Space2Place – An E-Learning Module to Empower Stakeholders of UNESCO Sites

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ABSTRACT: With World Heritage Sites, Biosphere Re- serves and Global Geoparks, the UNESCO has declared a huge variety of places that are worth being preserved in almost all countries. An increasing number of these sites are "in Danger", being affected by environmental pro- cesses, or impacted by climate change and human devastation. The adaptive e-learning module Space2Place gives stakeholders of UNESCO sites the opportunity to benefit from advantages of Earth observation and to improve the management of their respective UNESCO sites. Space2Place is embedded in a larger e-learning environment and is connected with the online remote sensing analysis application BLIF. As e-learning module independent of time and location, it provides an introduction to Earth observation data and gives clear guidelines on how to incorporate such information into daily working routines of stakeholders of the various UNESCO sites. The gained knowledge can empower stakeholders to specifically claim help and formulate demands for future activities. It contributes to determine the needs of UNESCO sites and communicate their specific requirements. Accordingly, the e-learning module can have an impact on future developments with regard to the implementation of the Sustainable Development Goals and the Global Agenda 2030.

Keywords: UNESCO, UNESCO sites, Sustainable Development Goals, MAB Program, e-Learning, Earth Observation

Introduction

Nowadays, Earth observation plays a major role in documenting, analyzing, and monitoring our environment. Many applications have left the trial phase, e.g. change detection approaches and Interferometric Synthetic Aperture Radar (InSAR) (Cerra et al., 2016; Tapete & Cigna, 2017). They became constant workhorses by an increasing number of end-users.

However, only a small portion of the United Nations Educational, Scientific and Cultural Organization (UNESCO) sites constantly benefit from the advantages that Earth observation offers, e.g. quick first analysis, near real-time data acquisition, large area coverage, different sensors for specific applications, and retrospective analyses. The Copernicus Programme is currently the most comprehensive global Earth observation programme and the flagship of the European Union's Earth Observation and Monitoring programme (Showstack, 2014). Based on a variety of technologies, Copernicus

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delivers operational data and services for a wide range of applications. These include applications in the fields of agriculture, energy, security, transportation and information to protect and safeguard cultural and natural heritages sites worldwide (European Commission, 2015).

UNESCO currently incorporates 1 073 World Heritage Sites (UNESCO, 2018f), 669 Biosphere Reserves (UNESCO, 2018a), and 127 Global Geoparks (UNESCO, 2018e) all around the world. The World Heritage Convention, adopted by UNESCO in 1972, has proven to be widely acknowledged and was adopted by 193 countries worldwide. By signing the convention, state parties ensure the protection of cultural and natural heritage by e.g. integration into regional planning, financing of staff and related services, and promotion of research as well as monitoring on a daily basis (UNESCO, 2018d). The Man and the Biosphere Programme was launched in 1971 and focuses mainly on natural sites. The label UNESCO Global Geoparks was born in 2015 with rapid development in recent years.

Despite all success of the different initiatives, many designated sites are “In Danger”, inscribed in the “List of World Heritage in Danger”. As part of the World Heritage Convention (article 11, 4), the World Heritage Committee is responsible to keep this list updated and include necessary actions or requested assistance (UNESCO, 2018d). Other UNESCO sites do not currently fulfil necessary requirements for their evaluation and reaffirmation. Based on a two years consultation with experts, in 2008 UNESCO compiled a list of 14 primary factors that can affect the value of World Heritage properties (UNESCO, 2018c). This list includes, amongst others sudden ecological or geological events, urban sprawl or impacts of climate change. But also manmade destructions including terrorism or civil unrests are causes for sometimes irreversible destruction. In 2003, UNESCO and the European Space Agency (ESA) signed the “Open Initiative on the Use of Space Technologies to Support the World Heritage Convention”, which was also joined by the German Aerospace Centre (DLR) (UNESCO, 2018b) as partner in 2007 (Ito, 2011).

Despite establishing networks between space agencies, research institutions, and the UNESCO in order to facilitate the use of Earth observation data for heritage sites with various examples (Cerra et al., 2016; Hernandez et al., 2008; Patias, 2007; Remondino, 2011), currently only a limited number of UNESCO sites benefit from the above-mentioned advantages. Well-known potentials of Earth observation are not yet fully exploited. Site managers are often unaware about these potentials including free and open data access. This is aggravated by a lack of knowledge about basics of remote sensing and related image analysis skills.

