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## Digitizing natural history and contextualizing environmental education: the Natural Europe project as mediator of innovative and effective learning

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### Abstract

Natural History Museums (NHMs) are unique spaces that have only recently come to comprehend the effectiveness of the learning opportunities they offer to their visitors. Their collections form a rich source of knowledge about Earth's biodiversity and natural history with a high quality scientific content aiming with the exploitation of new online technologies and tools to become available to everyone. In this paper, we focus in the use of digital cultural resources, and more specifically digital natural history and biodiversity content, for the development of educational activities in the context of Natural History Museums and Science Centers. Moreover the proposed approach aims to enhance the learning process that takes place in the formal environment of the classroom, in fulfilling ways that cannot be compared to school learning, while also building on the National Curriculum. The Natural Europe project goal is to study and adopt educational methods recognized by European Union and to implement them deploying innovative learning design tools.

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**Keywords:** Type your keywords here, separated by semicolons ; Natural Europe project; Natural History Museums; educational pathways; Europeana; National Curriculum; Inquiry-based learning; Game-based learning; digital libraries; Contextual Model of Learning; learning design; educational pathway templates

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## 1. Introduction

Natural History Museums (NHMs) are unique spaces that have only recently come to comprehend the effectiveness of the learning opportunities they offer to their visitors (Falk & Storksdieck 2005). Their collections form a rich source of knowledge about Earth's biodiversity and natural history, rendering them custodians of natural history and knowledge-keepers of high quality scientific content that is gradually being digitized, aiming to become available to everyone. Still, the increase of digital resources becoming available to all signifies a need to organize this knowledge more effectively (MacPherson 2006). Up to now an impressive abundance of these high quality resources from NHMs around Europe has been largely unexploited due to a number of barriers.

Responding to this need, the Natural Europe project brings together digital collections from NHMs around Europe and makes them accessible through Europeana portal ([www.europeana.eu](http://www.europeana.eu)) for educational reasons. To this end, software tools have been designed and cutting-edge educational approaches have been studied, developed, adapted and applied to address the needs of different categories of museum visitors (school groups, lifelong learners) through innovative online educational pathway modes that correspond to the needs of each of the aforementioned audiences. To implement the Natural Europe vision, the consortium brings together a balanced mix of NHMs, pedagogues, educational technologists, metadata experts, user groups and standardization bodies. After the approach is tested through a set of "proof-of-concept" experiments that will try out the different theoretical approaches, it will extensively validate the proposed approach in real-life usage contexts employing the user groups represented in the consortium. The proposed approach aims to enhance the learning process that takes place in the formal environment of the classroom, in fulfilling ways that cannot be compared to school learning, while also building on the National Curriculum.

In this paper we start by presenting the background of this approach, which is based on innovative methods as well as completed projects. After presenting the natural Europe project, we analyze the learning design of the inquiry-based educational model used for the design of educational activities that connect formal to non-formal institutions (namely natural history museums). What follows is a discussion on the tools developed for the implementation of the inquiry-based educational model. Finally we discuss the initial/ preliminary evaluation of the Natural Europe learning design and respective tools.

## 2. Background

Major inadequacies regarding natural history education, data management, proper communication of scientific findings to the wider European public, as well as nonexistence of a common European policy, led to the Natural Europe initiative. The goal set was to form a digital library and learning tools that would harvest educational and cultural material from the digital libraries of the collaborating NHMs rendering it open to learning communities in engaging ways. To achieve this, the outcomes of previous joint European efforts systematizing learning through innovative educational approaches were taken in consideration; educational methods and national and international learning standards were carefully studied; software tools were deployed; and novel graphical interfaces for the formation and retrieval of educational approaches were designed. More specifically, building on the experience of COSMOS project, the first to organize science-related learning objects in educational design made available through digital repositories (Sampson et.al 2011), Natural Europe has created a net of online fully customizable repositories, one for each of the five (5) NHMs and the one (1) Science Center participating in the project,

for educational activities related to natural history. The participating museums, coming from six different European countries (Hungary, Greece, Portugal, Estonia, Germany and Finland), digitize their collections in order to use them in such educational activities along with resources from educational repositories like Ariadne (<http://www.ariadne-eu.org/>) but also to render them available to the wide public through Europeana. As for the educational model used for Natural Europe, that is, the inquiry-based learning model, which is highly valued by the European Union, connected to the Contextual Model of Learning proposed by Falk and Dierking (1997), this was first used in previous projects such as the award-winning OpenScienceResources project (<http://www.openscienceresources.eu/>). The result of this practice is a methodology building upon the strengths of non-formal learning taking place in NHM science centers and museums, while also achieving a pan-European standardization process in the field of engaging the cultural heritage of NHMs of Europe.

