically told the
359 biology of the species included in the study, such as the climate of their natural habitat, and the
360 occurrence of misinformation was much lower in the treatment groups.

361 The motivation for anthropocentric comments is less clear. Almeida et al. (2013) and Borchers
362 et al. (2014) reported that environmental education may reduce anthropocentrism in children,
363 but at Fota Wildlife Park the treatment group made more anthropocentric comments than the
364 control group. Many of the anthropocentric comments heard in the present study involved
365 children commenting that they could or would make the animals do something ('I can make
366 them run!' 'See if you can make him jump'), suggesting that there is a link between
367 anthropocentric comments and frustration that the animals are not active. The enrichment
368 (present with the treatment groups) was intended to promote animal activity; however, it was
369 not especially effective, and Collins et al. (2019) found that the animals were not necessarily

more active when the treatment groups were present. A more effective type of enrichment which encourages animal activity may reduce anthropocentric comments and increase positive comments (Altman, 1998; Wood, 1998). Conversely at Dingle Aquarium, the treatment groups made fewer anthropocentric comments. The traditional type of enclosure at Dingle may have affected learning differently. The reason for anthropocentric comments and how they are influenced by education, enclosure type and display species should be explored in future research.

Mellish et al. (2019) state that only 25% of the zoological education studies that they analyzed collected data from two or more sources, which only gives a narrow insight into an intervention tested. However, the results reported in the present study help to corroborate the findings from the other parts of a larger study. For example, here it was discovered that treatment groups engaged in more diverse positive conversation as they viewed animals. When this is considered together with the results of Collins et al. (2020), which showed that the treatment groups were more likely to have increases in knowledge and behavior on the survey than control groups, this reinforces the evidence that the educational intervention enhanced learning in the zoo. Also, in the present study it was discovered that treatment groups made fewer negative comments about touching or feeding the animals, which supports the findings of Collins et al. (2019) that treatment groups are less likely to exhibit negative behavior, such as feeding or touching, while viewing animals. Not only does the conversation data strengthen the findings of the results from the larger study, but it shows that conversational content analysis provides a unique and valid insight into learning at the zoo (Tunnicliffe, 1996a), and is useful to uncover less traditional learning. For instance, it was previously discovered that children were disinclined to answer open-ended questions on a survey (Collins et al., 2020) and interviewing children can be logistically difficult. However, listening to what children say as they view

394 animals is efficient and may reveal learning that would not be discovered with survey data
395 alone, such as emotional engagement with animals.

396 Yet, limitations did occur during this study. For example, for zoos to fulfil their goals as
397 conservation educators, it is imperative that zoological education inspires pro-conservation
398 action not just factual knowledge gain. While the children in this study, particularly those in
399 the treatment groups, were inclined to make emotive comments and talk about conservation
400 and science, conversational content analysis does not allow for the evaluation of post-visit pro-
401 conservation actions that might result from the visit. It would be beneficial to do a follow-up
402 study after the initial visit to assess if expressed words inspired future actions. Furthermore, it
403 is challenging to accurately listen to conversations in the dynamic zoo environment. This
404 confound can be mitigated with proper training and observer experience. Also, familiarity with
405 the group could make individual identification of the speaker possible, which would add
406 interest and value to future research since individuals assimilate knowledge differently. Like
407 all evaluations of informal science experiences, assessment of learning in the zoo can be
408 compromised by uncontrolled variables such as teacher preparedness or different prior
409 experiences of participants. Here, the groups of children were considered approximately
410 similar, but unknown differences could have occurred. Additionally, learning at specific
411 exhibits is positively related to the attractiveness of the animal (Moss and Esson, 2013). The
412 research in the current study was conducted with animals that are considered popular with
413 visitors. Future research should consider conducting similar research across a greater diversity
414 of species and with less popular species.

415 **Conclusions**

416 Evaluating informal science education in any setting can be challenging. Many evaluation
417 tools, such as surveys, are one dimensional and do not account for the complex and personal

nature surrounding learning in an informal setting. Despite some limitations, conversational content analysis revealed evidence of in-depth learning by children particularly when they participated in the purposefully designed educational intervention. A pattern emerged which indicated similar results occurred at both institutions and at all three exhibits, suggesting that these findings may be generalizable to other institutions. Furthermore, both the educational intervention and the methodology used in this study were cost effective and easy to implement. Thus, this research will benefit zoo educators and staff as they strive to maximize the learning experience of their visitors. Additionally, the methodology in this study could be adapted to most informal science experiences where children engage in hands-on activities, and these findings could be built upon to increase the efficacy of learning outside the classroom.