Space2Place tries to build capacity on Earth observation and to provide stakeholders of UNESCO sites with a learning environment on how Earth observation data can be used. By attending the module, stakeholders of UNESCO sites should be empowered to incorporate Earth observation data in their daily working routines. Furthermore, based on an increased awareness about the subject, they can request specific assistance and cooperation more easily. By incorporating Earth observation data, UNESCO sites will benefit from a faster and more reliable documentation of their sites as well as from a more accurate analysis and improved monitoring. Additionally, the derived information can be prepared for public relations, tourism, and education purposes. The impact of the e-learning modules should finally contribute to prevent UNESCO sites from being endangered and to safeguard existing sites. This will be a chance of UNESCO sites to fulfil their objectives and contribute to the Sustainable Development Goals (SDGs) and the Global Agenda 2030.

Educational Concepts

Backbone of Space2Place is an e-learning environment established in the framework of the project “Space4Geography”, funded by the DLR from 2013 – 2017. Based on previous studies (Ditter, 2014; Siegmund, 2011), the project developed a comprehensive adaptive e- learning environment, in particular for secondary schools in Germany. This e-learning environment is called *Geo:spektiv*. Depicted topics as well as included materials and methods contribute to building the competences prescribed by Germany’s national education standards and federal curricula (Deutsche Gesellschaft für Geographie (Hrsg.), 2014; Kultusminister Konferenz, 2018). The e-learning modules of *Geo:spektiv* are widely used in schools, at DLR_School_Labs, and in courses offered

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by the Department of Geography itself. Since the launch of the website (www.geospektiv.de/) in late 2015, more than 2500 students attended the various e-learning modules. The success of the project-was strongly supported by considering the general interest and high motivation of students who work with satellite images and digital datasets. Further distribution is envisaged to raise awareness of future teachers and to improve the skills of today's teachers (Ditter et al., 2012). Accordingly, barriers to access Earth observation data and tools should be reduced (e.g. BLIF - Blickpunkt Fernerkundung – "Remote Sensing in Focus") as well as to offer applications with limited complexity to access broader target groups.

The e-learning module Space2Place was implemented by the UNESCO Chair on World Heritage and Biosphere Reserve Observation and Education at Heidelberg University of Education. It offers the user a brief introduction to Earth observation and related applications. The module provides several key features:

- Optimized presentation of the learning units on different end user devices to assure flexible utilization
- Introduction to various Earth observation applications, e.g. deforestation, forest fire mapping, drought mapping, monitoring of air pollution or surveillance of agricultural land
- Integration of various optical satellite images, e.g. Sentinel 2, Landsat 8, MODIS, and RapidEye
- Following an interactive approach and integration of different media, incl. photos, videos, and satellite images
- Adaptive course content to allow personalized learning paths and varying speed
- Interim and final quizzes to check learning success
- Total length of the learning unit is about 90 minutes to allow flexible utilization
- Learners receive a certificate based on their test results

Another key feature is the cross reference of learning units with the online remote sensing application BLIF. Participants practice their understanding and knowledge with the online remote sensing application using real satellite images. One more very important feature is the adaptability of the e-learning environment, as shown in figure 1. Modules implemented in *Geo:spektiv* can be dynamically combined to personalized learning paths with real-time adaptation of content and complexity, depending on the student's performance in test units. The approach takes into account the heterogeneity and varying speed of a learning group. It can thus be seen as a meaningful advancement of traditional one-size-fits-all approaches.

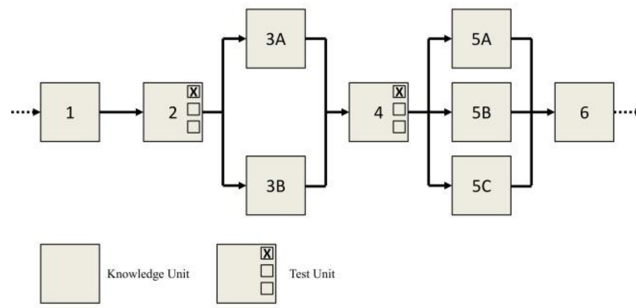

Figure 1. Adaptive approach with individual learning paths (Source: adapted from (Wolf et al., 2016).

