Navigation and Visualization of Knowledge Organization Systems using Virtual Reality Glasses: first insights

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Abstract. Given the great reception given to the use of mobile devices in recent years, and development of virtual-reality applications to access information, there has been a high demand for consumption of resources on the Internet. However within an educational environment, there are few studies that relate effective methods of navigation for access to resources, and even more for the association of cognitive level concepts. This article presents a proposal for a navigation system in virtual-reality based on Knowledge Organization System (KOS) in a zoo. The main goal is to analyze the association of concepts in a 3D navigation structure, and basic usability aspects through the use of mobile devices on a population of children aged 10 to 12 years.

Keywords: KOS, visualization, navigation, education, virtual reality, glasses.

1 Introduction

The basis of a Knowledge Organization Systems (KOS) is a set of terms which are linked through some kind of semantic relation. This makes possible to represent KOS terms and relations and not only visualize and also enable interaction mechanisms to navigate through them.

Knowledge Organization Systems' (KOS) visualization and navigation has been a long discussed topic in the past years [1, 2, 3]. Several authors have proposed different kind of interfaces and interaction options in order to make them more usable, attending to different purposes, context of use and users [4, 5].

Digital repositories frequently make use of some kind of KOS as them are helpful tools to organize resources and to assist users to better find and locate resources, providing valuable additional information [6].

Focusing on the educational context, it is amply demonstrated that the use of visualization techniques such as diagrams are highly valuable tools for learning purposes [7, 8].

Visualizing and navigating through KOS could be not only useful for resources' location and indexing, but also a learning experience itself [5, 7]. Fig. 1 depicts different mental processes which could occur while pupils are exploring a thesaurus about mammals, based on similar experiences gathered from previous experiments [references omitted for blind review process].

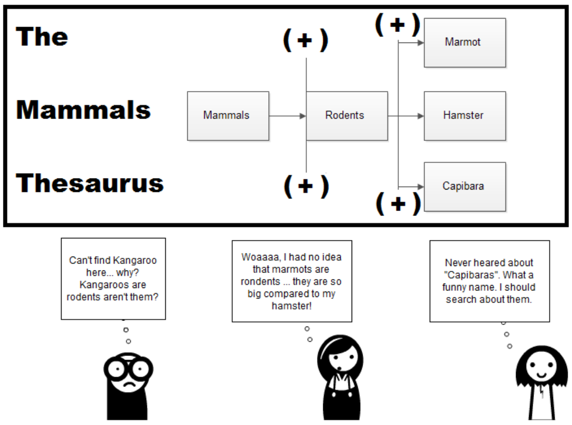

Fig. 1. Navigating through a mammals' thesaurus.

The possibility of acquiring virtual reality (VR) devices has spread through initiatives which could transform a smartphone into VR glasses for an extremely low cost like Google Cardboard[8] or even free as Mc Donald's[9] and Coca-Cola[10] initiatives. This initiative makes possible to everyone having a suitable smartphone to interact with VR interfaces.

Our paper aims to study the possibilities of using this VR interfaces for KOS visualization and navigation, providing first insights of their possible use in an educational context.

2 Background

Authors like [9] have proposed models which allow to connect data dynamically with visualization to quickly create visualizations of RDF data. This facilitates both users and data analysts to obtain an overview, explore and conduct a detailed analysis of the Linked Data cloud. Another proposal made by [10] presents an approach for creating visualizations on top of Linked Data using a Wizard Viewing Linked Data, based on an assessment of usability testing by potential users, as web developers and experts on semantic web.

Authors like [11] introduced ways to represent different ontologies through an structure according to "what" you want to represent (information in tabular form) and how (a structure defined ontology). The proposed approach allowed to represent the information of the ontology in different ways: i) a set of data from multiple ontologies: is displayed as nodes organized by different sections such as education, agriculture, health, etc; ii) an ontology of multiple datasets: display multiple Web pages of banks, and iii) visualization of a consultative relations: it shows how to visualize a warehouse inventory of printers showing the amount of each type utilizing a directed graph.

[8] https://www.google.com/get/cardboard/ [Last consulted: 4 April 2016]
[9] https://www.geektopia.es/es/technology/2016/03/01/noticias/en-suecia-la-caja-del-happy-meal-se-convierte-en-gafas-de-realidad-virtual.html [Last consulted: 4 April 2016]
[10] https://www.geektopia.es/es/technology/2016/03/04/noticias/coca-cola-tambien-quiere-que-uses-sus-cajas-para-hacer-gafas-de-realidad-virtual.html [Last consulted: 4 April 2016]

Regarding the use of this techniques in immersive environments [12] proposed to display an ontology in a 3D environment simulation as a tool for managing variables and parameters. The simulation where the tests were performed consisted on a model of hypovolemic shock, this is when the heart fails to pump enough blood to the body. The authors constructed an ontology on arterial connections that are involved in hypovolemic shock so the ontology could be used to specify and manage all the variables involved in the simulation model.