### 3. Educational Approach and design

The partner museums have set the audiences, thematic areas and educational needs to be addressed by the Natural Europe project, in order to ensure innovation in terms of education. In this context, the Natural Europe project has taken into consideration the three main components of NHMs (collections – educational activities put forward by museum educators – visitors) for the design of educational activities and the respective tools. The three aforementioned factors are interconnected, seeing that proper recognition of the visitors leads to educational activities designed to address the needs of specific age clusters and of groups. Regarding this, one of the major particularities of NHMs' visitors lies in the fact that most people visit such spaces twice in their lives: once as children with their families or schools, and then again as parents accompanying their children (Windsor 2007<sup>1</sup>). Therefore, the two most prominent visitor groups of NHMs are school groups and lifelong learners, each with their own particularities and requirements.

The Natural Europe project offers a properly designed educational methodology adapted to the needs of each of the aforementioned visitor categories, based on an array of different and rigorous pedagogical and theoretical approaches, including the Contextualised Model of Learning, Inquiry-Based learning, and Game-Based learning. Following the Contextual Model of Learning, the approach of the Natural Europe project is to promote a contextually-driven dialogue, i.e., a dialogue between the relevant science content and the individual's personal, socio-cultural and physical contexts. None of these three contexts is ever stable or constant; all are changing across the life of the individual. This twofold approach that concerns both formal and non-formal learning is closely linked to the science curriculum as well as to the NHMs exhibits and topics examined. Whether visiting a museum collection physically or virtually, each visitor will come across specially designed activities that correspond to his/her needs (Willson 2006). The designed activities are organized as educational pathways, inviting the visitor to obtain knowledge through carefully structured and specially designed educational actions. According to the audiences identified by the museums, the templates of two main pathways were created: the first one, addressed to schools, is based on the context set by Inquiry-learning theory. The second one, regarding families and general public, uses the steps set by Inquiry learning theory to build a game-based learning pathway form.

Students have been found to welcome the opportunity to learn in a setting significantly different from the classroom, designed to provoke curiosity about the natural phenomena through highly entertaining activities (Collins & Lee 2006) and to extend visitors' knowledge on issues previously studied (Falk and Needham 2011). In an experiment performed in 1997 by Falk and Dierking, all elementary and middle

school students could remember at least one thing they were informed about during a visit to a non-formal environment. The positive effect is maximized when the experience is hence structured to combine both hands-on activities and time for structured learning, as this combination helps the learners to remain concentrated.

The Natural Europe project adopted the educational approach recognized by the European Union as the most effective for school students: inquiry-based learning model (Rocard 2007). Inquiry-based learning engages students in the investigative nature of science (Sandoval & Bell 2004), through active search for knowledge or understanding to satisfy a curiosity. Research findings indicate that, "students are likely to begin to understand the natural world if they work directly with natural phenomena, using their senses to observe and using instruments to extend the power of their senses" (National Science Board 1991). To correspond to the educational purposes of the Natural Europe project, the 5-stage inquiry-based learning model was matched to a three-phase pattern that regards activities in the classroom, prior to and following the museum visit, which basically enrich the middle, main, phase. Inquiry Learners engage in the route of scientific research experiencing all the steps, from indicating the inquiries to be investigated to presenting and discussing their findings with their peers.