The Learning Module Space2Place

The Space2Place e-learning module includes 21 units in total. The module is designed for participants without any extensive prior knowledge and an estimated duration of approximately 90 minutes to pass the whole module. Based on a general introduction into the learning module and the expected outcomes (figure 2a), the course starts with knowledge units about Earth observation applications and their relevance for stakeholders of UNESCO sites. A separate knowledge unit leads to the SDGs and the Global Agenda 2030 including their specific indicators. Hereafter, the Copernicus programme with its fleet of Sentinel satellites is introduced. Based on the current amount of free satellite data for a large diversity of applications, a particular emphasis was placed on images from the Sentinel satellites. Following this background introduction, remote sensing in general and its advantages are described, accompanied by an introduction of different radar and optical satellite systems. After introducing the most important past and currently available satellites, satellite images themselves are explained more in detail (figure 2b). By using various examples, spatial, spectral, temporal, and radiometric resolutions are

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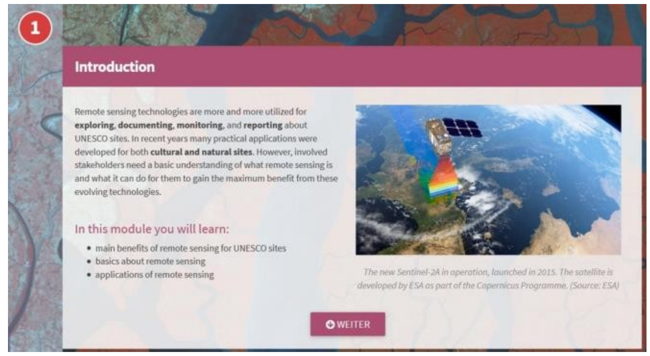
further described. A short intermediate quiz afterwards assesses the learning success that was achieved so far.

After these introductory units, the focus is set on image enhancements and analyses with small quizzes in between. Colour composite and contrast enhancements are explained and carried out by the participants within the linked BLIF application. Vegetation indices, especially the well-established Normalized Difference Vegetation Index (NDVI), are introduced and tested by participants in a practical exercise. The same applies for manual and automatic classification approaches including an example of centre-pivot irrigation in Kansas (USA). An introduction to change detection with related examples illustrates the last topic of the module (figure 2c). A final quiz will assess the learning success of the participants and will summarize and return the score in the certificate. The last unit is used to motivate participants to incorporate Earth observation techniques in their daily working routine by presenting more advanced applications that can benefit from remote sensing techniques, such as forest fire monitoring, archaeology and 3D modelling by drone technology.

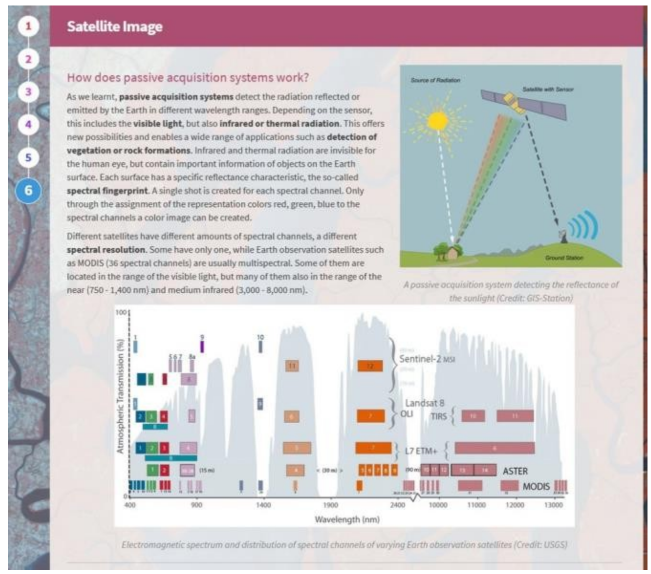
Based on increased awareness and knowledge by *Geo:spektiv*, stakeholders of UNESCO sites are supposed to request specific Earth observation applications, in particular for their respective areas and in general about Earth observation. Advertisement of the e-learning module is planned on various occasions. First feedbacks were promising and a global distribution is envisaged.

Prospects and Outlook

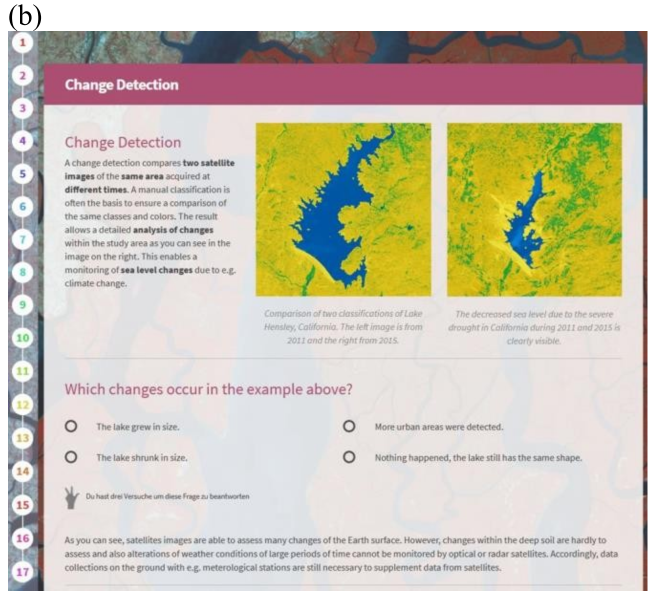
Based on evaluation of the project Space4Geography, usage behaviour of participants of *Geo:spektiv* modules, and specific requests by colleagues and partners, several existing e-learning modules will be translated from German to English in the near future.