Authors like [13] address the issue of creating virtual environments or scenarios through the use of ontologies. Define the problem of generating 3D environments manually. The authors propose the creation of scenarios using schemes for the definition of environment (UML, RDF and OWL), first define all the rules, objects and animations that must have the virtual environment to generate and then by inference functions a package that allows display the 3D world is designed based on designed schemes GEDA-3D is a project of 2D and 3D engine for the representation of knowledge structures. Basically generate 3D environments using an ontology, similar to the form generation software using UML diagrams and structure.

From the framework's viewpoint [14] proposed the creation of 3D scenes using an architecture divided into three layers. Each layer would have ontologies describing a part of the 3D world to be created. These layers are distributed as follows: i) Layer Scene: has ontologies containing the proportions designed for stage and all objects that are within such a scenario, for example the size of the table, floor length, etc; ii) layer spatial relationships: contains ontologies that describe the position of objects in the scene you want to model, for example if a book is above or below where it is located a chair, bed, etc., iii) layer application restrictions: describes all the rules that will govern the 3D scene, for example gravity or what if a glass breaks.

An approach in the educational area is proposed by [15], where the author presents the use of ontologies for knowledge organization and academic resources such as graphics, audio, video images arises, etc. These ontologies are divided by areas of knowledge such as philosophy, engineering or economics. The system was conceived to connect resources in repositories and display them to students and teachers. The way to visualize the information is not explicit but presented a kind of schematic showing how ontologies for educational resources would be created. Another study proposed by [16] presents a combination of Augmented Reality (AR) and Semantic Web technologies in order to enhance the existing mobile Augmented Reality browsers using Semantic Web technologies.

There is a limited literature regarding KOS visualization in 3D environments and most of them is focused on 3D ontology visualizations involving highly specific applications. We were unable to find previous usability studies linking the visualization of KOS using virtual reality in the learning environment. Therefore the following article takes the first step to analyze the possibilities of visual search interface using virtual reality tools to conduct immersive navigation mechanisms on children, using a thesaurus based on a real zoo animals as a use case.

3 Materials and Methods

a. Development of the KOS

The application was developed as a videogame using unity 3D engine, the idea was using 3D objects of a videogame scene to represent the KOS structure of de Bioparc as a node parent-child frame. For this purpose the Google Cardboard API was used for input touch events and the head motion tracking also for generate the connection between nodes some scripts were built, the class diagram shown below illustrates de design of these scripts. Fig. 1, presents a representation of classes used in the 3D environment.

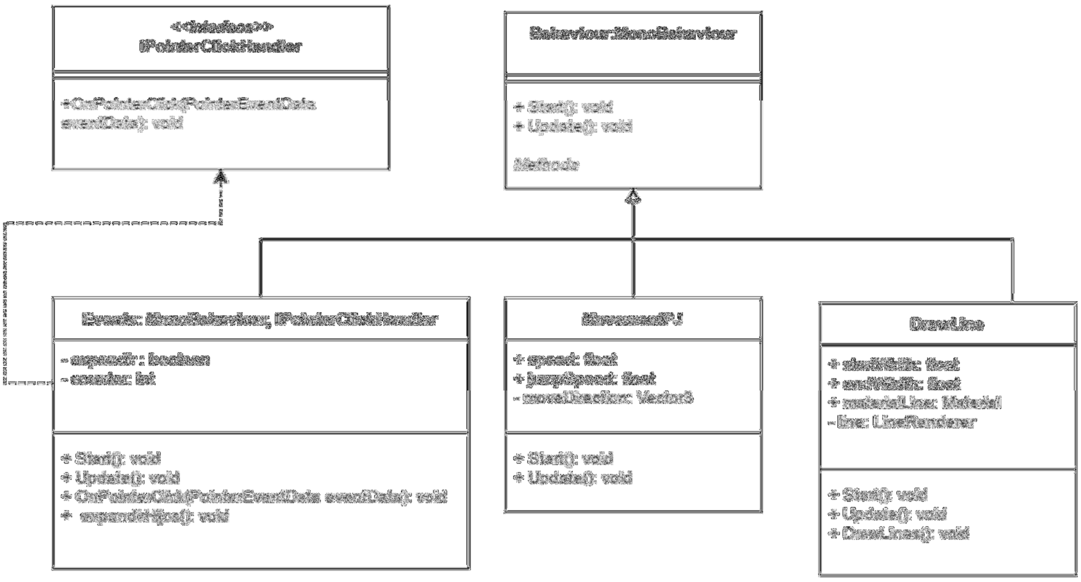

Fig. 1. Class diagram of scripts used on application.

Classes Description:

- IPointerClickHandler: It’s an interface of Unity that allows to detect a touch or click input event, it’s useful to perceive when a node want to be expanded.

