

Exploring the Potential of Portable Digital Devices in Science Museum Outreach: A Diverse Approach

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Abstract

Centro Ciência Viva do Algarve (CCVAlg) is an Interactive Science Museum located in southern Portugal, which mission is to promote scientific and technological culture among the population and especially the youth community. Besides the interactive modules in the permanent exhibition, we design and deploy a wide range of science activities inside and outside our facilities. However, as we are nowadays facing a society (and a science environment) more and more “digital”, the use of technological tools and channels to carry out this mission cannot be ignored, otherwise it will give a biased and obsolete view of today’s reality regarding the techniques and methodologies that the XXI century scientific community uses. On this basis, CCVAlg’s strategy for the last couple of years has been to try to overcome such technological gap introducing and developing new methodologies for our activities. Having this in mind, we approached a Portuguese hardware manufacturer and achieved to forge a partnership that granted 10 detachable tablets with several specific sensors and add-ons that allowed us to design new and innovative outreach activities. The integration of the received devices into the Center’s educational offer allowed us to diversify the pedagogical offer and to involve cerca 3300 participants in the new activities. This type of collaboration reinforces the fact that Science museums should play a key role as strategic partners in the implementation of Information and Communication Technologies (ITC) pilot projects.

Keywords: Non formal education, Science Museum, portables.

1 INTRODUCTION

The Centro Ciência Viva do Algarve (CCVAlg) is an Interactive Science Museum located in southern Portugal, Faro, near Ria Formosa Natural Park, being the oldest Centro Ciência Viva, created at the very beginning of the “Ciência Viva Network”, more than twenty years ago. The main purpose of this Portuguese “Ciência Viva” Network is to create and support Centres “to promote an active citizenship based on scientific knowledge” [1]. “Ciência Viva” Centres are dynamic places of learning and diversion, where all sorts of people are invited to become “inspired and mobilized through science” [1], and develop their curiosity, creativity and critical thinking by exploiting the scientific knowledge of activities and interactive exhibitions. So, they are places of modern scientific museology where the desire to learn is stimulated. Inside CCVAlg, the visitors can find *cerca* 20 interactive science modules. Besides providing the contact with our modules for occasional visitors or scheduled group visits (e.g. student school trips), CCVAlg also offers a variety of science related activities inside and outside its facilities. Accordingly, CCVAlg establishes effective link between research (universities, research centres or institutes) and the population, being able to reach a diversity of public, both in age and social status. In fact, as we are located in a heavily touristic region, our visitor’s profile is very heterogeneous. However, like the other “Ciência Viva” Centres, we give a special attention to the articulation with schools and with the local scientific community. The Centre is a participating institution in several national research projects for science promotion and divulgation as well as for knowledge transfer and creation of scientific activities for scholars. This confers a particular role to CCVAlg regarding innovation in science outreach field.

We thus believe that by raising the interest to science and to scientific subjects through pleasant and informal experiences, we are contributing to increase the confidence of our visitors for facing today’s society demand of a personal commitment in continuous knowledge improvement and long life learning. But we also recognize that this mission, to be succeeded, should make use of *nouvelle* strategies and innovative methodologies that take advantage of the new tools that science and technology are giving.

In fact, science and technology have been fuelling the “digital revolution” which has been speeding up today’s changing society.[2] However, the “rapid pace of change in the world today - scientifically, technologically, demographically and economically - offers both challenges and new opportunities” [3] Luckily, science and technology are also the powerful source of new tools that not only support and boost the scientific knowledge development, but also upgrade the way that today’s science is made.

Embracing the spirit of the Mechelen Declaration, CCVAlg is thus committed to “develop the best methods for engaging learners and optimize their education in both formal and informal settings using appropriate technologies in widely varying contexts” [4] in ways that allow us to “transform the way in which people of all ages think and act”[4].

