Encouraging children's learning and curiosity towards fish: The importance of outdoor science experiences and the inclusion of didactic activities

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Abstract:

Outdoor educational activities provide unique opportunities to observe and understand wild animals, to enhance curiosity and to cope with misconceptions regarding the natural environment. The present work, addressed to 3-12 years-old children, focuses on three aims. First, we assessed whether a scientific fishing activity involving live animals, led by scientists and aimed at families, helps to improve the knowledge of children (N=28) regarding the diversity of fish in the river. Second, we studied to what extent the activity allows the redirection of misconceptions and permits the elaboration of more complete mental models about fish morphology. Third, we studied if the participation and curiosity of children (N=14) are encouraged by the incorporation of didactic dynamics into the initial proposal. The activity was performed in an urban park near the mouth of the Besòs river (Catalonia, Spain). In the first fishing, questionnaires and a drawing exercise where children had to depict a fish were distributed before and after the activity. In the second fishing, which included a game and a story in addition to the questionnaires and the drawing, the children's behaviour while they observed the fish before and after these activities was monitored. Results show that a fishing activity contributes to improving the knowledge about the fish species that live in the river and can correct misconceptions about fish morphology for some children. It was also found that including didactic activities stimulates the curiosity, participation and satisfaction of children. Finally, some aspects to be improved are discussed.

Keywords: Outdoor education, Misconceptions, Natural environment, Curiosity, Didactic activities

Introduction

Currently, it is an educational priority to provide people with an adequate and coherent body of knowledge, as well as the necessary skills to become responsible and informed citizens able to understand, prevent and solve environmental problems (Parra et al., 2020). In this context, early experiences with science are foundational for children's later learning (Greenfield et al., 2017) and outdoor educative activities stand as privileged opportunities to develop experimentation, cooperative teamwork and enhance curiosity (Harun & Salamuddin, 2014). The correct planification of this kind of

interventions is challenging, and one key factor that educators should understand and assess carefully to better guide the learning process is children's misconceptions (Kazunga & Bansilal, 2018).

Misconceptions can be defined as concepts that are alternative to the scientific vision and that are acquired through experience or transmitted by other people (Baysen et al., 2012). There is some disagreement about the role of these alternative conceptions in learning; while some authors advocate that they cause problems for the acquisition of new knowledge because they are persistent and difficult to change (Dağdelen & Kösterelioğlu, 2015), others claim that they can play a useful role in the learning process since they provide rich opportunities to question whether a certain knowledge is appropriate or not (Kazunga & Bansilal, 2018). This means that some existing conceptions can be productive in certain circumstances and unproductive in others (Vosniadou, 2022). It is common to find misconceptions related to animals in children (e.g. Kubiatko & Prokop, 2018). Specifically, when it comes to understand fish, some general difficulties exist related to morphological functions such as respiration mode (Aziz & Akram, 2022) and to biodiversity issues, for instance the perception that fish are abundant and impossible to overfish (Feller, 2007). Restricting environmental education to textbooks can result in impoverished visions of reality (Gavidia Catalán & Cristerna, 2000) and might promote the elaboration of misconceptions (Suprapto, 2020). Outdoor educational activities might be a useful resource to cope with misconceptions since they provide practical experiences in the natural environment (Johnson & Činčera, 2019) and seem to be better suited for teaching knowledges and attitudes towards biodiversity as compared to traditional indoor school perspectives (Fančovičová & Prokop, 2011). Nowadays, children in cities have less opportunities to experience close contact with nature leading to the consequent acquisition of misunderstandings, disaffection and even repulsive behaviours such as biophobia (Soga et al., 2020). A poor understanding of living beings' characteristics and biodiversity is related to the underestimation of environmental impacts (Soanes et al., 2019). On the contrary, observing wild animals favours the understanding of the relationship between the organism and its environment (Patrick & Tunnicliffe, 2011) and permits to build a pedagogical vision of conviviality where humans and animals are materially and ethically embedded in relational, natural-cultural environments (Russel & Fawcett, 2018).

An outdoor educational activity requires a careful planning by the educators to motivate and engage children for a successful learning experience (Gilbertson et al., 2022). Finding ways to enhance children's curiosity is a must, since this trait is closely related to greater learning (Carr & Claxton, 2002). In the present study, a fishing activity aimed at families was analysed with the objective of defining adequate procedures to redirect children's misconceptions as well as good practices to promote their curiosity and participation.