- MonoBehaviour: Unity class that allows to manage the entire scene, their methods start and update allows initialize components and update them in time.

- Events: This script was crated and implements the IPointerClickHandler interface and extends from MonoBehaviour, with this script seeks detect when a sphere (node) is selected and trigger the event of expand the node.

- MovementPJ: the Script controls the movement in the scene therefore the user can navigate in the KOS structure in an immersive way.

- DrawLine: it is a simple script that draw the lines between nodes.

App interplay:

On the other hand for the interaction process with the application its important give to user some immersion and free navigation into the KOS. For this reason has been decided to connect the computer keyboard with the application in this way the users can use it to navigate into the KOS space. For this process we use the tool named Putty that uses a Telnet protocol to connect the mobile device with the computer and detect which keys are tipping on the keyboard.

The interaction with de APP shows below in the figure 2, the user with de Putty application on his computer connects with the KOS application developed when this is done its time to use the Google Cardboard and the keyboard keys to navigate into the KOS space.

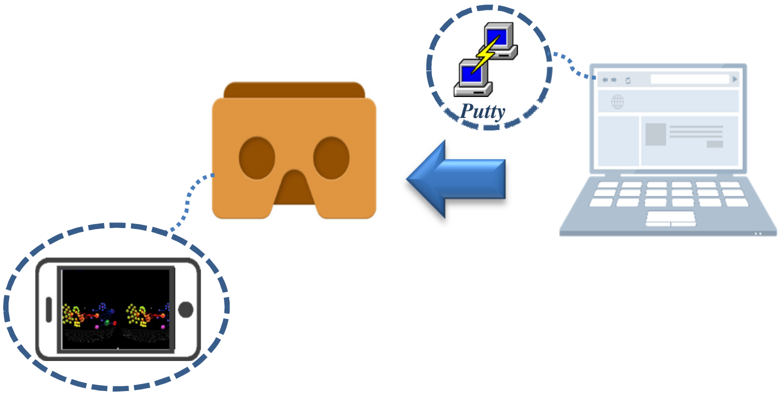

Fig. 2. Interaction between the mobile device inside Google Cardboard and the computer with the Putty application.

Using visualization techniques to represent and navigate through knowledge classification schemes could be a very helpful tool for learning purposes, however, to reach this goal an important effort on the usability side must be done during its implementation. This includes the use of a proper knowledge organization schema [7], built up considering the users' profiles, objectives and context of use.

In order to avoid problems arising from the use of existing KOS, which were not built according to these principles, we decided to create a simple KOS, aiming to ensure the use of a proper sample for the experiment. This KOS was constructed to represent the animals in Bioparc Fuengirola Zoo (Málaga, Spain), which allowed us to construct a thesaurus, where the broader / narrower relation was established according to the animal's habitat. Table 1 present a representation of concepts used to develop navigational interface.

Table 1. Concepts used to develop KOS navigation

AFRICA ECUATORIAL	**SUDESTE ASIÁTICO**	**ISLAS INDO-PACÍFICO**
HUMEDALES	**TEMPLO DE ANKOR**	**RUINAS DEL TEMPLO**
	TIGRE DE SUMATRA	
COCODRILO DEL NILO		DRAGÓN DE KOMODO
FLAMENCO ROSA	**BOSQUE RIBEREÑO**	CIERVO MOTEADO DE FILIPINAS
FLAMENCO ENANO		TORTUGA GIGANTE DE LAS GALÁPAGOS
ESPÁTULA AFRICANA	TAPIR MALAYO	IGUANA RINOCERONTE
ALCARAVÁN DEL CABO	BINTURONG	ESTORNINOS DE BALI
GRULLA CORONADA	MUNTJAC CHINO	CÁLAO DE LAS BISAYAS
TÁNTALO AFRICANO	NUTRIA CHICA	URRACA PIQUIRROJA
SITATUNGA	TOMISTOMA	FAISAN NOBLE DE BORNEO
CERCETA DEL CABO	CASUARIO COMUN	ESPOLONERO DE PALAWAN
CERCETA HOTTENTOTA	SUIRIRI CARIBLANCO	
ANADE PICOLIMON	CORMORAN PÍO	
PATO CRESTUDO	TORTUGA GIGANTE MALAYA	**CENTRO INTERPRETATIVO**
CIGÜEÑA DE ABDIM	GANSO URRACO	
TORTUGA DE CONCHA BLANDA AFRICANA	TARRO RAJÁ	CAMALEÓN PANTERA
ANADE MALGACHE	PORRON MOÑUDO	PITON RETICULADA
	SUIRIRI BICOLOR	VARANO AZUL
TRONCO CAÍDO		VARANO ESMERALDA
		VARANO DE PAPÚA
ESCORPIÓN IMPERIAL	**DOSEL DEL BOSQUE**	PITON DIAMANTINA DE LA JUNGLA
CUCARACHA SILBADORA MALGACHE		
GECKO DIURNO MALGACHE	ARDILLA TRICOLOR	
MILPIES GIGANTE AFRICANO	GIBON DE MEJILLAS DORADAS	
PITÓN REAL	ORANGUTAN DE BORNEO	
CARACOL GIGANTE AFRICANO		

The interface was built using Unity 3D engine, figures 3 and 4 show different views of the thesaurus. Fig. 3 shows the different animals that can be found in the location of "Humedales" (wetland) in the Bioparc. This structure can be obtained from the catalog of species provided by the park. Humedales is a child node from Africa zone, in this way we can deduce that all species In Humedales belongs to Africa and can be found in a determinate context.