To reach such an objective, we consider that it is strategical to grant a partnership in the educational ITC area, that we managed to obtain. Ten detachable tablets in Windows 8.1 environment (Office Home and Student) and with software and hardware add-ons (thermal sensor, microlense) have been donated by a Portuguese hardware manufacturer to the CCVAlg.[5]

Accordingly, the purpose of the present work is to: i) present the methodology designed for integrating the received devices into the Center’s educational offer, ii) show the diversity of the generated pedagogical offer involved cerca 3300 participants and iii) discuss the role of Science museums as strategic partners in the implementation of ICT pilot projects.

2 METHODOLOGY

This work is an ongoing research and development. We intend to improve and diversify the activities that CCVAlg provides to the public. After the reception of the detachable keyboard tablets and the public announcement of the partnership on November 30th of 2016, CCVAlg’s staff started to freely explore the devices. Then, after a short period, the more enthusiastic staff elements began to use the devices on activities that already were included in CCVAlg pedagogical offer. One month later, all the staff received one morning training provided by a team member capacitated in the use of the sensors and software stack present on those devices, as showed in Fig. 1.



Figure 1. CCVAlg staff training session on software stack.

During the first year of the project, two meetings with the device’s producer were made to evaluate the ongoing project and to report equipment’s bugs when they were detected. This first year allowed to present a communication reporting the start of the project, and the milestones reached along the process, at Scicom.pt congress [6] (Fig. 2).

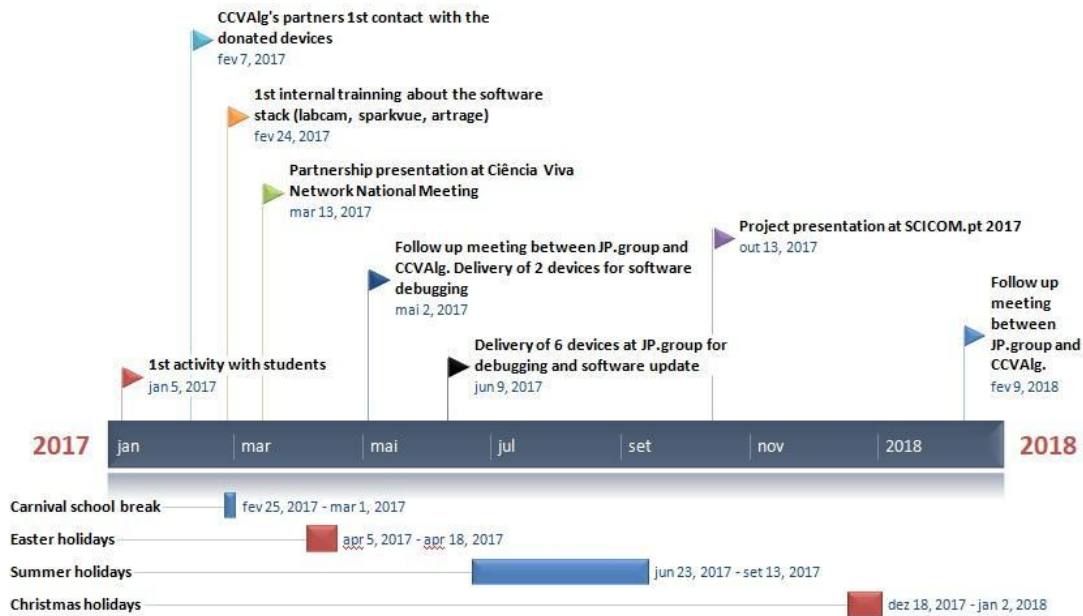


Figure 2. Milestones during the first year of the project.

3 RESULTS

After one year, the portable devices were used in 54 public science outreach initiatives that engaged with a total of 3291 persons. Seventeen of these initiatives were inside CCVALg facilities which involved 958 visitors, while 37 actions happened outdoors, involving 2333 participants.

Table 1 characterizes the activities implemented with the devices. Some activities intersect more than one field of knowledge, so the total number of events is different in both tables.

