DEVELOPMENT OF TEACHING STRATEGIES USING VIRTUALIZATION STRATEGIES AS COMPLEMENTARY RESOURCES ON GEOLOGY, CRYSTALLOGRAPHY, AND ARCHAEOLOGY

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Abstract

In the last couple of years, the high-education system has quickly adopted and developed new virtual teaching resources and strategies, looking forward to suitable alternatives to face-to-face teaching. Some knowledge fields faced significant challenges on that path, but the remarkable effort performed by the high-education professionals overcome most of them in record time.

Nowadays, the developed virtual resources continue helping on a daily basis in a situation in which some necessary safety restrictions (e.g., distances between students, the maximum number of students per room, etc.) continue to impede the normal development of classes.

However, once the pandemic has been completely overcome, what will be the fate of these virtual resources?

After these years of enormous efforts by university professors, an immediate return to pre-pandemic methodologies cannot be ruled out. Returning to methodologies within the comfort zone is something perfectly understandable, but it would lead to the abandonment of new and powerful virtual resources, and the wasting of the effort made over the years. Despite this situation, the implementation of these virtual resources must necessarily become a first-level tool to alleviate the lack of equipment and the limitations of teaching materials that a wide part of educational centers suffer now.

Accordingly, it is necessary to study and discuss how the virtualization strategies and virtual resources can coexist and improve the pre-pandemic teaching methodologies and strategies, looking forward to synergies that strengthen the high-education system. The Crystallography and Mineralogy area of the University of Valladolid has recently started a teaching innovation project focused on the further development of virtual teaching resources and the implementation of mixed teaching strategies capable of taking advantage of these resources in normal teaching scenarios.

Herein, the design and development of this project are described, providing information about the implementation of these strategies in subjects related to Geology, Crystallography, Natural Sciences, and Archaeology.

Keywords: virtual learning, photogrammetry, history

1 INTRODUCTION

Quality virtual teaching resources became an urgent need in the last years due to the COVID-19 pandemic, focusing enormous efforts on the educative community attempting to mitigate the negative effects of the pandemic on the normal development of classes [1,2]. The Crystallography and Mineralogy area of the University of Valladolid quickly joined these efforts and took advantage of the acquired experience to develop a teaching innovation project in 2020-2021 focused on the development of virtual resources and evaluation tools on the fields of Crystallography and Geology [3].

In brief, that project developed and employed 3D photogrammetric models of minerals, rocks, and fossils, complemented with additional information about their main features or their vibrational and static structure (in the case of minerals); as well as evaluation and training tools which could be implemented in Moodle [3]. Fortunately, during the course 2021-2022 it has been no need of using

these resources as an alternative to face-to-face activities, while the perspectives for the next courses are optimistic in this regard. However, these resources have been employed during the face-to-face classes, looking forward to improving student learning and avoiding the loss of these resources once virtual teaching is no longer necessary.

Achieving a proper synergy between these virtual resources and the pre-pandemic methodologies requires to consider their potential role on each knowledge field. It can be expected that a 3D model of quartz could be more useful for a Geology student than for a Physics student, but in both cases a proper design of the teaching activities/resources would lead into improved teaching methodologies. With this aim, the Crystallography and Mineralogy area of the University of Valladolid started a new teaching innovative project during the course 2021-2022, focused on exploring the integration of photogrammetric 3D models on the pre-pandemic methodologies of Geology, Crystallography, and Natural Sciences subjects.

Moreover, it was noticed that these virtualization strategies could be extended to the Archaeology field. In November 2021, the European Commission published a recommendation on a common European data space for cultural heritage which highlights how the use of advanced digital technologies can empower and increase the resilience of cultural heritage institutions. Disruptive technologies such as 3D modelling and printing, virtual reality and augmented reality are identified as unprecedented opportunities for the digitisation, online access and digital preservation of cultural heritage, as well as to promote the European recovery and growth following the COVID-19 pandemic, making Europe's cultural resources an important pillar of the digital economy [4]. These virtual resources are expected also to offer new opportunities for heritage education, such as the virtual educommunication of heritage, which eliminates boundaries to knowledge and allows working in an accessible and collaborative way [5]. Diverse works emphasize how digital environments democratize, educate and socialize heritage, as well as facilitate the inclusion of socially isolated groups of people [6]. Accordingly, the new teaching innovative project considers the use of the virtualization strategies of teaching resources previously developed to the Archaeology field, as well as the desing of potential teaching strategies based on these resources aiming to achieve a broad impact.

