# Let's Learn Biodiversity with a Virtual "Robot"?

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**Abstract.** As climate change and biodiversity loss are threatening the natural world's equilibrium and survival, people's concerns about these topics have increased significantly. The work presented in this paper lies at the cross-section between the areas of education, biodiversity and technologies. More specifically, this project builds on research in virtual agents in educational settings to promote young children's engagement with a biodiversity curriculum. In this context, we conducted an observational study with 105 primary school's children with the goal of evaluating the effectiveness of a virtual robotic agent (presented through a multimedia application), in providing an effective and engaging learning experience about local biodiversity to children. Our results suggested that a) older children (8 to 10 years) knowledge about certain animals and plants from their local biodiversity is well matured; b) younger children (6 to 7 years) present more faithful conceptualisations about nature-related scenarios compared to older children and c) both young and older children exhibited a preference for nature-related scenarios when compared to human-made ones. Our findings provide useful information in favour of the usefulness of implementing user-adaptive learning systems, by considering factors like the children's previous level of knowledge. Besides, this personalised and interactive type of system might provide

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an essential advantage in learning scenarios, compared to "static" systems, in enhancing children's learning outcomes.

**Keywords:** Biodiversity · Virtual robot · Learning

## 1 Introduction

The next decade is likely to witness a considerable rise in awareness of biodiversity. Climate change, continuing deforestation and large-scale fires are some of the current threats posed to the conservation of biodiversity. Efforts to educate and raise awareness to this problem in young children are an important strategy to prevent biodiversity's further decline [21,25]. Madeira island has a large diversity of flora and endemic species, being considered one of the biodiversity hot-spots of the Mediterranean region [3,18]. However, its ecosystem is exposed to several threats and it needs *in situ* and *ex situ* conservation efforts.

In this context, educating the next generation about local wildlife and the importance of its' conservation in maintaining a biodiversity equilibrium is fundamental. In particular, research has suggested that indirect experiences are important in shaping children's perception of nature and may influence attitudes towards conservation [6]. Research also shown that in order to empower and motivate learners to engage in this topic, a learner-centre pedagogy approach is preferred [11,13]. Thus, children prior knowledge and experiences about their local biodiversity are the starting point for stimulating the learning process.

More recently, researchers have also been studying the effectiveness of the combination of different pedagogical approaches with the use of new technologies and virtual agents. The agents can be used as teachable agents, tutors, peer learners or just as simple social characters [5,10,12,23,27]. They have been shown to be useful tools that can aid children to develop and improve language and reading skills, handwriting and in increasing children's feelings of persistence and enjoyment during learning activities.

In the specific context of biodiversity education, virtual agents have also been shown to be useful tools in biodiversity management and conservation efforts [26], biodiversity education [4,8], and for raising awareness about the importance of biodiversity preservation [14,15,22].

In this paper, we sought to extend previous findings about the effectiveness of educational virtual agents in the area of biodiversity education, by proposing and evaluating a new application involving a virtual version of the *Pepper* robot. Our findings show that this application was successful at providing an engaging learning experience to young children and underlines the need for future work to further explore the role of children's individual characteristics (such as previous knowledge) in the development of similar educational applications.

## 2 Goals and Hypotheses

The goal of this project was to understand how children's previous knowledge about local biodiversity had an effect in their conceptualisations of local biodi-

versity with the help of a Virtual Agent-driven application. More specifically, we analysed the children's existing knowledge about biodiversity (as indicated by their school year) by measuring their ability to a) correctly identify local biodiversity elements (thorough the app) and b) create complex conceptualisations of local biodiversity (as measured by the complexity of their drawings about biodiversity scenarios, see Sect. 3.3), after interacting with a digital app.

To achieve this goal, we made an observational study with children enrolled in primary education. In this context, we devised the following hypotheses:

- **H1** - Children with some existing knowledge about local biodiversity ($3^{rd}$ and $4^{th}$ school years) will be able to correctly identify elements of local diversity more frequently when compared with younger children with less or no knowledge about biodiversity ($1^{st}$ and $2^{nd}$ school years).
- **H2** - Younger children will exhibit more misconceptions about local wildlife when compared to children with some existing knowledge.
- **H3** - Children will prioritise representations of nature-like scenarios compared with man-made representations.
- **H4** - Children will prioritise representations of local biodiversity elements when compared to non-local biodiversity elements.