(a)



(b)



(c)

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Figure 2. Screenshots of different Space2Place units; a) Introduction unit; b) Knowledge unit “Satellite Image”; c) Knowledge and test unit “Change Detection”

These modules can then be used for educational purposes on an international level. After catching the low-hanging fruits, further translations into Spanish and French will follow. Besides e-learning modules for students, Space2Place is the first English module especially designed for stakeholders of UNESCO sites. It contains important basic information about Earth observation and will raise the awareness of stakeholders of UNESCO sites on its potentials. After launching and advertising Space2Place at the beginning of 2018, feedback from participants for further improvements will be collected and evaluated. At the same time, two more specific e- learning modules in English will be created.

The first module will focus on the relation between Earth observation and the topic of health. Together with different partners, it will provide an overview about opportunities given by satellite systems and their potential applications within the health sector. This e- learning module addresses SDG 3 in particular and is intended to facilitate the use of Earth observation data especially in the global south. Simultaneously, the module emphasizes the importance of the health sector for sustainable development in and around UNESCO designated sites, such as biosphere reserves. A key aspect of this module will be the detection and monitoring of malaria transmission in Africa based on Earth observation data. Early studies in the 1990s revealed relations between specific environmental factors, detectable by Earth observation, and factors influencing the transmission of malaria (Thomson et al., 1996). However, secure monitoring and standardized services are still missing. Similar relationships were already discovered for other diseases (Bavia et al., 2001). Smaller digressions allow the introduction of e.g. other health related environmental impact factors such as air pollution. They can be monitored on a regional scale by using innovative satellite systems such as Sentinel 5P (Ingmann et al., 2012).

The second module will examine the value of Earth observation data for UNESCO cultural heritage sites. Documentation, monitoring, and analysis of changes as well as communication are key aspects for actors and involved stakeholders. Earth observation data from Synthetic Aperture Radar (SAR) satellites or Unmanned Aerial Vehicle (UAV) can play a vital role for these tasks (Schreier & Dech, 2005). Recent examples and publications indicate that applications are already successfully used on large scales (Negula et al., 2015). However, despite a significant INSAR geoinformation stock and available clusters of knowledge and innovation, the involvement of practitioners and heritage stakeholders is still limited (Tapete & Cigna, 2017). Accordingly, despite these potentials, an area-wide deployment is still missing. In collaboration with other partners, the module will give an introduction on well-established applications as well as state-of-the-art developments in the field of 3D modelling and geo-archaeology. Those new courses will be available in mid-2018.

By attending the course, stakeholders of UNESCO sites and actors in the field of cultural heritage management will benefit from a better understanding of the opportunities and limitations of Earth observation data. By raising their awareness and interest, the creation of new contacts, professional links and projects will be promoted. By constantly evaluating the feedback given by participants, new ideas and requests can be integrated into the existing portfolio.

Summary

Digital geomedia are currently in vogue. This is confirmed by the rising number of massive open online courses (MOOCs) and knowledge sharing platforms on this topic. *Geo:spektiv* is an excellent and frequently used example on how Earth observation data can be implemented in classroom activities, currently mainly in Germany. Space2Place is based on these foundations and contributes to the empowerment of stakeholders of UNESCO sites on an international level. By integrating key factors, such as cross-links with online remote sensing applications and personalized learning paths, Space2Place will facilitate the use of Earth observation data and gives information on its inherent benefits. Additionally, the Copernicus Programme supports the initiative by providing its valuable amount of free data for a wide range of applications.

The offered courses will be constantly improved and extended by more specific modules. By increasing the

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dissemination of e-learning modules the existing knowledge will be shared. Cooperation with UNESCO, national space agencies and other partners will ensure a dynamic exchange to provide necessary feedback. A key driver will be the active involvement of practitioners and stakeholders of UNESCO sites. Besides conferences, workshops, and face-to-face training events, e-learning platforms such as Space2Place will empower stakeholders to better manage their sites, providing a contribution to achieve the SDGs and to safeguard existing UNESCO sites. Additionally, the presented e- learning module will be a contribution to engage heritage stakeholders and to facilitate the knowledge transfer between Earth observation experts and non-experts.

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