Using drawings to detect scientific conceptions and observation to measure curiosity

There are several tools for detecting misconceptions, such as open questions, multiple-choice questions and drawings (Patil et al., 2019). Although some difficulties are associated with drawings as an assessment tool (Kenneth & Hite, 2020),

some authors state that they are a highly underestimated instrument for examining children's misconceptions (Plotz & Hollenthoner, 2019). Drawing is a process in which all children naturally engage (Ainsworth et al., 2011), and it might be a good way for them to express their thinking about science topics (Rybska et al., 2014). Drawing is a good resource due to its low cost, time efficiency and ease of conduction (Fančovičová & Prokop, 2019), as well as an adequate assessment tool for children with difficulties in oral communication (Chin & Teou, 2010).

Historically, several theories have been proposed to explain the relationship between drawings and learning processes. The "drawing to learn theory" alludes to children using drawings to express their thinking and knowledge (Ainsworth et al., 2011). This theory delves into how a child's initial understanding evolves to a more adjusted view after a hands-on activity, expressed by the consecutive drawings produced, thus allowing us to explore misconceptions and improve the learning procedures (Anning, 1999). Within the science education domain, several authors have proposed different indicators and rubrics to help interpret the degree of accuracy of scientific drawings (e.g., Lunde & Gregers, 2021) and present them as useful tools for assessing learning processes and obtaining summative assessments (Otto et al., 2017). Direct observation of natural phenomena, as well as of specific species, helps to improve knowledge and, consequently, the drawings made by students (e.g., Gómez Llombart & Gavidia Catalán, 2015). Previous works have also explored the use of drawings to assess outdoor learning activities (Bowker, 2007).

On the other hand, certain behaviours, such as paying attention and approaching observed objects, seeking answers by examining the environment, asking questions and persisting in exploration, are good indicators of curiosity (e.g., Kibga et al., 2021).

Design of significant outdoor science activities for children

Outdoor activities are often less effective than expected owing to the lack of suitable learning resources, since learners might be scattered in different locations and with no guidance (Dillon et al. 2006). For a scientific activity to provide a meaningful learning experience, it is important to help children elaborate their notions throughout the performance of observations within a disciplinary framework (Eberbach & Crowley, 2009). The addition of personal observations, games and emotions is also suggested to more strongly engage audiences in activities (Shwartz et al., 2012). Some studies have described the positive effects of other factors on learning, curiosity and participation, such as interacting with scientists (Karacam et al., 2021), adding ludic dynamics (Ambu-saidi & Balushi, 2009), being in a natural setting (Turkmen, 2010) or interacting with wild animals (Harvey et al., 2020). A few among them focus on scientists using stories (Suzuki et al., 2018), games (Illingworth, 2020), or outdoor activities (Shwartz et al., 2012) to interact with their audiences. The goal of this study was to answer the following research questions for an outdoor activity displaying live fish while scientists interact with families: First, does a scientific fishing activity improve children's knowledge about fish species living in

the river? Second, does the activity permit the redirection of initial misconceptions regarding fish morphology (such as anthropomorphic characteristics or incorrect position of fins) as well as the elaboration of more complete mental models? Third, does the inclusion of dynamics to the activity in addition to retaining the benefits stated in question 1 and 2, such as a scientific story or a didactic game, affect children's curiosity about fish and enhance their participation? A better understanding of these aspects serves the purpose of analysing the efficacy of a scientific fishing for the transmission of knowledge and the induction of curiosity in participants. Achieving these goals is required in order to inform and sensitize children about freshwater fish, a poorly known and highly jeopardized group of animals (Helfman et al., 2009). Other similar proposals might also benefit from the conclusions extracted from this experience.

Methods

For this study, an exploratory research design of the case-study type was employed (Yin, 1994). Two scientific fishing events in the Besòs river (one in 2016 and another in 2021) were analysed and contextualized. Both events consisted of showing the captured fish to the citizens and were designed as to provide the same type of interaction with the animals and the same scientific contents regarding fish morphology and biodiversity. Events had also in common the distribution of a pre- and a post- questionnaire (hereinafter, pre-test and post-test) aimed at measuring the improvements in fish biodiversity knowledge (naming of correct species) and the potential redirection of misconceptions and changes in mental models after the activity (through the elaboration of a drawing). What differentiates the events was that the first one consisted of a unique activity (displaying of the fish) while the second one included several consecutive dynamics (Figure 1). For this event, families were divided into two groups (A and B) that followed a distinct sequence of dynamics, permitting to compare curiosity and participation of children during fish observation depending on the type of the previous activity (no-activity, story or game). Anonymous monitorization and behavioural observations (Obs.1 and Obs.2) of children were only performed in this second event.