# 3 Method

## 3.1 Sample

One hundred and five children enrolled in primary education participated in our experiment. Of these, 56 were male and 49 were female, (29 from $1^{st}$ school year; 25 from $2^{nd}$ year; 26 from $3^{rd}$ year and 25 from $4^{th}$ year), aged between 6 and 10 years old.

## 3.2 Procedure

Data collection for this experiment took place during the course of one week, at a public school during the regular daily class schedule. Informed consents were obtained from the parents prior to the beginning of the experiment. Approvals from the university Ethical Commission and the Ministry of Education were also granted before the start of the study. Participants were told that they would be interacting with a virtual robot that needed assistance in order to identify biodiversity elements that exist in Madeira island.

Students interacted with the application previously installed in the school computers (see Fig. 1) and filled out a questionnaire about their engagement with the app. The experiment took approximately 20 min.

**Fig. 1.** Children setup during the study.

### 3.3 Application

A Unity application, which included a free 3D model of Pepper robot[1], was developed. The virtual robot played the role of narrator and storyteller during children's interaction with the application. All scenes were narrated using the Unity plugin RT-Voice PRO[2], since we assumed that not all children would have sufficiently good reading skills. After children finished their drawing task (more details below), the virtual robot also played the role of storyteller (not analysed in the scope of this paper) by telling each children a personalised tale involving their drawings.

Together with the narration, we also included subtitles and visual cues to enhance clarity. The visual cues were implemented through (a) the virtual robot and (b) through the use of pictures of the local biodiversity elements being mentioned throughout children's interaction with the application.

The visual cues in the virtual robot were implemented using the Mixamo platform[3] with its free animations. Our target animations (idle, pointing, waving, thoughtful, acknowledging, happy hand gesture, excited, nodding, disappointed, happy and angry) were used to create a more interactive, life-like agent. The pictures used were collected through a photography contest set up for local participants of all ages and from the Global Biodiversity Information Facility[4] (GBIF) database. The photography contest was disseminated using social media

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1 Pepper robot from SoftBank, available in https://www.softbank.jp/robot/pepper/. Accessed: Jan-15-20.

2 RT-Voice PRO available https://www.crosstales.com. Accessed: Jan-15-20.

3 Mixamo platform for the animation of 3D characters available at https://www.mixamo.com/. Accessed: Jan-15-20.

4 "*GBIF—the Global Biodiversity Information Facility—is an international network and research infrastructure funded by the world's governments and aimed at providing*

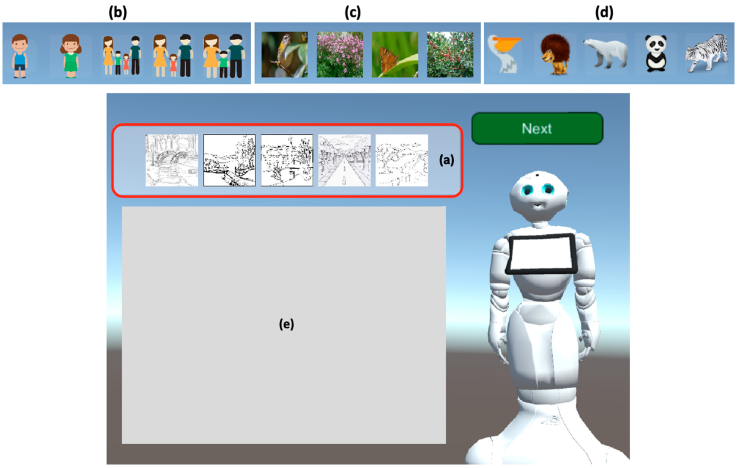


**Fig. 2.** Drawing stages composition, (a) scenarios, (b) characters, (c) animals and plants seen in app, (d) animals that do not belong to local biodiversity and (e) drawing area.

during one month, and participants were asked to submit images that captured the local biodiversity of Madeira island. They had to submit original photographs of elements of wildlife, taken by themselves, and allow its use in the application. Data regarding the names of the biodiversity elements, groups and characteristics were validated by a team of specialists from Funchal Natural History Museum and biodiversity books [2,3,24].