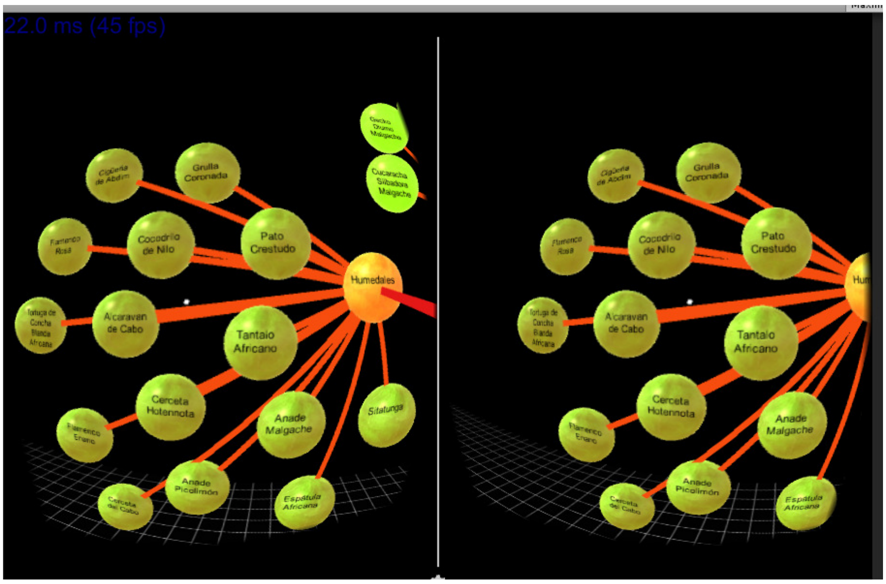

Fig. 3. Bioparc's thesaurus, user is centered in the "Humedales" (wetland) node.

Fig. 4 shows all KOS structure expanded and the camera that follows the navigation process in the application. On the other hand the figure shows the colors of the structure, each zone has its own color and their children have a similar color scale that indicates its linkage with the parent.

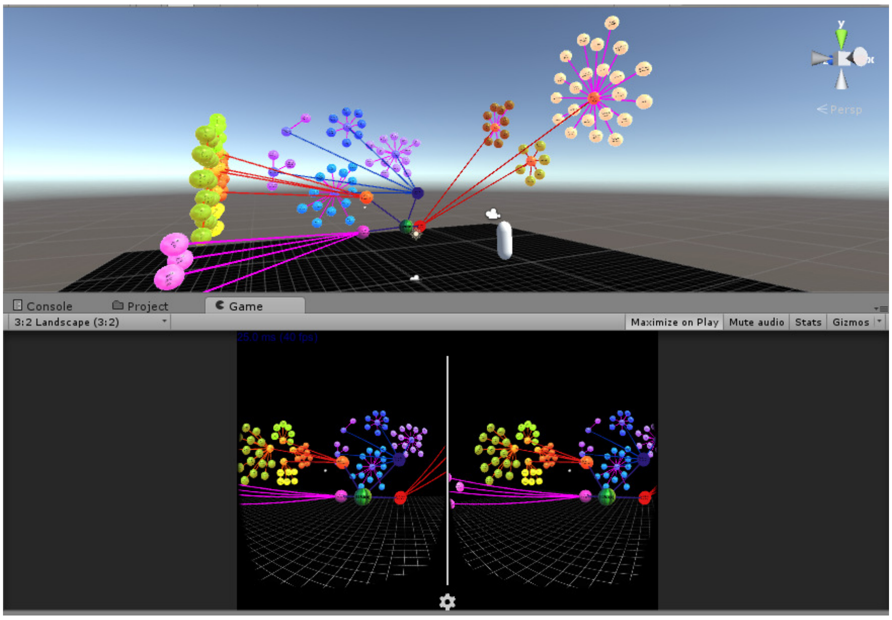

Fig. 4. A broader view of Bioparc's thesaurus – Unity SDK

Fig. 5 present an overview of the KOS implemented in 3D.