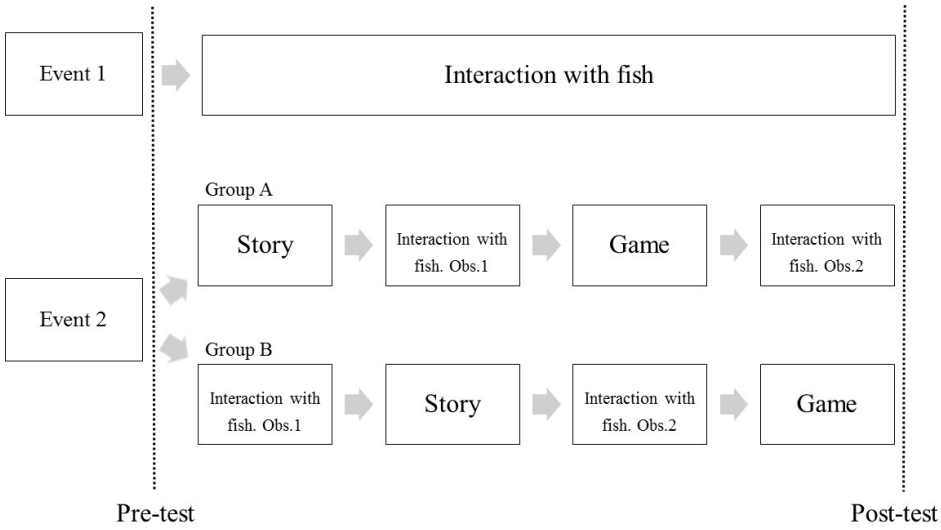

Fig.1 Sequence of actions for Event 1 and Event 2.

Participants

The target group in both fishing events was children 3-12 years-old (3-years-old were only considered for behavioural observations). The type of public that attended the activity corresponded to families. It is estimated that the number of attendants who went through the activity (considering the two events) was approximately 90 adults and 84 children. Despite the high number of attendants, only 28 children participated in the study (by completing the questionnaire before and after the activity) (Table 1). This small sample size obtained in both events was due to the open design of the session, as most families either just stood for a while and left before the end or joined in the middle of it.

Table 1 Participants' characterisation

Event	Children that participated in the activity	Age ± SD	Group division and number of children	Children Monitored
1	10	8.4 ±2.2	No division	No Observation
2	18	6.6 ± 2.2	A: 10 B: 8	A: 7 B: 7

Instruments

a. ***Questionnaires***

To assess the knowledge of the children about the fish species present in the river, as well as misconception redirection and mental model improvement, a questionnaire was completed before and after the execution of the activity. Each questionnaire consisted of a series of questions (from one to three) and a prompt for a drawing in an estimated time of 5-10 minutes. In the pre-test questionnaire, one question was asked: *Which fish species inhabit the Besòs river? Write down*

their names (open answer). In the next section corresponding to the drawing, they were asked to draw a fish in a small 5x8 cm box. The questionnaires were distributed in paper format accompanied by a pencil, a rubber and a plastic tablet to provide a surface of support. After the activity, in the post-test questionnaire, the same question as in the pretest questionnaire was formulated, and two more were added: *Did you like the activity?* (binary answer) and *Which aspects of the activity did you like the most?* (open answer). They were also asked to redraw a fish in a box identical to that of the first questionnaire. If the child was too young to read and answer the questionnaire, we asked the parents to complete it based on the answers of the child. Previously to their application, the questionnaires were assessed by three different experts in the fields of ichthyology, education science and human behaviour, with all raters considering the instrument as being suitable for the experiment. The final version was applied to a pilot sample of children (7 children with ages comprised between 4 and 12 years-old) and no comprehension or application difficulties were detected.

b. ***Drawings produced by the participants***

To analyse the knowledge and misconceptions expressed by the drawings, the criterion used by Lunde & Gregers (2021) was adapted. In our particular case, each category was defined as follows:

- Level 1: No drawing.
- Level 2: Non-representative drawing.
- Level 3: Drawing with misconceptions.
- Level 4: Simple partial drawings: The drawing is correct but incomplete. At least two of the following basic elements are missing: eyes, mouth, all the fins depicted in the right place, scales, rays and gills.
- Level 4.2: Complex partial drawings: The drawing is correct but incomplete. Only one of the basic elements described in Level 4 is missing.
- Level 5: Complete drawings: Drawings containing all the basic elements described in Level 4 are present.