Herein, the preliminary results of this innovative project are presented.

2 METHODOLOGY

2.1 Teaching strategies on diverse knowledge fields

Although the potential of virtual 3D models in teaching activities is well-known, their particular use should be necessarily adapted to each knowledge field in order to make the most of these resources. Accordingly, specific teaching strategies are proposed for each field: Geology, Crystallography, Natural Sciences, and Archaeology. These strategies have been designed and tested by professors with significant experience of each field.

2.2 Photogrammetry models

A dedicated photogrammetry setup was developed, including a portable lightbox, diffuse annular lighting, an automatic rotatory platform, and a camera Canon 2000DK. Photogrammetric reconstructions were obtained using Agisoft Metashape Standard Edition (Educational Licence). The developed models were uploaded to the Sketchfab platform (https://sketchfab.com/AHMAT-UVa, Figure 1). Moreover, already high-quality available models developed by other educational or research institutions were reviewed, selecting the most representative for their use as virtual educative resources.

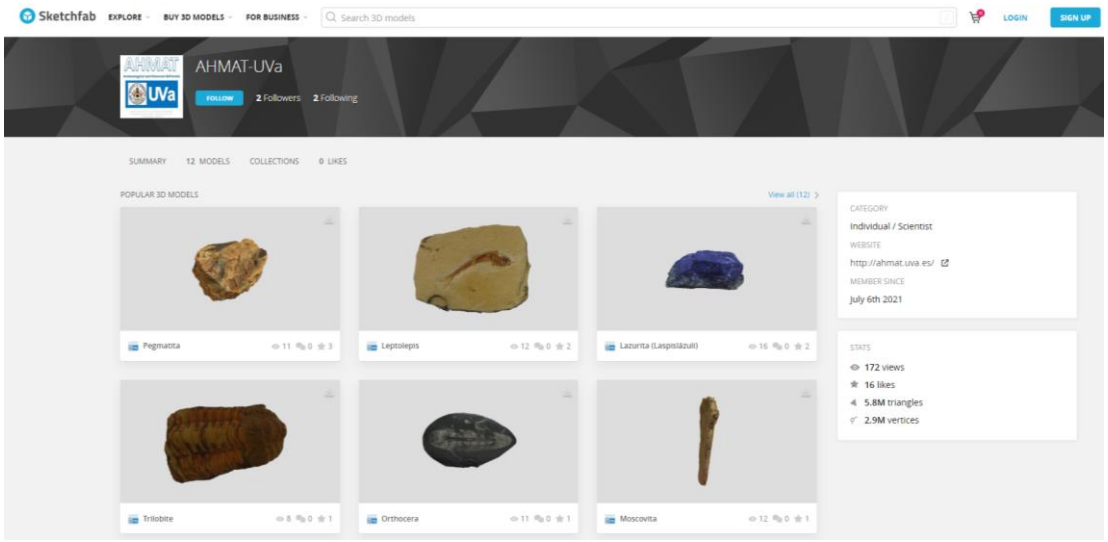

Figure 1. Preview of the AHMAT-UVa site on Sketchfab.

3 RESULTS

3.1 Teaching strategies incorporating virtual resources in Geology subjects

A previous work [3] already discussed the potential of high-quality three-dimensional models to develop self-evaluation activities, even creating simulations of the *visu* exams usually included in the competitive examinations for future Geology teachers. Accordingly, we will focus on the use of these resources during the development of face-to-face classes following pre-pandemic methodologies.