Table 1: Overview on developed activities by type (left) and by field of knowledge (right)

Type of action	Field of knowledge	# events
Astronomical observation	Maths and Modelling	1
Debate/assembly	Physics and Chemistry	9
Field activity	Earth Sciences	2
Hands on activity	Space Sciences	6
Institutional event	Life Sciences	31
Scientific communication	Social Sciences	3
	Applied Sciences (Engineering, ...)	13
	History and Culture	3

3.1 Indoor activities



Figure 3. Pictures of some indoor activities in which the devices were used, namely activity 3.1.2 (top-left picture), activity 3.1.7 (top-right picture), activity 3.1.1 (bottom-left picture), activity 3.1.5 (bottom-right picture) and activity 3.1.6 (center picture). See text below for more information.

3.1.1 Observation and identification of marine organisms

In this activity, children from schools far away from shoreline were invited to manipulate real shells and watch images or videos of marine animals on the portable devices, and then challenged to recognize the morphologies of those animals to reproduce the marine organisms doing hand sketches or colored drawings by hand or on tablet.

3.1.2 Creating multimedia records during CCVALg's school visits

The interactive module and the staging of CCVALg's spaces enable fun experiences and excellent scenarios for films, either alone or in group.

We have received at CCVALg the finalists of "Mitose: Ciência a Sul" contest, an initiative from University of Algarve to promote the learning of science and its communication. These young finalists have produced small scientific clips that later were used for the creation of small scientific films.

3.1.3 Microscopy workshop

This activity introduced children to the basic principles of optics and optical instruments. The students needed to recognize the differences between images from the same objects observed with the help of different optical equipments (lenses, Binocular magnifying glass, microscope, and digital camera of the tablet with a microlense) .

3.1.4 Sound workshop

In this activity, the Audacity [7] software was used with the tablets to explore how the sound can be produced, the nature of sound waves and how the sound properties (pitch, intensity and timbre) are associated to soundwaves. The children were able to observe the soundwaves representation generated by the sounds they produced with the tablets. At the end of the activity, the younger participants were invited to learn a choreography of a song about sound.

3.1.5 Molecular Modelling

The participants were invited to design a molecule using the software Accelrys 3D Studio, now property of Dassault Systems [8]. During the design process, some basic principles about molecular geometry and chemical bonding (hydrogen atoms only establish bonds with one other atom, bonding order and

bonding angle concepts). The participants were also able to try reproducing some simple molecular models with the program.

3.1.6 Holograms

During the CCVAlg's annual "Scientific Halloween" party, participating families were invited to create hologram systems with transparent sheets. The tablets were used to play the films that allowed the production of the hologram.

3.1.7 Introduction to the 3D modelling

During this activity, the students were challenged to draw a cup and a boat with the "1,2,3 Design" [9] software. Later, they were invited to personalize their 3D virtual models.

3.2 Outdoor activities



Figure 4. Pictures of some indoor activities in which the devices were used, namely activity 3.2.7 (top-left picture), activity 3.2.1 (top-right picture), activity 3.2.10 (bottom-left picture), activity 3.2.11 (bottom-right picture) and activity 3.2.8 (center picture). See text below for more information.

3.2.1 Birdwatching and vegetal invasive species observation and collection

This activity takes place in the Natural Park of Ria Formosa and has two components. During an initial walk, birds are observed and the morphological differences and habits of the species being observed are explained. Later, in an area already identified as having invasive flora, students are prompt to characterize the existing species using the tablets and a dedicated internet site, namely invasoras.pt [10]. It is noteworthy to refer that a mobile card is used for accessing internet. The activity ends with the removal of invasive plants.

3.2.2 Microplastic Detection

The students collect sand samples from the beach and afterward they observed the collected samples with the help of the tablets' microlenses, attempting to identify contamination by small particles, like microplastic and synthetic fibers.