In order to compare the fish mental models produced, we also noted whether there was an improvement in the representation of details between the first and the second drawing for each child; for example, if elements such as fins or barbels were added in the second drawing.

c. ***Behavioural observations***

In the second fishing event, the main objective was to study how different dynamics might affect children curiosity and participation. To do so, the following behaviours corresponding to the indicators adapted by Kibga et al. (2021) constituted the coding manual:

- Category a: Reacts positively to novel, mysterious or incongruous stimuli in the environment, approaching them, observing them, listening to them and manipulating them.
- Category b: Expresses the need or desire to know more through affirmations or questions.
- Category c: Examines the environment in search of new experiences.
- Distraction (additional parameter): Not paying attention to the activity.

The first observation lasted for 12 minutes, while the second was 15 minutes long. Observer 1 and 2 monitored different, selected children and recorded the predominant behaviour (Verver et al., 2020) for each of them for each minute of observation following a momentary time sampling (Schenkelberg et al., 2021). Other than the codes, these two observers transcribed children's oral interventions when interacting with the scientist (this limited the number of children they could follow to 3-4 per minute). Observer 3, on the other hand, served as a control, and noted only the behaviours of all the children. To ensure between-observer reliability, preliminary training observations were undertaken by the three observers after which a reliability test was done (K= 80 % according to Kappa's coefficient). After each observation, observer 1 and 2 compared their notes with the ones from observer 3. Few significant inconsistencies were detected in the codes and when they occurred, the final coding was decided based on consensus between the observers and the scientist performing the activity right at the end of the observations.

Context and procedures

The Besòs is an 18 Km-long river located in NE Spain. It used to be one of the most polluted rivers in Europe during the 1970's. From 1990 onwards, the implementation and enforcement of environmental laws improved the water quality (Mas-Ponce et al., 2021) favouring the return of numerous species such as macroinvertebrates, amphibians, reptiles, fish and mammals. The study was conducted in its lower stretch (transformed into an urban park), in Santa Coloma de Gramenet (Barcelona) and it was possible thanks to the collaboration between [This information has been removed from this version to preserve anonymity]. The fish fauna found in this section of the river consists of native species, such as the eel (*Anguilla anguilla*), the Catalan chub (*Squalius laietanus*), the Mediterranean barbel (*Barbus meridionalis*) and the striped mullet (*Mugil cephalus*), and non-native species, such as the carp (*Cyprinus carpio*), the eastern mosquitofish (*Gambusia holbrooki*) and the Iberian loach (*Cobitis paludica*).

The first fishing event was held on March 13th, 2016. That day, Catalan chubs, Mediterranean barbels, carps and red swamp crayfish were caught. This event consisted only in the fish interaction dynamic: four scientists presented the fish in a tent arranged on the riverbank and in which tables, aquariums and measuring devices were available. In this facility, the fish caught were classified by species, anaesthetized, measured and weighed. The data obtained were noted on a field sheet and were collected to monitor fish stocks for their management and conservation. While scientists did

their work, they provided explanations and answered citizens' questions. At the end, the fish were returned unharmed to the river in the presence of the public and with their collaboration. Pre-test and post-test questionnaires were distributed before and after the activity.

The second fishing event was held on May 9th, 2021. That day, eels, Catalan chubs, Mediterranean barbels, carps, Iberian loaches and red swamp crayfish were caught. In this case, before starting, participants were divided into groups A and B. The same pre-test questionnaire that was completed at the first fishing was distributed. Adhesive labels were handed out to the children for them to write a nickname on it and then stick them on their chests. This was intended to facilitate both the dialogue with the scientists (who also wore distinctive labels) and the anonymous identification of the children by the observers. During the day, both groups went through different dynamics: interaction with fish (two times), story and game. The interaction with fish dynamics consisted of gathering at the observation area, which was located inside the tent where a scientist showed the fish kept in aquariums to the participants and provided several explanations. At these instances, behavioural observations were performed. In this fishing event, there was only one scientist showing the fish to the families to facilitate a better control of the verbal interactions.

Story and game dynamics were conducted at the ludic area, consisting of a flat zone in which participants could sit on chairs that had been arranged before the start of the activity. The Story dynamic consisted of explaining a story about the journey of the eels from the Besòs river to the Sargasso Sea. This is an illustrated story written by the fishing team, and it has a solid scientific basis. For this dynamic, DIN A3 sheets were used with illustrations of the story, and a scientist, with the help of a microphone, was telling the story. Throughout the story, some questions were asked at certain times to encourage the participation of the children. The focus of the story was put on species biodiversity in the river. On the other hand, the game dynamic started by giving each child a piece of a puzzle with one body part of a fish (a carp) represented as a realistic illustration. The pieces had a magnet on the back, and throughout the game, the scientist explained the functions and characteristics of the different parts of the fish as a riddle; the child who thought he or she had the right piece had to get up and hook it on the magnetized board. The focus here was learning about fish morphology. At the end of the session the participants were reunited, and a post-test questionnaire was distributed.