The interaction with the application begins with *Pepper* introducing itself and requesting children's help to learn more about the local biodiversity. Next, *Pepper* asks children to introduce themselves by typing their name and select their gender using the boy and girl icon available. After the introductions are finished, four different pictures of animals and plants, starting with a bird, followed by a flower, an invertebrate and finally a tree were shown to children. For each animal and plant, children were asked (a) if they know the animal or plant presented in the picture, (b) if they know the group that animal or plant belongs to and (c) if they know what are their characteristics (see [7] for more details on the characteristics for each element).

If children answer yes to the first question, they are then asked to indicate the common name of the shown animal or plant choosing from a group of four options; if they answered no, the virtual robot would tell them the plant or animals' common name. For the second question, children were asked to choose to which group the identified animal or plant belonged to. Children had to choose from a list of eight options (Amphibians, Birds, Fish, Fungi, Invertebrates, Mammals, Plants, and Reptiles). Each one of the 8 groups was represented by an

*anyone, anywhere, open access to data about all types of life on Earth."* available at http://www.gbif.pt/?language=en. Accessed: Jan-15-20.

icon that the children would visually recognise, without the voice over narration of the robot. The same icon representation was used to illustrate the element characteristics. It should be noted that each element (animal or plant) has its own specific qualities. Before moving to the next stage, pictures of all four elements that children had seen up to this point, was presented to them along with their correct common names (see [7] for more details on the flow of the app).

**Drawings.** After completing the first stage of the experiment, children were requested to create a small story, in the form of a drawing. The request was formulated by the virtual agent *Pepper*, who wanted to show the drawing to its' own friends later on. The drawing activity of the children's was split into four stages. First children were requested to choose and drag their selection into the drawing area, see Fig. 2(e). This first element corresponded to the scenario of their story, and they could choose one from five possible options (see Fig. 2(a)), three nature-related scenarios and two with a city and road background.

Secondly, children were requested to drag one or more characters, see Fig. 2(b), (c) and (d), into their scenario. These characters could be human (little boy, little girl and three families), animals and plants (the four elements they saw during their interaction with the application) and five elements that did not belong to the local biodiversity.

After children selected all the elements, a small storytelling activity[5] was generated using that information.

**Fig. 3.** Full drawing classification on the left with light blue representing Air areas (sky and clouds); dark blue representing Water; brown representing Ground (paths and ground areas); and green Nature (trees, bushes and flowers). On the right, detail of the markers for each element, green squares surrounded by red are corners identification and the dark blue square the middle bottom point (the place where feet, paws, trunk/roots and stem might be). (Color figure online)

[5] All the data regarding the storytelling activity is outside of the scope of this paper.

**Questionnaires.** Finally, a short questionnaire (five questions) was presented to children after they finished interacting with the application, and completed the drawing. The survey was displayed in the application, in text and simultaneously narrated by *Pepper*. Children used an emoticon scale [20] to provide their answers and were informed about the faces' meaning before answering.

Children were questioned if they liked *Pepper*; if they liked the application used; if they enjoyed creating the drawing; if they liked the story created with their drawing and if they understood *Pepper*'s speech throughout the app.

## 4 Data Analysis

### 4.1 Misconceptions Classification

From a pilot study in which we asked children to depict a story including the animals and plants they saw in the application (same as the ones in this study), we found that children often exhibited several misconceptions about the local wildlife. These misconceptions were evident through their depiction of these elements (e.g., placing ground-based elements, like snails, flying in the air).

In the context of this study, children' drawings were analysed based on the position of the biodiversity elements in the scenario they chose. For each scenario, five areas were created according to the background present (Air, Water, Ground, Nature and Buildings; see Fig. 3 left). The classification of the position of each element was calculated based on the location of the bottom middle point of each element (see Fig. 3 right). By using the bottom middle point, usually correspondent to the position of the feet, paws or base of each biodiversity element, we can guarantee that each item can only be identified as overlapping with one background scenario area. By comparing this information to the correct information about each biodiversity element's usual locations, we can classify whether each element was placed in the correct location. For example, regarding the snail example mentioned above, we know that snails can not fly; so when a child places the snail in the air, we considered that a misconception regarding the location of this animal. This process was applied for all elements present in the drawing and the information recorded.