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570 **Table 1. Children's conversation comments recorded at exhibits at Fota Wildlife Park (lemurs and**
571 **penguins) and Dingle Aquarium (penguins).**

Positive comments*	**Definition**	**Example**
Non-zoo related	Social discourse not related to animals or the zoo	'I like your coat,' 'Do you want to come to my house?'
Management	Directional, management	'Look,' 'over there,' 'let's go'
Naming	Naming the animals on view, discussion of what to call them	'It's a penguin,' 'Is it a monkey?'
Descriptive	Describing the animal on view	'It's small,' 'They're fluffy'
Behavior	Mention of the animals' behavior	'They're swimming,' 'He's eating'
Location	Discussion of the animals' location	'It's over there,' 'Where are they?'
Exhibit	Discussion of the exhibit	'They're not in cages,' 'There's snow in there'
Information	Seeking or giving information	'They can't fly,' 'Where do they come from?'
Affective	An emotional comment, generally positive	'I love them!'
Enrichment	Reference to the enrichment provided	'He's looking at it,' 'Do they see it,' 'It's working'
Visitor effects	Discussion of visitor effects on animals, generally positive	'Don't frighten them,' 'I wonder if they notice us?'
Anthropomorphic	Reference to human characteristics of the animals	'He's waving,' 'They look like us'
Media	Reference or discussion of animals in the media	'I saw this on TV,' 'They're from that movie'
Science	Reference to science	'The hypothesis was right!' 'This is our experiment'
Conservation/zoo-related	Anything having to do with conservation, or zoo-related discussion	'Tigers are going extinct,' 'Deforestation is bad'
Negative comments*	**Definition**	**Example**
Feed/touch/Bang	Discussion of feeding or touching with a negative reference or banging the glass at Dingle Aquarium	'Give them this,' 'Let's touch one'
Negative comments	Generally negative comments	'This is boring,' 'I hate them'
Misinformation	Giving incorrect information	'There should be ice in there' 'He'll fly out'
Anthropocentric	Reference to people controlling animals or being 'in charge' of them.	'They can't live without us,' 'I'll make them run'

572 *** Adapted from the TCOR (Tunnicliffe, 2005; Patrick and Tunnicliffe, 2012; p. 157).**

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576 **Table 2. Details of the dependent and independent group variables investigated.**

Dependent variables	Independent variables	Response options
1) Positive comments	1) Condition	Control or Treatment
2) Negative comments*	2) Species	Gentoo penguins; Humboldt penguins; Ring-tailed lemurs
	3) Educational experience	1-day school tour or 5-day camp
	4) Age	0=< 8; 1=9-13; 2=9-10; 3=11-13
	5) Length of session	Time in minutes
	6) No. of children	No. of children counted in the group

577 *Condition only

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601 **Table 3. Results of children's conversation at each animal exhibit presented as the proportion of control**
602 **and treatment groups to express the different categories of conversation.**

	Ring-tailed lemurs		Humboldt penguins		Gentoo penguins	
Positive comments	**Control group n=16**	**Treatment group n=6**	**Control group n=24**	**Treatment group n=15**	**Control group n=7**	**Treatment group n=6**
Non-zoo related	1.00	1.00	1.00	1.00	1.00	1.00
Management	1.00	1.00	0.71	0.93	0.86	1.00
Naming	0.63	0.83	1.00	0.93	1.00	0.83
Descriptive	0.50	0.67	0.13	0.40	0.14	1.00
Behavior	0.69	1.00	0.33	1.00	1.00	1.00
Location	0.69	0.67	0.38	0.33	0.14	0.17
Exhibit	0.56	0.33	0.17	0.13	0.71	0.33
Information (give/seek)	0.88	1.00	0.71	0.87	0.71	1.00
Affective	0.56	0.83	0.46	0.67	0.86	0.83
Enrichment	0.69	1.00	0.00	1.00	0.00	1.00
Visitor effects	0.19	0.67	0.04	0.07	0.14	0.17
Anthropomorphic	0.63	0.67	0.13	0.53	0.71	1.00
Media	0.56	0.00	0.13	0.07	0.00	0.17
Science	0.00	0.33	0.00	0.60	0.00	0.50
Conservation	0.06	0.33	0.08	0.00	0.00	0.17
Negative Comments						
Let's feed/touch	0.38	0.17	0.25	0.07	0.00	0.00
Negative	0.06	0.00	0.25	0.00	0.14	0.00
Misinformation	0.19	0.00	0.63	0.07	0.43	0.00
Anthropocentric	0.25	0.33	0.17	0.20	0.43	0.17

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