Observations on children were non-invasive and non-interactive, and focused on public behaviour. Questionnaires were anonymous and did not contain sensitive information. The activity was designed to be done freely, and to enhance fun and enjoyment, so that participation did not induce any sort of psychological stress or anxiety. Due to these characteristics, the research proposal did not require to be submitted to an ethical review board. However, to ensure participants' full consent, parents, families and children were given oral and written information about the study before they gave written consent upon participation through the completion of the questionnaire. Parents and children were encouraged to ask questions about the study all through the activity and were free to withdraw at any time. There were no cases of rejection but in case it would have been so, no observation or questionnaire would have been done on that

subject. Regarding animal ethics, fish collection was approved by the Regional Government of Catalonia (Ref: AP/003 and AP/004). All procedures were conducted in accordance with the European Directive for animal experimentation (2010/63/EU).

Data analysis

To enable triangulation, data was obtained from different convergent sources (Cowie & Hipkins, 2014). Analysis of drawings was rounded out by children's comments. When children and their families delivered the questionnaires, the person collecting them asked to clarify any aspect of the drawing that was not clear and noted this in the margin. On the other hand, oral transcriptions and opinions collected in the post-test permitted to better understand children's behavioural observations. Data from questionnaires, drawings and behavioural observations were used to calculate frequencies. Open questions from the questionnaires and oral transcriptions were analysed qualitatively (Cohen et al., 2007) following a thematic approach that defined emerging categories (Patton, 2002).

Results

Which fish species live in the river: questionnaire analysis

Regarding the correct identification of species, the post-test indicated that the activity improved the knowledge of the Besòs fish fauna for almost all the children (93% of the children mentioned a higher number of correct species and no incorrect species appeared in the post-test as compared to the pre-test). For this reason, data from event 1 and event 2 were merged (Table 2).

Table 2. Correct Fish Species named in Pre-test and Post-Test

Number of correct species named in Pre-test (Mean ± SD)	Species named in Pre-test	Number of correct species named in Post-test (Mean ± SD)	Species named in Post-test
0.43 ± 0.63	Eel (correct)	2.54 ± 1.14	Eel (correct)
	Carp (correct)		Carp (correct)
	Salmon		Mediterranean barbel (correct)
	Monkfish		Iberian loach (correct)
	Sardine		Catalan chub (correct)
	Trout		
	Triton		
	Turtle		
	Tadpole		
	Whale		
	Dolphin		

Redirection of misconceptions and complexity of models: analysis of drawings

Among the 28 children who completed the questionnaire, 25 also accepted to make the drawings. Table 3 shows that, among them, 11 children made correct drawings both in the first and second try (Category 4 or 4.2), and 10 showed misconceptions in the first drawing (Category 3) such as incorrect placement of fins or representation of forehead eyes. Among the latter, half of them changed their misconceptions for a more realistic view in the second drawing. Data show that both events permitted misconception redirection.

Table 3 Evolution of the category of the drawings for each child in each fishing event; improvements are highlighted in bold.

Event	Child ID	Age and Gender (M/F)	Evolution of category between pre- and post-drawing	Correction (C) or error (E) in the post-drawing	Added in the post-drawing
1	5	5 M	**Goes from 2 to 3**	E: Draws a crayfish	
1	7	5 F	**Goes from 3 to 4**	C: Forehead eyes	Fn (2)
1	11	7 F	Remains at 4		
1	12	8 F	**Goes from 3 to 4**	C: Fin with scales	
1	17	9 F	Remains at 3	C: Fin with scales E: Incorrect fins	
1	19	9 M	Remains at 4		Fn (1)
1	20	9 M	Remains at 4.2		Ba
1	21	10 F	Remains at 4		
1	23	11 F	**Goes from 3 to 4**	C: Fin with scales	Fn (2), Rd
1	25	11 F	**Goes from 4 to 4.2**		Gll, Sc
2	1	4 M	Null		
2	2	4 M	Remains at 2		
2	3	4 F	Remains at 4		
2	4	4 M	Remains at 4		Fn (3)
2	6	5 M	Remains at 3	E: Wrong fins, forehead eyes	Ba, Fn (1)
2	8	6 M	Remains at 3	E: Forehead eyes	Fn (1)
2	9	6 F	Remains at 4		
2	10	7 F	Remains at 3	E: Fin with scales	Fn (4), Ba
2	13	8 F	**Goes from 3 to 4**	C: Fin shape	
2	14	8 M	Remains at 4		Ba
2	15	9 F	Goes from 4 to 3	E: Fin with scales	Ba, Sc
2	16	9 F	Remains at 3	E: Fin with	Fn (4)

				scales	
2	18	9 F	**Goes from 3 to 4**	C: Head with scales	Ba, Ps
2	22	10 F	Remains at 4		Ba, Op