### 4.2 Categorisation of the Level of Knowledge

We computed the knowledge level of all children based on their answers for the four elements seen on the app, see Eq. 3. We had into consideration their knowledge about the names of the elements (EK) and the group they belonged to (GK), the number of characteristics selected (TCS), see Eq. 1, and the number of features they selected for each biodiversity element: food(CF), location(CL), physical(CPF), need for life(CNL), and all features (CAll), see Eq. 2. Plus we also consider the maximum number of features each element seen could have and that for each four elements they had to identify three things (name, group and features).

$$ElementsInfo = \sum_{1}^{4} [EK(i) + GK(i) + TCS(i)] \quad (1)$$

$$Feature = \sum_{1}^{4} [CF(i) + CL(i) + CPF(i) + CNL(i) + CAll(i)] \quad (2)$$

$$KnowledgeLevel = \frac{ElementsInfo + Features}{\sum_{1}^{4} [MaxFeatures(i)] + 12} \quad (3)$$

A Cluster Analyses was applied to Knowledge level variable (Eq. 3) using a *Hierarchical cluster* with a single solution of three groups. We used the *Interval - Square Euclidean Distance* for the cluster measure and the *between-groups linkage* for the cluster method. Our results grouped our data into the following categories of Knowledge: **Low** with values between $[.20 - .31]$; **Medium** with values between $[.33 - .54]$ and **High** with values between $[.55 - .85]$.

### 4.3 Data Analysis Strategy

The data was analysed using SPSS software (v. 26). H1 and H2 were tested using one-way ANOVA, whereas H3 was tested by performing a $\chi^2$ test of independence and H4 was tested using one-way MANOVA. Post-hoc analysis were conducted using the Tukey test. Regarding the assumptions for the tests conducted, we found that the distribution of the level knowledge according to the school year did not conform to the normal distribution ($p < .001$); however, given that both the skewness and kurtosis values were contained between $-1$ and 1 (.13 and $-.47$, respectively), in which conditions has been shown that the F test remains robust (thus controlling for Type 1 Error within the bounds of Bradley's criterion) [17]; and considering that a sufficient sample size tends to minimise this disparity [9], we opted to conduct the comparisons using parametric methods. In addition, although we will use the conventional alpha value of .05, we also calculated a Dunn-Sidak's adjustment to the p-value in order to correct for multiple comparisons and provide a more conservative standard for interpretation of results, which yielded an ideal alpha value of approximately 0.

### 4.4 Results

**H1 - Children's Previous Knowledge.** We found a main effect of children's level of knowledge in their ability to correctly identify biodiversity elements ($F(3, 94) = 5.489, p = .002$). In particular, we observed that children from $4^{th}$ ($.54 \pm .12, p = .001$) and $3^{rd}$ ($.49 \pm .15, p = .043$) years were able to identify more elements correctly than children from the $1^{st}$ year ($.39 \pm .13$). We found no difference between the $1^{st}$ and $2^{nd}$ years ($p = .063$); $2^{nd}$ and $3^{rd}$ ($p = 1$); $2^{nd}$ and $4^{th}$ ($p = .47$) and $3^{rd}$, and $4^{th}$ ($p = .52$) school years.

**H2 - Children misconceptions on drawings.** We found a main effect of children's previous knowledge on the number of misconceptions represented by children in the drawing task ($F(3, 101) = 8.151, p = .0$). In particular, the number of misconceptions was significantly lower for $1^{st}$ ($1.69 \pm 1.75, p = .007$), $2^{nd}$ ($.88 \pm .73, p = .0$) and $3^{rd}$ ($1.46 \pm 1.45, p = .002$) years when compared to $4^{th}$ year ($3.44 \pm 3.07, p = .007$). No differences were observed between the $1^{st}$ and $2^{nd}$ ($p = .421$); $1^{st}$ and $3^{rd}$ (p=.972); and $2^{nd}$ and $3^{rd}$ (p=.706) school years.

**H3 - Children scenario preferences.** We found a relation between children's previous level of knowledge and their choice of scenario for the story ($\chi^2$ ($3\ N = 105) = 7.85; p = .049$). Overall, children demonstrated a preference towards nature-based scenarios ($n = 17, 22, 22, 18$ for $1^{st}$ to $4^{th}$ years respectively), when compared to the human-made ones ($n = 12, 3, 4, 7$ for $1^{st}$ to $4^{th}$ years, respectively).