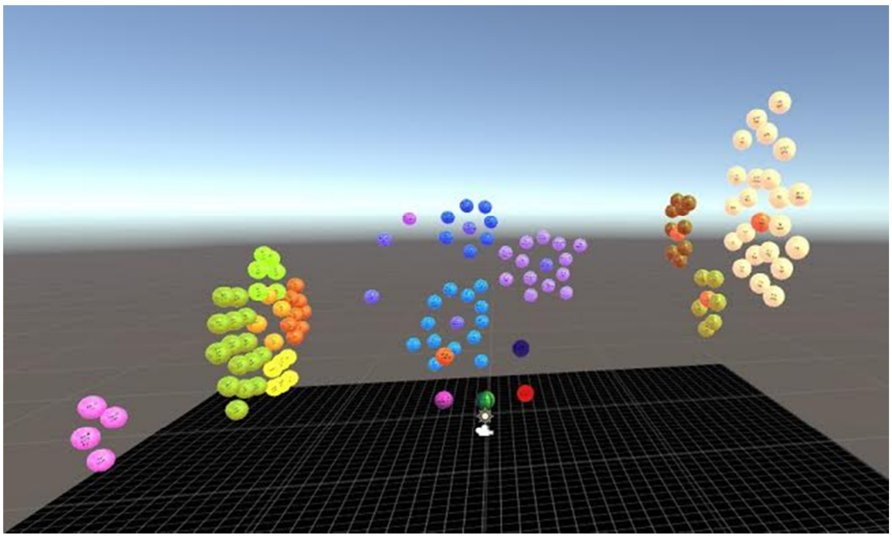

Fig. 5. An overview of KOS implemented

Finally in figure 6 and 7, we present a preliminary representation of the Bioparc zoo.

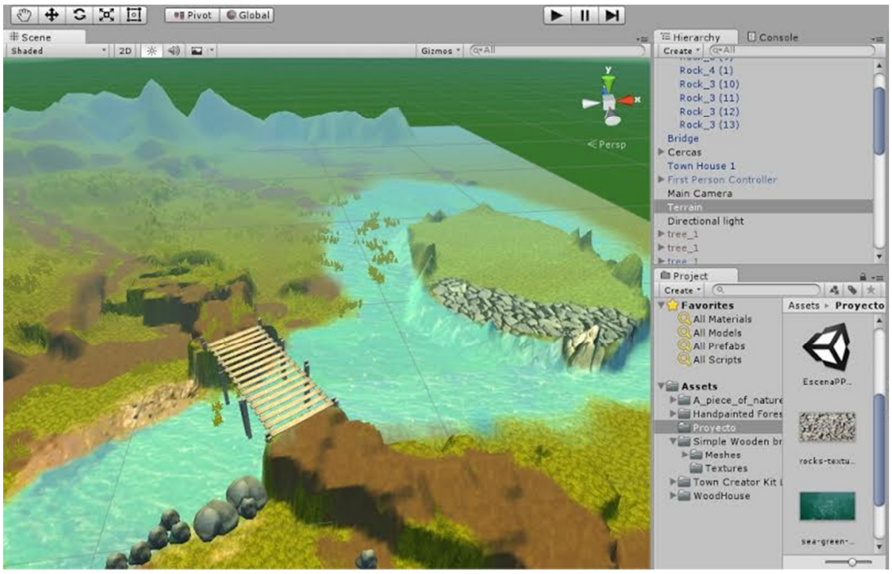

Fig. 6. 3D representation of Bioparc zoo.

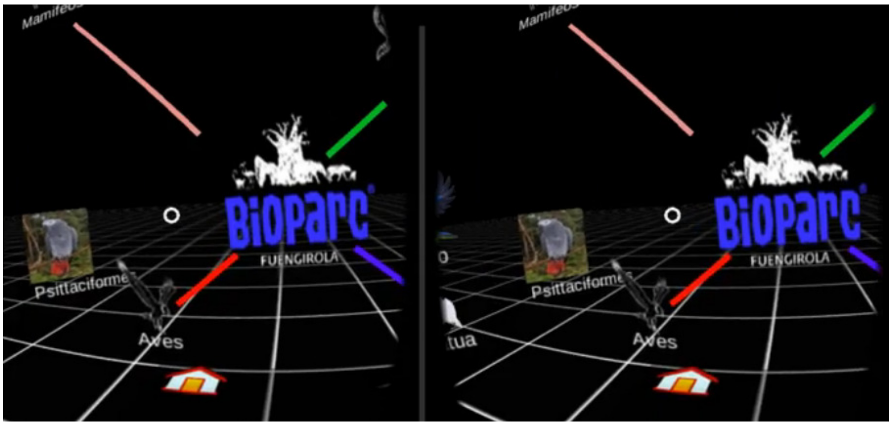

Fig. 7. Preliminary method of navigation using Google cardboard.

b. Evaluation methodology

The evaluation of the prototype was carried out by the use of the System Usability Scale (SUS) [16] supplemented with personal interviews in order to extract additional qualitative data about the interface and the knowledge extracted by the users while navigating through the KOS, related to perception assessment.