3.2.3 Dune ecology: determination of biodiversity index

In this activity, which starts at the beach, the students identify the plant species in a pre-defined dune area. All the records related to the identified species are digitally made on the spot with the help of the tablets. Then, back to CCVAlg, the students proceed to the treatment of the data collected, in order to

determine various indices of flora biodiversity in the study area. This activity is especially suitable for high school students

3.2.4 Macroinvertebrates monitoring of water masses.

The presence or absence of certain organisms in a water body makes it possible to determine the environmental health of the site and the quality of the existing water. Benthic macroinvertebrates (aquatic insects, larvae, etc.) have been used since the beginning of the 20th century, in Europe as well as in other parts of the globe, as bioindicators of river water quality and coastal zones. Although simple, the methodology is effective and produces scientifically valid results, even when performed by young volunteers. For this reason, the results of the monitoring carried out within the scope of the Environmental Volunteer for Water Network [11] (<http://voluntariadoambientalagua.apambiente.pt>) are taken into account by the Portuguese Environment Agency in monitoring the water quality of the Algarve rivers. [12]

3.2.5 Life under a trunk

Students are invited to go to the field with magnifiers, tweezers, petri dishes and tablets and asked to turn stones and branches for discovering the beings that hide below them. The animals found with the magnifying glasses were collected by students with the tweezers into petri dishes and photographed with the tablets under magnifying microlens. Back in the classroom, the photographs were displayed in the class in order to identify the species and to know their characteristics.

3.2.6 The beach through a magnifying glasses

Children explore the intertidal zone and collect small materials and / or fragments, which origin was difficult to uncover. Some time later, the students returned to the headquarters to try, with the help of binoculars and tablets with microlens, to really understand what each of the collected objects was. This activity allowed us to approach themes such as material wear, material degradation time, erosion and coastal dynamics, anthropogenic environmental degradation factors, etc.

3.2.7 Corporate "Peddy tablet",

In this corporate team building activity, a peddy paper style activity was made using the tablet as a route map. The devices were also used to collect some evidences for the tasks that the teams managed to complete successfully.

3.2.8 Nocturnal astronomical observations

Tablets with Stellarium [13] software were used during nocturnal astronomical observations as a complement to direct observation, and as a support to recognize the stars and constellations from the night sky.

3.2.9 Activities with thermal probe

The thermal probe of the tablets was used to check temperature changes in three contexts:

- Heating Speed of different materials in a solar oven
In this context, a solar oven was used to heat two liquids in identical containers (water and glycerin). During the heating, the temperature of each liquid was monitored with tablets and their respective thermal probes, in order to measure the heating rate and deduce which of the substances has the highest calorific mass.
- Heat transfers between materials
In this activity, water-filled rubber balloons were heated to the flame, with the thermal probe being introduced into the interior of the balloon. The participants were able to see that the balloon did not burst or burn because the energy was being transferred to the water.
- Liquid mixtures and thermal equilibrium.
In this activity, we monitored, with the thermal probes, the temperature changes, when two liquids with different initial temperatures are mixed.

3.2.10 Labcam Graph Challenge

One of the applications that came pre-installed in the devices was LabCam [14] which, after a manufacturer software update included the mode "Graph Challenge". This mode allows, in a playful and

interactive perspective, to better understand physics, mainly the concepts associated with motion graphics. This mode was used in some events, like fairs where CCVAIlg was present.

3.2.11 Submarine acoustic measurement

As sound propagates very easily underwater, it is suspected that the underwater noise generated by boat engines may affect the behavior of many marine species. Since a local builder developed solar power boats, CCVAIlg performed underwater acoustic measurements with a tablet and an hydrophone kindly provided by Marsensing (<http://www.marsensing.com/>) in order to better demonstrate the advantages of this type of technology. The measurements were made both at the passage of the solar boat and other vessels with traditional propulsion systems, in order to demonstrate the differences of the generated underwater noises.

3.3 Other relevant applications



Figure 5. Pictures of some other application in which the devices were used, namely web streaming (top-left picture), meetings' support (top-right picture), aquarium maintenance (bottom-left picture), public surveys (bottom-right picture) and National Census of Fishing Eagle (center picture). See text for more information.