**H4 - Children selection preferences regarding animals.** Our results revealed that there was a main effect of children's previous level of knowledge in their choices related to the inclusion of wildlife elements in their drawings ($F(6, 200) = 6.31, p = 0$; Wilk's $\Lambda = .71$, partial $\eta^2 = .16$); but only regarding their inclusion of non-local biodiversity elements ($F(3, 101) = 12.82; p = 0$; partial $\eta^2 = .28$) and not on the selection of local biodiversity elements ($F(3, 57) = .63; p = .6$; partial $\eta^2 = .01$).

The mean scores for non-biodiversity elements were statistically significantly different between $1^{st}$ and $2^{nd}$ school years ($p < .001$), $1^{st}$ and $3^{rd}$ school years ($p < .001$) and $1^{st}$ and $4^{th}$ school years ($p < .001$), but not between $2^{nd}$ and $3^{rd}$ school years ($p = .95$), $2^{nd}$ and $4^{th}$ school years ($p = .91$) and $3^{rd}$ and $4^{th}$ school years ($p = .63$). Regarding the mean scores for the local biodiversity elements, those did not present statistically significantly differences among each school year ($p > .05$ for all cases).

Our data reveals that most of children choices regarding the total number of non-biodiversity elements varied across a total of 1 and 2 elements. On the $1^{st}$ year, majority of children picked a total of 5 elements ($n = 20$) from non-biodiversity options. Children on the $2^{nd}$ year preferred a total of 1, 2 and 3 elements as their main choices ($n = 19$). Plus, the $3^{rd}$ year students elected a total of 1, 2 and 5 elements ($n = 21$) on their drawings. Finally, the majority of children on $4^{th}$ school year ($n = 20$) selected a total of 1, 2 and 3 elements from non-biodiversity options into their drawings.

**User Subjective Evaluations.** The overall feedback provided by children through the questionnaire was very positive. 91.4% of the children reported liking *Pepper* and enjoyed the interaction a lot. The remaining children either reported merely liking *Pepper* (8.6%) and the application (7.6%) or not liking the application (1%). When questioned about the drawing activity, the majority (88.6%) reported enjoying the activity a lot, whereas the remaining children reported medium (9.5%) or neutral levels of enjoyment (1.9%). Regarding their comprehension of *Pepper* speech, three children reported having some issues,

with these children reporting poor levels of comprehension. However, the majority (9.5% ($n$ = 10), 14.3% ($n$ = 15) and 73% ($n$ = 77)) reported not having issues understanding *Pepper*'s speech (neutral, good and very good understanding respectively).

## 5 Discussion

In this study, we sought to characterise children's knowledge and illustrations of biodiversity elements during a task related to biodiversity identification. Plus, from the four hypotheses, we proposed to analyse, we partially validated H1, validated H3 and H4, but did not validate H2.

We hypothesised that children level of previous knowledge would have an impact on children ability to identify elements of local biodiversity correctly. In particular, older children would get more elements than younger ones. Our analysis revealed some differences among children of the $4^{th}$ and $1^{st}$school year and $3^{rd}$ and $1^{st}$, but not among $2^{nd}$ and the remaining years.

Our expectations regarding misplacement elements on the drawings revealed to be opposite of what we anticipated. We did not foresee that children with a higher level of knowledge would place more elements in wrong areas. Could this fact be related to children's organisation of elements according to their beliefs and understanding about theme (biodiversity environment) [1]? Alternatively, this phenomenon can be related to our scenarios being displayed at black and white and not fully coloured. There is the possibility that the lack of colour lead to children failure to recognise certain areas. For instance, in the scenario with a fence and a small stream, children might have though of the stream area as being a trail delimitation. Further work needs to be done in order to asses if this issue is related with children idealisations; the scenarios we presented (black and white vs colourful) or if children were just disengaged in the drawing activity.

Children preferences regarding scenarios were congruent with our H3. Most children chose scenarios related to nature instead of scenarios that included human-made structures. Despite that, the first-year students almost matched the number of choices between the two types of scenarios (nature - 17 and human-made - 12) when compared to the remaining school years. This could indicate that younger children are more used to see animals and plants in their surroundings (city areas) than in their natural habitat. Concerning the other school years, the difference between the two types of scenarios was much higher, 17 to 22 children choose nature-related options and 3 to 7 children human-made ones (among school years).