SUS is a widely used and freely distributed questionnaire consisting of 10 items which are scored using a five-point scale ranging from “Strongly Agree” to “Strongly Disagree”. It’s considered to be a quick, easy, reliable [17] and technology agnostic, making it suitable to be used by a broad group of usability practitioners to evaluate almost any type of user interface tool [18] either for small and big samples [17][18].

We introduced some minor changes to the original SUS following the recommendations stated by Finstad [19] regarding the problems while using this scale with non-native English speakers, the change of the word "system" for "interface", the inclusion of a short set of instructions [20] and other minor modifications in order to facilitate the understanding of the questions to the users, according to their age. The final set of statements were the following:

1.I think that I would like to use this visual tool frequently.
2.I found the visual tool unnecessarily complex.
3.I thought the visual tool was easy to use.
4.I think that I would need help to be able to use this visual tool.
5.I found the options in the visual tool to be well integrated.
6.I thought there was too much inconsistency in this visual tool.
7.I imagine that most people would learn to use this visual tool very quickly.
8.I found the visual tool very awkward to use.
9.I felt very confident using the visual tool.
10.I need to learn a lot of things before I could get going with this visual tool.

Participants were 13 kids ranging from 10 to 12 years who were invited to test the interface for fifteen minutes, allowing them first to freely navigate through the KOS without providing any additional information about it, just asking them to learn as much as possible from the information they could find on it. After this, participants used the system to reply a set of questions which could be answered just by extracting the information from the KOS. The set of questions was:

1.What does the KOS represent? (*Animals in a zoo and their habitats*)
2.What kind of habitats are represented? (*All of them are jungle-type*)
3.What was your favourite animal? (*Open answer*)
4.Where does he lives? (*Open answer*)
5.What is the name of the habitat were Lemurs live? (*Madagascar*)
6.Only there? (Yes)
7. What is the habitat with more animals? (*Mangrove Swamp, Indo-Pacific*)
8.What kind of animals live there? (*Mostly fishes*)
9.Find an habitat where there is only one animal living. (*The tiger at the Ankor temple*)
10. Did you feel dizzy or any other sickness while navigating through the diagram? (*We use the term diagram instead of KOS for better users' understanding*)

For questions from 1 to 9 we collected data regarding effectiveness – Was the answer correct? – and efficiency – How long did the participant take to reply? Did the participant need help?

4 Preliminary results

Several authors like [21], employ statements 4 and 10 from the questionnaire as representative of learnability, while the rest of the statements are representative of the construct usability. However when trying to analyze aspects of learning about children, it took majority of the questions associated with learning, and only one aspect (10) based on the physical conditions (dizziness), that may affect the conditions of navigation by the 3D interface. We considered learnability as an essential factor for the acceptance of the interface, so we took this approach in our analysis. Fig. 8 shows these results by participant.

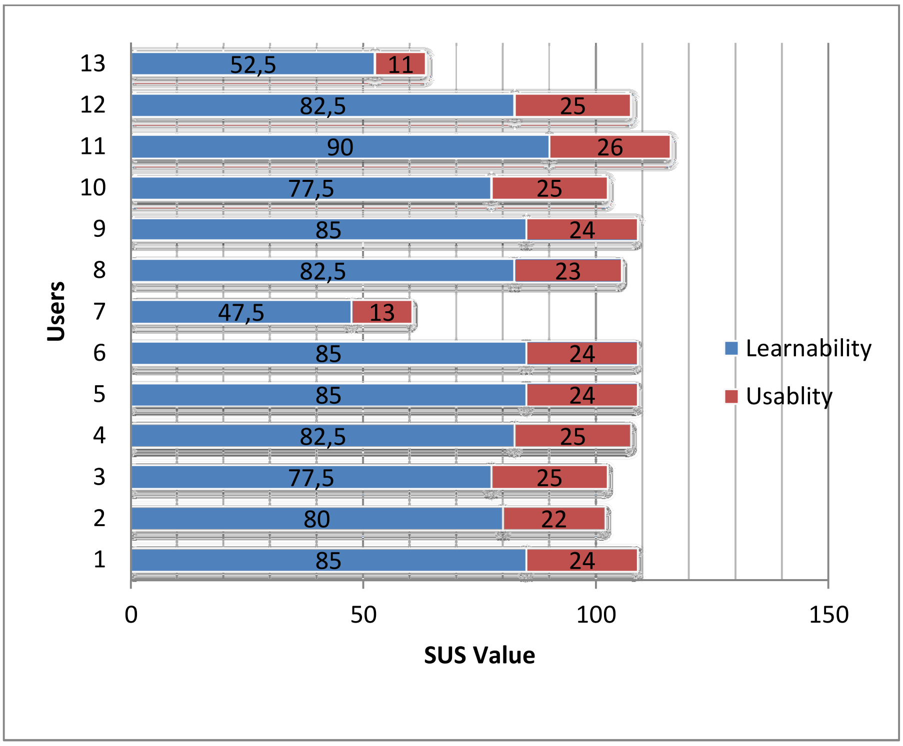

Fig. 8. Measure for SUS scale in in 3D interface.