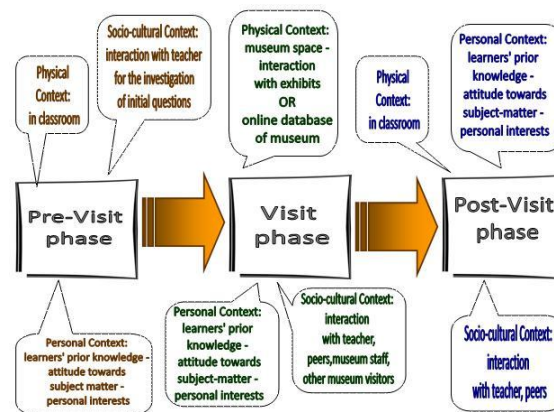


Fig. 1. Natural Europe Educational Pathway - School Visit Phases in CML context

Independent museum visitors, whether families or adult individuals, are found to appreciate the opportunity to determine the activities they prefer to engage in and the ways to access information (Kelly 2007). Families in particular demonstrate great interest to museum activities that allow experimentation and high social interaction, which incites questioning, making predictions, and evaluating evidence (Caulton 1998). The dynamic exchange of ideas and reflection that usually takes place in museums, enhances the visitors' understanding and strengthens their relationship with their family while introducing them to resources available to the community and promoting lifelong learning (Fenichel et al 2010). Although the focus is traditionally on families, individual adults too favor the opportunity to engage in highly interactive and hands-on experiences in a museum setting, even if sometimes they appear hesitant (Angliss 2006).

To address this second category's needs, the highly engaging game-based learning approach was chosen, ensuring learning by experimentation with games through a defined pathway. This combination

of learning and doing, called ‘edutainment’ (White 2003) aims to both educate and entertain engaged visitors, who choose their actions and experience their consequences along the way. The Natural Europe educational activities, interactive by definition, can be mental actions, technology-based or board games, to be carried out either on an individual or a group basis. Independent visitors can benefit significantly by Internet-based, technology-related educational activities. As for independent adult visitors, computer-literate independent adults would be more willing to visit a museum if the exhibits were based on technology and interactivity, though they are generally hesitant to interact with ‘hands-on’ exhibits, as they see them being addressed to younger generations (Gammon & Burch 2002). Online activities could solve this obstacle: they are based on technology, and are interactive and educative.

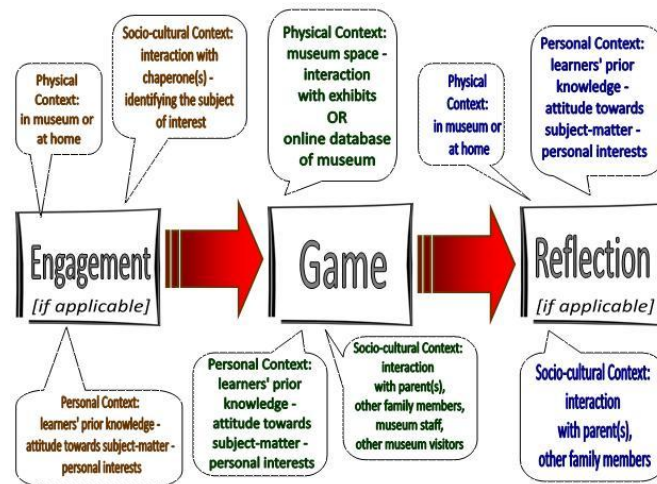


Fig. 2. Natural Europe Educational Pathway - Family Visit Phases in CML context

The combination of the Contextual Model of Learning, Inquiry-based learning and Game-based learning provided the theoretical context for the development of two separate pathway formats, one highly structured addressed to school communities and a second one referring to families and individual visitors. The identification of the NHMs’ visitor groups and their educational needs provided the required tangible aspect to the pathway templates. A set of tools, platforms and interactive installations were developed to match the requirements mirrored through these models, resulting from the analysis, discussion and theoretical research.

#### 4. Natural Europe Platform and tool

The Natural Europe digital tools were developed in accordance to the needs of both the material providers and the targeted audiences. The inquiry based model being a sequence of phases can be supported by web based tools such as Content Management Systems (CMS) and web publishing platforms. A web based platform has been previously been used in ORS to create educational pathways. In Natural Europe project the development of the educational Pathway Authoring Tool (PAT) ([http://education.natural-europe.eu/natural\\_europe/](http://education.natural-europe.eu/natural_europe/)) is over a customized OMEKA (<http://omeka.org/>) installation. Omeka is a free, flexible, and open source web-publishing platform for the display of library, museum, archives, and scholarly collections and exhibitions. Omeka falls at a crossroads of Web Content

Management, Collections Management, and Archival Digital Collections Systems. Omeka is designed with non-IT specialists in mind, allowing users to focus on content and interpretation rather than programming.

In the context of Natural Europe project we have focused in the deployment of four extensions of the standard Omeka installation. In the first we have developed a metadata editor of the annotation of learning resources (both single resources and pathways) using an IEEE LOM based application profile. The second refers to the ability of ingesting cultural and learning resources from external sources such as Europeana portal, and for educational from Ariadne. Another issue in the deployment of the tool has been the implementation of the educational pathways templates, as these have been analyzed in the previous section. The last one is a functionality that enables the integration of supporting material (Fig. 5) to each phase of the educational pathway.