Note: Event 1 (2016) and Event 2 (2021) are indicated in the 1st column. In the 5th column, *C* indicates Corrections and *E* indicates Errors made in the second drawing. In the 6th column, acronyms are used to indicate the fish body parts added in the second drawing: Fins (*Fn*) (the number refers to the number of new fins added), barbels (*Ba*), gills (*Gll*), scales (*Sc*), operculum (*Op*), pattern of spots (*Ps*) and rays (*Rd*).

The increase in detail was a phenomenon observed in both events; indeed, it was observed that for 56% of the children, the number of details depicted increased (Table 3, last column). Interestingly, the most common misconception under 7 years of age is drawing forehead eyes while, above this age, the most common mistake is drawing scales in places where they are not present (fins or head). Some drawings are shown in Figure 2.

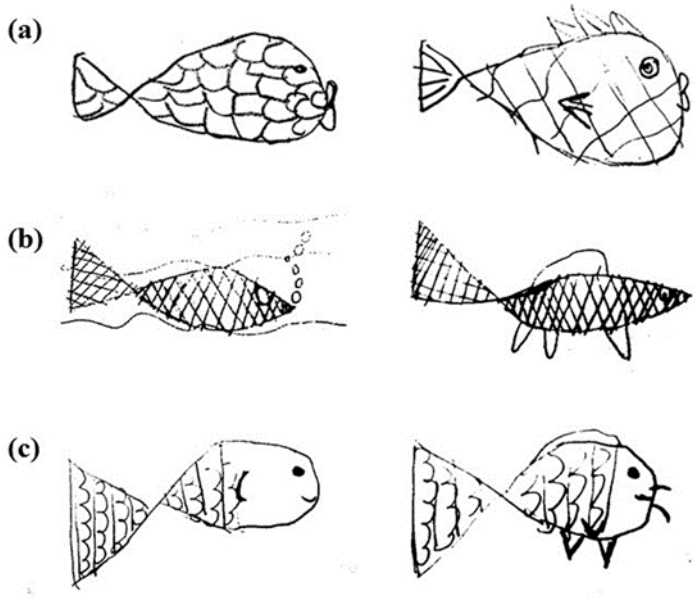

Fig.2 Drawings produced by three children in the first event. In (*a*), it is observed how children 23 corrects the error of the continuity of scales in the second drawing. In drawings (*b*) (children 16) and (*c*) (children 10), the erroneous conception of the continuity of the scales is maintained, but more details are added

Inclusion of Story/Game, effect on children curiosity and participation: behavioural observations and questionnaire analysis

Table 4 shows that *Category a* behaviours (observe, listen and touch) occurred in a higher proportion during the first observation than during the second in the second fishing event. However, it was observed that the children asked more questions and had more *searching* behaviours (they looked around in search of new experiences, for example, inspecting materials or empty containers) during the second observation than during the first. It should also be noted that during the second observation, more distraction was detected in most children (independent of age). It was observed that the children asked questions to the scientist and presented searching behaviours from 6 years old onwards. Small children (3-4 years old) were more static and stayed for long periods observing the aquaria from a very short distance.

Table 4 Results for each category of behaviour expressed as a proportion of the total time observed

		Observe, Listen and Touch (Cat. a)		Ask (Cat. b)		Search (Cat. c)		Distraction	
Child ID and group	**Age and Gender (M/F)**	**Obs.1**	**Obs.2**	**Obs.1**	**Obs.2**	**Obs.1**	**Obs.2**	**Obs.1**	**Obs.2**
1 (A)	4 M	50%	80%	-	-	-	-	50%	20%
26 (A)	4 F	100%	87%	-	-	-	-	-	13%
6 (A)	5 M	100%	93%	-	-	-	-	-	7%
9 (A)	6 F	92%	73%	-	-	-	7%	8%	20%
8 (A)	6 M	75%	13%	8%	13%	-	7%	17%	67%
13 (A)	8 F	100%	60%	-	7%	-	27%	-	7%
22 (A)	10 F	67%	73%	8%	7%	-	20%	25%	13%
27(B)	3 M	100%	60%	-	-	-	27%	8%	13%
2 (B)	4 M	83%	53%	-	-	-	27%	25%	20%
10 (B)	7 F	92%	67%	-	-	-	13%	8%	20%
14 (B)	8 M	100%	33%	-	27%	-	27%	-	13%
15 (B)	9 F	75%	67%	-	13%	-	20%	25%	-
16 (B)	9 F	100%	73%	-	-	-	13%	-	13%
18 (B)	9 F	100%	67%	-	13%	-	20%	-	-