Based on the results on figure 7, the evaluation of the learnability shows that the concepts related in 3D navigational structure has a mean score of 74,45 (SD = 6,85), which is above the average established by SUS (SUS > 68). The average of usability score was 21,46, although there were participants with a rating below average, in general this aspect was highly valued despite two participants scored below the average in usability aspects, which felt dizziness in the test. The construct learnability average score was 75,57. These results mean that majority of participants in test identified animals and relationships with the habitat, and category of animal selected according to the classification of KOS defined for the zoo. Table 2 presents these results in a detailed statistical description.

Table 2. Statistical description of learnability.

	N	Mean	SD	Error
Task 1	13	3,000	0,226	0,816
Task 2	13	4,307	0,174	0,630
Task 5	13	3,384	0,140	0,506
Task 6	13	4,230	0,520	1,877
Task 7	13	4,230	0,520	1,877
Task 8	13	3,692	0,364	1,315
Task 9	13	3,923	0,177	0,640

Table 2 details the maximum and minimum results of three aspects of learnability that participants valued negatively when using search interface. This aspect was related to the complexity of the tool (Mean=3,000; SD=0,226). However, three aspects of learnability were highly valued related whit concepts used in KOS interface (Mean=4,307; SD=0,174), the location of animals in habitat (Mean 4,230; SD=0,520) and issues related to ease of learning to potential users in different knowledge areas (Mean 4,230; SD=0,520). Finally in figure 9 we present a summary of task by user satisfaction.

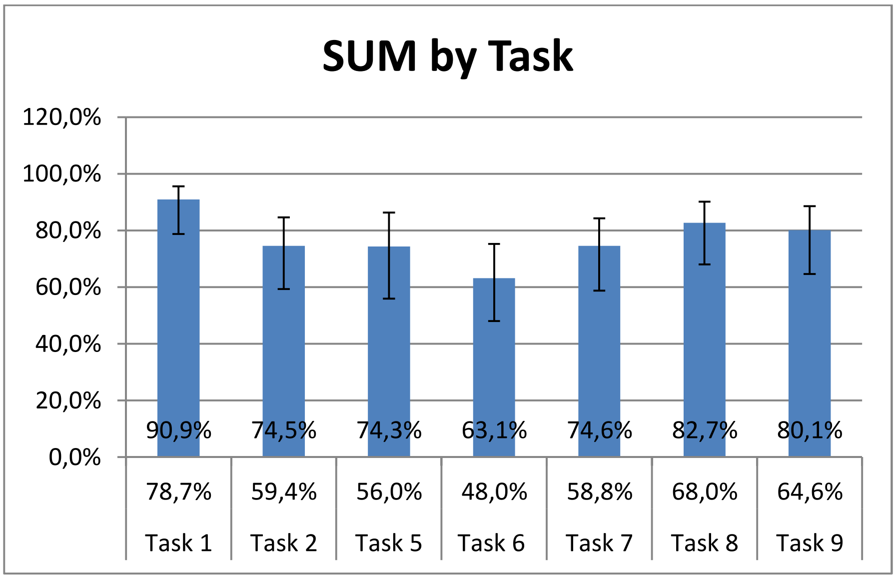

Fig. 9. Summary of user satisfaction by task.

As showed in figure 9, task 1 was the best activity evaluated, and task 6 presented a low satisfaction of all activities by children's. However task 1 was the activity most high evaluated.

5 Conclusions and future work

We carried out a mechanism for navigation through a simple knowledge representation scheme KOS, based on the definition of a thesaurus of animals in a zoo. Their representation has allowed us to analyze some aspects related to learnability and usability. However, one of the key aspects that pursued our analysis was to identify whether the participants (children between 10 and 12 years) provided them processes of navigation-concepts through 3D technologies, and most important, if not generate problems of dizziness using google cardboard glasses.

According to the results of the study associated with learnability aspects, the representation of knowledge schemes KOS in navigation mechanisms is possible using techniques of virtual-reality insofar as there aspects like: i) the use of simple navigation schemes where few levels deep are used, ii) few relationships between concepts, iii) use of concepts that did not involve association with other concepts in different levels of navigation.

It is important to mention that there are still relevant usability aspects to explore, to perform navigation tasks on taxonomies. Therefore, it is necessary to have more accurate enabled devices when interacting navigation 3D environments. The above, because we do not delve on some aspects that were found, such as: i) problems associated with dizziness when surfing more than two levels deep, ii) headache when interacting with the navigation scheme, and iii) difficulty to access nodes using google cardboard.