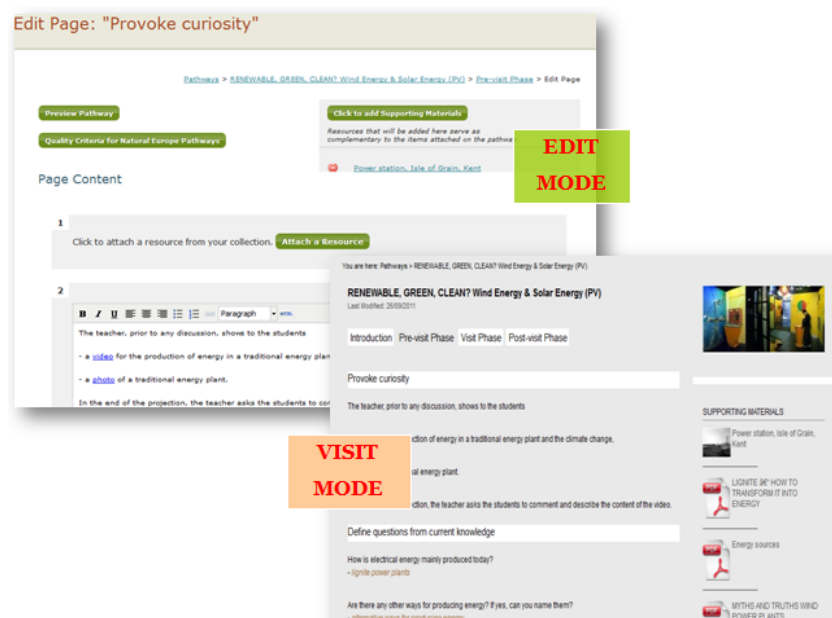


Fig. 3: Edit a page in edit and visit mode

While using the PAT museum educators and teachers can create their own educational pathways (Fig. 3) and share them with the community, while making use of a large collection of digital resources from Natural History Museums and collections and federations such as Europeana and Ariadne (Fig. 4). Learners can use the tool to follow educational pathways and browse digital resources. The learning resources can be easily searched, retrieved and integrated into a pathway, but there is also the option to create and manage ones' own learning resources (Fig. 5). Moreover, pathway creators are welcome to enhance the educational material and the pathways by adding educational metadata (Fig. 6). More than being just an authoring tool for teachers and educators, the PAT allows visitors to follow educational pathways and use with digital resources belonging to various museums.





Fig. 4. Ingest a resource from Natural Europe Federation



Fig. 5 Edit a Resource in Edit and Visit Mode

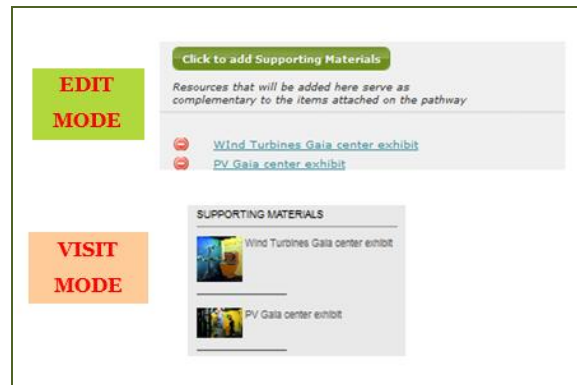


Fig. 6: Add supporting material in edit and visit mode

## 5. Results – evaluation

The Natural Europe educational pathways were developed by the NHM participating in the Natural Europe project as well as primary and secondary education teachers and museum educators that have been involved in the project through a continuous series of workshops. Regarding the pathways prepared by teachers, two preparatory schools have been organised in the context of Natural Europe project, one summer and one winter school, aiming to provide training on the essence and methods of developing an educational pathway. The participants, mainly teachers, museum educators, and project partners, were engaged in hands-on workshops regarding the creation of educational pathways, using the Natural Europe Pathway Authoring Tool. The Natural Europe Pathway Authoring Tool includes 34 pathways in total, all available public and free for others to use; this number is constantly increasing as new workshops and training sessions are held.

Some of these guided pathways are connected with one or more topics from the curriculum named the generic pathways, whereas other pathways are linked with only one specific topic from the curriculum and thus called the specific pathways. Though, most pathways are connected with the curriculum, in some cases museum educators designed pathways addressing to families and general public named the open pathways.