The tablets were used also by the CCVAIlg team members in some relevant situations without direct contact with the public. A portable was used by a team member as a tool in the National Census of the Fishing Eagle. Our birdwatcher used a tablet and Google Maps to determine and record the direction of flight of the fishing eagles from our rooftop and compare the observations made with those made by others observers distributed along the Ria Formosa, ensuring that no duplicate records were made [14]

The devices were also used in meetings, for public surveys, web streaming and content production for interactive modules or social networks.

Tablets with thermal sensors were also used in some aquarium maintenance operations.

4 CONCLUSIONS

The methodology used for introducing the tablet devices in CCVAIlg's environment gave positive results. The portables were used during this first year of the project in a way that allowed to diversify the activities and accordingly, do a better job for the community.

Thus, we considerer that science museums are an excellent opportunity to test educational software and/or hardware because this kind of institutions have access to a significative number of students, and people in general, in "free" and open learning context, without the restrictions imposed by school curricula, fulfillment demands or evaluations calendar. In fact, the user experience over the devices was reported to the manufacturer, helping the development of new devices. With this partnership we

considerer that we “Engage the public more directly with research, using this engagement to help empower people, broaden attitudes and ensure that the work of universities and research institutions is relevant to society and to wider social concerns on a global scale”[3].

REFERENCES

- [1] Pavilhão do Conhecimento, Missão identidade, atividade e valores, Accessed 13 Abril 2019 Retrieved from <https://www.pavconhecimento.pt/conheca-nos/missao/>
- [2] Reis, Emanuel. (2015). Ciência + meios e recursos educativos digitais: metamorfoses numa educação que busca ajustar-se às necessidades de uma sociedade que se transforma. Zenodo. <http://doi.org/10.5281/zenodo.2581414>
- [3] Tokyo Protocol, Accessed 13 Abril 2019 Retrieved from https://scws2017.org/tokyo_protocol/
- [4] Mechelen Declaration, Accessed 13 Abril 2019 Retrieved from https://www.ecsite.eu/sites/default/files/mechelen-declaration_def.pdf
- [5] Prenda de Natal Accessed 13 Abril 2019 Retrieved https://www.youtube.com/watch?v=Qy4LTU_DKKI
- [6] Reis, Emanuel, Colaço, Ana, Miguel, Carlos, Veiga-Pires, Cristina, Ferreira, Clara, Dias, Filipe, ... kisarauské, Vaiva. (2017). Infusão tecnológica na oferta educativa do Centro Ciência Viva do Algarve. Zenodo. <http://doi.org/10.5281/zenodo.1141826>
- [7] Audacity Accessed 13 Abril 2019 Retrieved from <https://www.audacityteam.org/>
- [8] Dassault Systèmes and Accelrys Join Forces Accessed 13 Abril 2019 Retrieved <https://www.3ds.com/about-3ds/announcement/accelrys/>
- [9] Autodesk 123D Design Accessed 13 Abril 2019 Retrieved from <https://autodesk-123ddesign.en.lo4d.com/windows>
- [10] Invasoras.pt, Accessed 13 Abril 2019 Retrieved from <http://invasoras.pt/>
- [11] Agência Portuguesa do Ambiente, Voluntariado Ambiental para a água Accessed 13 Abril 2019 Retrieved from <http://voluntariadoambientalagua.apambiente.pt>
- [12] OSPAR Commission, *Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area*, London, OSPAR Commission, 2010, [E-Reader Version]. Retrieved from https://www.ospar.org/ospar-data/10-02e_beachlitter%20guideline_english%20only.pdf
- [13] Stellarium Accessed 13 Abril 2019 Retrieved from <https://stellarium.org/pt/>
- [14] Inspiring Knowledge Education Software, Accessed 13 Abril 2019 Retrieved from: <https://ikes.jpik.com/en/>
- [15] Aves de Portugal Accessed 13 Abril 2019 Retrieved from <http://www.avesdeportugal.info/panhalcenso.html>