Note: Data are presented for the first observation (*Obs.1*) and the second observation (*Obs.2*) for each child in each group (*A* and *B*). Behaviours are classified into Category a (*Cat.a*), Category b (*Cat.b*) and Category c (*Cat.c*) according to Lunde & Gregers, (2021).

The verbal interactions collected permitted to elucidate the effect of the previous activity on children curiosity and participation. After the analysis of the content of transcriptions, interventions could be classified in 4 categories: 1) interventions related to something observable, 2) interventions connected to something explained in the previous activity (story or game), 3) independent explanations or exclamations made by children, 4) independent questions made by children. In both groups (A and B), more verbal interactions were observed during the second observation than during the first one (Table 5). During the first observation of Group B, which was not preceded by any activity, there were no verbal interactions. Children listened and showed a shy attitude towards the scientist. During the first observation of Group A (after the story), there were only four interventions. For the second observation in both groups (A and B) a

similar number and typology of verbal interactions were observed. Diversity of fish was the topic that most interested the children after the story dynamic while morphology was the one that predominated in interventions after the game dynamic.

Table 5 Interventions classified by categories for each group (A and B)

Group	Obs.	Previous didactic activity	Number of interventions for each category	Example for each category
A	1	Story	Category 1(N=1)	*These fish have wounds*
			Category 2 (N=1)	*Carp comes from another country*
			Category 3 (N=0)	-
			Category 4 (N=2)	*How do they adapt to warm water?*
A	2	Game	Category 1(N=4)	*Why do you add more water?*
			Category 2 (N=5)	*Barbels are used to find food*
			Category 3 (N=1)	*Flies also can bite*
			Category 4 (N=1)	*Do this eel produce electricity?*
B	1	None	Category 1(N=0)	-
			Category 2 (N=0)	-
			Category 3 (N=0)	-
			Category 4 (N=0)	-
B	2	Story	Category 1(N=5)	*Why are they moving their cheeks?*
			Category 2 (N=4)	*Small fish must be somewhere else because it is not reproductive time*
			Category 3 (N=2)	*I want to see crabs!*
			Category 4 (N=5)	*Are there Betta fish in the river?*

Note: *A* and *B* indicates the group to which the children belonged. *Obs.* indicates the number of observation (first or second). Intervention categories were: *Category 1:* interventions related to observations, *Category 2:* interventions connected to the previous activity, *Category 3:* independent explanations or exclamations, *Category 4:* independent questions.

Concerning the post-test questionnaire, all participants expressed that they liked the activity. The most prominent positive aspect was, according to the children in both events, the ability to observe live animals closely. For children from event 2, the next most valued aspect was the didactic activities. The aspects that the children reported having learned thanks to the activity (in both cases) were, in order of importance, knowing the species of fish and morphological aspects of the fish. These opinions were useful to complete observations in order to better understand curiosity.

Discussion

The questionnaires used in this study allowed us to detect that the scientific fishing activity in both events improved the knowledge of the children regarding the number of species recalled. In the pre-test questionnaire only carp and eel accounted for correct fish species. This might be due to carps being easy to spot from the shore on the one hand, and

because eels are being the focus of several conservation campaigns in the area, on the other. Results indicate that this fishing activity permits to expand the knowledge about fish biodiversity (adding species such as the Mediterranean barbel, Iberian loach and Catalan chub) and redirects some misconceptions, since in the second questionnaire no marine fish or non-fish species are mentioned. Regarding misconceptions related to fish morphology, in both events there were children who improved some mistakes in their drawings such as forehead eyes and scales on fins. This change in the model produced by observation is in accordance with previous literature (Gómez Llombart & Gavidia Catalán, 2015). Furthermore, in both events there is an improvement in the picking up of details in many drawings. This seems to be a positive outcome since it is suggested by some authors that a progression from simpler drawings to more complex ones can be observed as the child learns more about what he or she is drawing (Glynn, 1997). Our main results show an association of certain misconceptions with the cognitive development of children. Small children's difficulties are based on the generalisation of swimming animals and the representation of anthropomorphic traits. On the other hand, in older children the main problems are due to the resistance to change their misconceptions and the confusion between fish and reptiles. In table 6 our results are aligned with those of other studies that explain such phenomena.