In order to ensure the quality of the educational pathways some core criteria eliciting from the project requirements have been stated. According to these criteria all guided pathways should be connected with one or more topics from the curriculum divided to the specific and to the generic ones. Another parameter is that all pathways should include digital resources from the Natural Europe Repository as well as from the Europeana portal, ensuring that way the quality of the educational material used. The pathways must also contain a visit to a NHM or Science Centre as well as to another site, as for example an excursion to a protected natural area together with museum educators in order to watch animals in habitat. Moreover, all follow up educational and discussion taking place after the planned visit should be supported by educational material that is from Europeana and other sources. In addition, the pathways ought to have potential learning objectives. All aforementioned criteria are summarized in Fig. 7.

|   | Generic   | Specific                                    | Open                           |
|---|---|---|--------------------------------|
| <b>1. Connect Pathway with Curriculum</b>   | One or more topics from the curriculum can be facilitated | Only one specific topic will be facilitated | Optional/Open                  |
| <b>2. Pathway includes relevant digital resources</b>   | Collection<br>≥ 1 Resource<br>AND                         | Collection<br>≥ 1 Resource<br>OR            | Collection<br>≥ 1 Resource     |
|   | Europeana<br>≥ 5 Resources                                | Europeana<br>≥ 1 Resource                   | Europeana<br>Optional/Open     |
| <b>3. Pathway includes field trip/visit (gather evidence)</b>                                       | NHM<br>≥ 1 visit<br>virtual or physical                   | NHM<br>≥ 1 visit<br>same                    | NHM<br>≥ 1 visit<br>same       |
|   | Other site<br>AND ≥ 1 visit                               | Other site<br>OR ≥ 1 visit                  | Other site<br>Open/Optional    |
| <b>4. Pathway includes proposed discussion/reflection activity in classroom</b>                     | ≥ 1 activity  | Specific activity = 1                       | Open/Optional                  |
| <b>5. Pathway includes follow-up activities that come from external sources (related resources)</b> | Europeana<br>≥ 5  | Europeana<br>Open/Optional                  | Europeana<br>Open/Optional     |
|   | Other sources<br>≥ 5                                      | Other sources<br>Open/Optional              | Other sources<br>Open/Optional |
| <b>6. Potential Learning Objectives</b>   | ≥ 1 objective   | Open/Optional                               | Open/Optional                  |

Fig. 7. Quality Criteria for Natural Europe Pathways

By the end of the first year of the project a preliminary pathway quality assessment took place, where all pathways have been reviewed according to the aforementioned six core quality criteria. Pathways have been grouped in two different categories, to the ones designed by teachers and the others created by museum partners. Overall, museum educators have developed twenty one (21) pathways ten (10) of which were generic, eight (8) specific and three (3) open. On the same time thirteen (13) pathways have been developed by teachers, where seven (7) of them are generic and six (6) specific pathways. No open pathways have been developed by teachers.

## 6. Conclusions

This paper presented the educational methodology that has been studied, analysed and adopted for the design of well define educational activities that take place within the NHMs. Furthermore, the study presents the learning design tools supporting the educational methodologies for the development of rich educational material and pathways. The Natural Europe educational pathways were developed by the NHMs participating in the Natural Europe project as well as primary and secondary education teachers and museum educators that have been involved in the project through a continuous series of workshops. The Natural Europe Pathway Authoring Tool includes 34 pathways in total, all available public and free for others to use; this number is constantly increasing as new workshops and training sessions are held. In order to ensure the quality of the educational activities several different evaluation tasks have been foreseen. One first preliminary evaluation assessment has already been set as an internal process, where all published pathways have been checked upon the quality criteria grid. Future plans involve the engagement of external users in the evaluation process through pilot and validation trials that will be organized by all museum involved in the project. During these pilot trials teachers and museum educators

will be introduced to the educational pathways concept and trained with the Natural Europe Pathway Authoring Tool. Moreover, all participants will be asked to evaluate both the educational value of the pathways created and the tools, using well defined questionnaires as well as through interviews. Concluding, the aim of our approach is to enhance the learning process that takes place in the formal environment of the classroom, in fulfilling ways that cannot be compared to school learning, while also building on the National Curriculum.

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<sup>i</sup> interview with Loretta Windsor, Learning Officer, Learning Engagement Group, Natural History Museum of London, 2007.