Future work is projected to have a navigation system, using augmented reality, and the use of navigation structures with a higher level of utility, in terms of aid associated with: i) search method controlled by voice, ii) aid menus to visualize the selected concept related resources, and iii) use more specific usability methods for analyzing user behavior when using the tool.

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References

[1] Marchionini, G. (2008). Human–information interaction research and development. Library; Infor-mation Science Research, 30(3), 165-174. doi: 10.1016/j.lisr.2008.07.001

[2] Gaona-García, P.A., Martín-Moncunill, D., S., & Montenegro-Marin, C.E. (in press). Trends and challenges of visual search interfaces in digital libraries and repositories. The Electronic Library

[3] Martín-Moncunill D., García-Barriocanal, Sicilia-Urban, M., E., Sánchez-Alonso, S., (2015b) Evaluating the Practical Applicability of Thesaurus-Based Keyphrase Extraction in the Agricultural Domain: In-sights from the VOA3R Project. Knowledge Organization, Vol. 42. Iss:2, pp. 76-89

[4] Gaona-García, P.A., Martín-Moncunill, D., Sánchez-Alonso, S., & Fermoso, A. (2014a). A usability study of taxonomy visualisation user interfaces in digital repositories. Online Information Review, 38(2), 284-304. doi:10.1108/OIR-03-2013-0051.

[5] Gaona-García, P.A., Stoitsis, G., Sanchez-Alonso, S., & Biniari, K. (in press) An exploratory study of user perception in visual search interfaces based on SKOS. Knowledge Organization.

[6] Joo, S., & Yeon Lee, J. (2011). Measuring the usability of academic digital libraries: Instrument devel-opment and validation. The Electronic Library, 29(4), 523-537.

[7] Martín-Moncunill, D., Sánchez, S., Gaona-García, P., & Marianos, N. (2013). Applying visualization techniques to develop interfaces for educational repositories: the case of Organic. Lingua and VOA3R. Paper presented at the Proceedings of the Learning Innovations and Quality: The Future of Digital Re-sources, Rome.

[8] Gaona-García, P.A., Sánchez-Alonso, S., & Montenegro, C.E. (2014b). Visualization of information: a proposal to improve the search and access to digital resources in repositories. Journal Ingeniería e Inves-tigación, 34(1), 83-89.

[9] Brunetti, J. M., Auer, S., García, R., Klímek, J., & Nečaský, M. (2013). Formal linked data visualization model. In Proceedings of International Conference on Information Integration and Web-based Applications & Services (p. 309). ACM

[10] Atemezing, G. A., & Troncy, R. (2014). Towards a linked-data based visualization wizard. In Workshop on Consuming Linked Data

[11] Harmelen, F., Broekstra, J., Fluit, C., Horst, H. T., Kampman, A., Van der Meer, J., & Sabou, M. (2011). Ontology-based information visualisation. InInformation Visualisation, 2001. Proceedings. Fifth International Conference on(pp. 546-554). IEEE.

[12] Ezzell, Z., Fishwick, P., & Cendan, J. (2011). Linking simulation and visualization construction through interactions with an ontology visualization. In Simulation Conference (WSC), Proceedings of the 2011 Winter (pp. 2921-2932). IEEE.

[13] Ramos, F., Aguirre, A., Zaragoza, J., & Razo, L. (2006). The use of ontologies for creating virtual scenarios in GeDA-3D. In Electronics, Robotics and Automotive Mechanics Conference, 2006 (Vol. 2, pp. 230-235). IEEE.

[14] Wu, J., Cai, H., & Bu, F. (2014). A Distributed 3D scene modeling framework based on three-layer ontology. In Cyberspace Technology (CCT 2014), International Conference on (pp. 1-7). IET.

[15] Wang, S., & Cheng, J. (2008). Research on Organization Technology of Education Resource Based on Ontology. In 2008 4th International Conference on Wireless Communications, Networking and Mobile Computing (pp. 1-4)

[16] Tabuenca, B., Kalz, M., Ternier, S., & Specht, M. (2014). Mobile authoring of open educational resources for authentic learning scenarios. Universal Access in the Information Society, 1-15.

[17] Brooke, J. (1996). SUS-A quick and dirty usability scale. Usability evaluation in industry, 189(194), 4-7

[18] Sauro, J.: A Practical Guide to the System Usability Scale (SUS). Meas. usability, Denver, USA. 1, 152 (2011).

[19] Bangor, A., Kortum, P., & Miller, J. A. (2008). The system usability scale (SUS): An empirical evaluation. International Journal of Human-Computer Interaction, 24(6), 574-594.G. Eason, B. Noble, and I.N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (references)

[20] Finstad, K. (2006). The system usability scale and non-native english speakers. Journal of usability studies, 1(4), 185-188.
[21] Finstad, K. (2010). The usability metric for user experience. Interacting with Computers, 22(5), 323-327.

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