The use of virtual models favors the entrenchment of the theoretical concepts since it allows simultaneously visualizing the theoretical contents and the practical examples that demonstrate said concepts. Virtual models of minerals, rocks, and fossils have proven to be an invaluable resource for illustrating this diversity. For example, the various crystal growth habits (prismatic, acicular, colloidal, massive, etc.) or the types of luster (metallic, vitreous, resinous, etc.) in the scope of minerals; the degrees of metamorphism or the different types of clastic rocks in the ambit of petrology; or the different morphological elements of a fossil or the most significant members of a paleontological family. Hand specimens are the ideal methodology, but usually in educational centers it is not easy to have "specimen collections" that show all the existing variabilities, so the use of these virtual resources will help alleviate this deficit (Figure 2).

a) 

b) 

Figure 2. Example of models of Quartz available at Sketchfab: (a) https://sketchfab.com/3d-models/perfect-bipyramidal-smoky-quartz-macro-ba30cf203b4d4d169d0025e3b7d4b2d1, (b) https://sketchfab.com/3d-models/cristaux-de-quartz-8a6c7eaa97ab4df38a49899f14a4a9df.

Moreover, the possibility of using 3D models platforms (e.g., Sketchfab) in portable devices have proved to be useful during the classes. Instead of just showing a model in the screen, it is possible to

provide the students the link to the model (e.g., through a QR code in the screen) allowing them a close visualization of the model and free interaction possibilities.

Finally, aiming to strengthen the available models for both self-evaluation and teaching activities, it is possible to propose the students to perform a search of new 3D models available in diverse repositories during the laboratory practices. In this way, the students are involved in the generation of a database of which they are the first beneficiaries.

3.2 Teaching strategies incorporating virtual resources in Natural Sciences subjects

The developed virtual resources have been not only employed in teaching activities with future Geology professors, but also with future kindergarten and primary teachers in Natural Sciences subjects. The objectives and extension of the topics related to Geology and, in particular, to minerals, rocks, and fossils are significantly more concise. However, the 3D models could be used in the classes related to these topics.

Particularly, the 3D models are useful to exemplify during the classes features such as the habit of the crystals, being a significant improvement regarding the use of pictures. On the contrary, a more extensive use of the 3D models in portable devices during the classes proved to be inadequate, dispersing the attention of the class and providing to many examples and resources for the time dedicated for these topics.

However, these resources were again effective when used in combination with actual samples during the laboratory practices. The possibility of comparing the samples with the 3D models employed in class as example of certain habits or features helped the students to properly identify the features of the samples.

3.3 Teaching strategies incorporating virtual resources in Crystallography subjects

The use of the 3D models of minerals in Crystallography subjects is complementary to the description of the crystallographic structures, allowing to illustrate the origins of the Crystallography and how in quality single crystals it is possible to relate their geometry to those of their unit cell. Moreover, during the laboratory practices some minerals are characterized by techniques such as infrared or Raman spectroscopy or X-ray diffraction, but most of the available samples are powder samples. Currently, when it is not possible to provide an actual sample of the studied mineral, a link to a 3D virtual model of the mineral is provided to the students to allow a correlation between the experimental results obtained with those techniques and the actual aspect of those minerals.

3.4 Teaching strategies incorporating virtual resources in Archaeology subjects

As mentioned in the introduction, the virtualization of archaeological heritage is a priority in the EU for the next years. Hence, developing teaching strategies taking advantage of such virtual resources could have a significant impact and broad application.

The use of photorealistic 3D models, some of them even compatible with virtual reality environments, has proved to be a powerful tool in the teaching or Archaeology or History subjects. Particularly, the accessibility of these models with portable devices allows to perform an interactive guided explanation, promoting the engagement of the students with the lessons and improving the understanding of the archaeological remains under study.

In addition, two potential practical activities using these 3D models are proposed, both related to the documentation of archaeological findings. First, the models can be used to practice the documentation of archaeological samples using photography (which can be “simulated” by taking screen captures with the proper perspectives of the models) or drawing (Figure 3). In this way, all the students can access the same elements to perform such practical exercises, not being limited to the collections available at the University or local museums. The possibilities of elements to study that offer this activity are almost limitless, as several museums currently offer a wide selection of samples in virtual repositories (e.g., the British Museum (https://sketchfab.com/britishmuseum) or the Spanish National

Archaeological Museum (https://sketchfab.com/man), and EU policies will promote the availability of a huge number of virtual resources.