Our results suggested that children choices regarding animals that do not belong to local biodiversity were aligned to our expectations (H4). Children preferences for non-biodiversity elements ranged among 1 and 2 elements for children of the $2^{nd}$, $3^{rd}$ and $4^{th}$ years. While the majority of children on the $1^{st}$ year (n = 20 out of 29) actually demonstrated preferences for selecting all five elements (bear, tiger, panda, toucan and lion) that were out of local biodiversity. This outcome is not surprising; since most of young children at this stage (age of 6 to 7) still have an immature reasoning [19].

## 6 Conclusions and Future Work

Our main aim with this project is research on how virtual agents (and social robots) can promote young children's engagement with biodiversity issues and facilitate learning about this fascinating topic. Furthermore, we believe that learning about biodiversity needs grounding in local knowledge, situations, environment and stories. The findings here reported provide us information that such localisation is of paramount importance, and that individual differences must be taken into account. To further our efforts to achieve this goal, in the future we intend to use the data collected using this virtual agent and robot, to develop an educational adaptive system [16]. Such adaptive learning system will use an intelligent agent and in particular a physical robot (Pepper) to deliver customised information, tailored to the user's abilities, cognitive skills, and knowledge. We believe that our results so far will help us in the future create and train a model capable of adjusting to children individual needs. At the same time that we take advantage of the growing amount of evidence in favour of the benefits and potentialities that Human-computer interaction and Human-Robot interaction can have in the education of children [4,5,14,27].

## References

1. Anning, A., Ring, K.: Making Sense of Children's Drawings. Open University Press, Maidenhead (2004)
2. Biscoito, M., Zino, F.: Aves do Arquipélago da Madeira. Secretaria Regional do Ambiente e dos Recursos Naturais - Direção Regional do Ambiente, biodiversidade madeirense: avaliação e conservação edn (2002)
3. Borges, P.A.V., et al.: Listagem dos fungos, flora e fauna terrestres dos arquipélagos da Madeira e Selvagens = A list of the terrestrial fungi, flora and fauna of Madeira and Selvagens archipelagos. Secretaria Regional do Ambiente e dos Recursos Naturais do Governo Regional da Madeira (2008). https://repositorio.uac.pt/handle/10400.3/1955
4. Briot, J.P., et al.: A serious game and artificial agents to support intercultural participatory management of protected areas for biodiversity conservation and social inclusion. In: 2011 Second International Conference on Culture and Computing, pp. 15–20. IEEE (2011)
5. Chandra, S., Dillenbourg, P., Paiva, A.: Classification of children's handwriting errors for the design of an educational co-writer robotic peer. In: Proceedings of the 2017 Conference on Interaction Design and Children - IDC 2017, pp. 215–225. ACM Press, New York (2017). https://doi.org/10.1145/3078072.3079750. http://dl.acm.org/citation.cfm?doid=3078072.3079750
6. Duerden, M.D., Witt, P.A.: The impact of direct and indirect experiences on the development of environmental knowledge, attitudes, and behavior. J. Environ. Psychol. **30**(4), 379–392 (2010)
7. Ferreira, M.J., Oliveira, R.A.: Let's learn biodiversity with a virtual robot? August 2020. osf.io/9vk76
8. Ferreira, M.J., Nisi, V., Melo, F., Paiva, A.: Learning and teaching biodiversity through a storyteller robot. In: Nunes, N., Oakley, I., Nisi, V. (eds.) ICIDS 2017. LNCS, vol. 10690, pp. 367–371. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-71027-3_45