Table 6 Comparison between the findings of this research and previous findings

Age group	Findings in this research	Findings in previous works
4-6	- Most 4 year-old children were able to depict simple but correct shapes. However, confusing other animals with fish only was present in a 5 year-old child.	- Small children (three to four years old) can identify and describe an object when adjusting to an archetypal shape. Five-year-olds, on the contrary, are more prone to overgeneralize their fish concept and include non-fish animals (Allen, 2015).
	- The antropomorphic characteristic of two forehead eyes was found in children up to 5 years old.	- Books that anthropomorphize animals can affect up to 5 years-old children's conceptions of animals (Ganea et al., 2014).
7-12	- It seems that misconceptions are more difficult to change in older children (7-9 years) than in younger children (5-6 years)	- Children aged 6-7 base their interpretations on direct observation and experiences, while older children try to combine intuitive knowledge with that they have been actively taught, making them particularly resistant to modifying their misconceptions (Thompson & Logue, 2006)
	- Most frequent misconception was to draw scales on fins.	- Some children do not make a clear differentiation between fish and reptiles (Chen & Ku, 1998).

Our third objective was to ascertain if adding games and storytelling could improve curiosity and participation. In terms of curiosity, during the first observation children seemed to be much more predisposed to observation and listening than during the second observation, when behaviours were more focused on search and oral interventions. This shift can be attributed to a natural process, as when exposed to a new object, the primary behaviour of the child is to

observe, while other, more active behaviours appear later (Śniegulska & Pisula, 2013). Some behaviours were characteristic of certain ages, with children around 3-4 years being more static and less explorative and children above 6 years being more prone to ask questions. The results of our study reveal that ludic activities seemed to precede an increase in oral interventions. Ludic activities could have served as elements that broke the ice, thus facilitating dialogue. In fact, during the first observation, there were no interventions in one group, while there were few in the other. It is known that children are inhibited by people they do not know (Asendorpf, 1990), and the scientists could have intimidated them at first contact. These findings support previous studies indicating that interactions that occur when telling a story (Rotenberg et al., 2003) or sharing a game (Kovačević & Opić, 2014) can increase children's confidence. The children's interventions might have been influenced by the type of previous activity, with more interventions related to morphology after the puzzle and more interventions related to fish diversity after the story. According to Werbach (2013), games are a perfect way to increase the motivation provided by an activity, stimulating people to become engaged and prone to make efforts. Sauvé et al. (2007) linked games to an increase in critical thinking, communication and social interactions. In our study both stories and games stimulated in a similar way children's curiosity and participation, and this might be so because both were designed to be very interactive so that they stimulated thinking through questions. Our findings are in line with those of previous works that support the leading position of scientists as science mediators for learning in outdoor settings (Shwartz et al., 2012) and the use of ludic dynamics to facilitate the interaction between them and the audience (Illingworth, 2020).

To conclude, we would like to point out that this study highlights the importance of designing outdoor educative experiences that incorporate both the observation of live animals and didactic activities such as stories and games to enhance learning and curiosity. Favouring the understanding of the environment is a key factor that leads to sensitization and to higher levels of environmental responsibility (Slavoljub et al., 2015). As limitations, we recognize that our sample size was small and with a tiny representation for each age group. As such, it is possible that we did not identify the whole real complexity behind children understanding. Our results suggest that additional in-depth studies with a greater scope are necessary to compare learning outcomes for each type of dynamics and to investigate how the time exposed to the animals might have an impact on children. Although the proposed design succeeded on the redirection of misconceptions and improved the fish models for some children, how to design and improve scaffolding for each age is a question to be addressed in future research.

Conclusion

The main findings of this research suggest that (1) Thanks to the scientific fishing activity, children increased the mention of correct species inhabiting the river and decreased the naming of incorrect ones such as sea fish or non-fish,

(2) This activity permitted to redirect misconceptions and more complete models were produced by some of the children concerning fish external morphology. Although this is a good outcome, the proposal must be improved to reach those children that present more difficulties, and (3) Adding dynamics such as a story or a game to the activity improves children curiosity and participation.

Statements and declarations

Conflict of Interest: The authors have no conflicts of interest to disclose.

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