9. Hecke, T.V.: Power study of anova versus Kruskal-Wallis test. J. Stat. Manag. Syst. **15**(2–3), 241–247 (2012)
10. Hood, D., Lemaignan, S., Dillenbourg, P.: The cowriter project: teaching a robot how to write. In: Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts, pp. 269–269. ACM (2015)
11. Kasanda, C., Lubben, F., Gaoseb, N., Kandjeo-Marenga, U., Kapenda, H., Campbell, B.: The role of everyday contexts in learner-centred teaching: the practice in Namibian secondary schools. Int. J. Sci. Educ. **27**(15), 1805–1823 (2005)
12. Le Denmat, P., Gargot, T., Chetouani, M., Archambault, D., Cohen, D., Anzalone, S.M.: The CoWriter robot: improving attention in a learning-by-teaching setup. In: AIRO@ AI*IA, pp. 51–55 (2018)
13. Leicht, A., Heiss, J., Byun, W.J.: Issues and Trends in Education for Sustainable Development, vol. 5. UNESCO Publishing, Paris (2018)
14. Loureiro, P., Prandi, C., Nunes, N., Nisi, V.: Citizen science and game with a purpose to foster biodiversity awareness and bioacoustic data validation. In: Brooks, A.L., Brooks, E., Sylla, C. (eds.) ArtsIT/DLI -2018. LNICST, vol. 265, pp. 245–255. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-06134-0_29
15. Mathevet, R., et al.: BUTORSTAR: a role-playing game for collective awareness of wise reedbed use. Simul. Gaming **38**(2), 233–262 (2007)
16. Mehlmann, G., Häring, M., Bühling, R., Wißner, M., André, E.: Multiple agent roles in an adaptive virtual classroom environment. In: Allbeck, J., Badler, N., Bickmore, T., Pelachaud, C., Safonova, A. (eds.) IVA 2010. LNCS (LNAI), vol. 6356, pp. 250–256. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-15892-6_26
17. Mena, B., José, M., Alarcón, R., Arnau Gras, J., Bono Cabré, R., Bendayan, R.: Non-normal data: is ANOVA still a valid option? Psicothema **29**(4), 552–557 (2017)
18. Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A., Kent, J.: Biodiversity hotspots for conservation priorities. Nature **403**(6772), 853 (2000)
19. Piaget, J.: Piaget's theory. In: Inhelder, B., Chipman, H.H., Zwingmann, C. (eds.) Piaget and His School. SSE, pp. 11–23. Springer, Heidelberg (1976). https://doi.org/10.1007/978-3-642-46323-5_2
20. Read, J., Macfarlane, S., Casey, C.: Endurability, engagement and expectations: measuring children's fun. In: Interaction Design and Children, pp. 1–23. Shaker Publishing, Eindhoven (2002). https://www.researchgate.net/publication/228870976
21. Saito, C.H.: Environmental education and biodiversity concern: beyond the ecological literacy. Am. J. Agric. Biol. Sci. **8**(1), 12 (2013)
22. Sébastien, D., Conruyt, N., Courdier, R., Tanzi, T.: Generating virtual worlds from biodiversity information systems: requirements, general process and typology of the metaverse's models. In: 2009 Fourth International Conference on Internet and Web Applications and Services, pp. 549–554. IEEE (2009)
23. Sjödén, B., Lind, M., Silvervarg, A.: Can a teachable agent influence how students respond to competition in an educational game? In: André, E., Baker, R., Hu, X., Rodrigo, M.M.T., du Boulay, B. (eds.) AIED 2017. LNCS (LNAI), vol. 10331, pp. 347–358. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-61425-0_29
24. Teixeira, D., Abreu, C.: Moluscos Terrestres da Ponta de São Lourenço e Ilhéus Adjacentes. Secretaria Regional do Ambiente e dos Recursos Naturais - Direção Regional do Ambiente, biodiversidade madeirense: avaliação e conservação edn (2003). http://tiny.cc/MoluscosBook

25. Vane-Wright, R., Coppock, J.: Planetary awareness, worldviews and the conservation of biodiversity. In: The Coming Transformation. Values to Sustain Human and Natural Communities, pp. 353–382. Yale School of Forestry & Environmental Studies, New Haven (2009)
26. Vasconcelos, E., et al.: A serious game for exploring and training in participatory management of national parks for biodiversity conservation: design and experience. In: 2009 VIII Brazilian Symposium on Games and Digital Entertainment, pp. 93–100. IEEE (2009)
27. Yadollahi, E., Johal, W., Paiva, A., Dillenbourg, P.: When deictic gestures in a robot can harm child-robot collaboration. In: IDC 2018 - Proceedings of the 2018 ACM Conference on Interaction Design and Children, pp. 195–206. Association for Computing Machinery, Inc., June 2018. https://doi.org/10.1145/3202185.3202743