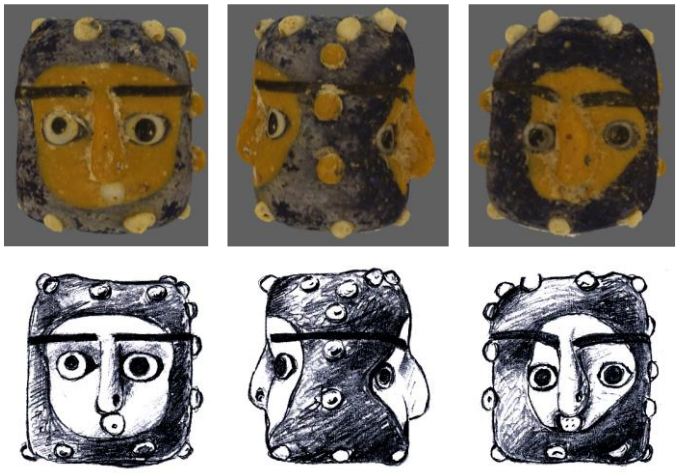

Figure 3. Example of photogrammetric model of an archaeological piece developed in this project (up) and its corresponding drawings (down). More information about this piece can be found in the literature [7,8].

The second activity is related to the documentation of the measurements of archaeological findings. Photogrammetric models can be scaled, being possible to perform accurate measurements directly on the models. Generally, virtual repositories offer some tools to perform measurements (Figure 4) or allow to download the models which can be opened with diverse open-source software to perform the measurements. Even when a model could be not correctly scaled, it would be possible to perform the measurements knowing any of the dimensions of the piece, which will be taken as a reference to calculate the actual values for the performed measurements. Once again, the wide availability of resources and the simultaneous access to any of them available for all the students make this activity of interest for the training of future archaeologist.

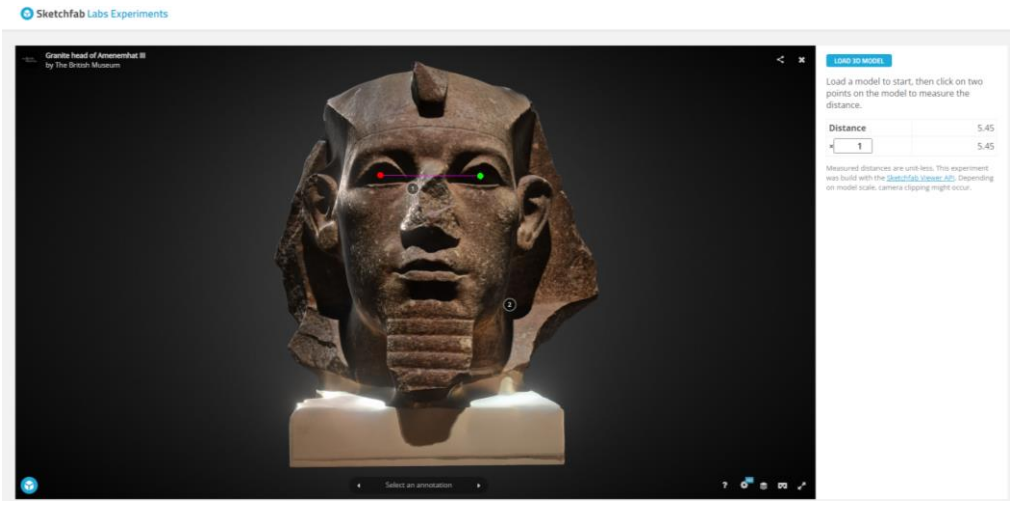

Figure 4. Example of measurements performed at the Sketchfab platform over a model available by the British Museum

4 CONCLUSIONS

The development and implementation of teaching strategies combining virtual resources initially developed for on-line education with the pre-pandemic face-to-face methodologies have proved to be successful. These resources have been introduced in Geology, Crystallography, Natural Sciences, and Archaeology subjects, adapting their use or teaching strategies to the particularities of each knowledge field, teaching objectives, and student's interests. In addition to their interest in Geology and Crystallography related subjects, proved in a previous innovation teaching project, this work evidenced the significant potential of these virtualization strategies and resources for the teaching of History and Archaeology, while at the same time these strategies promote the preservation of the original pieces.

ACKNOWLEDGEMENTS

Financial assistance from the University of Valladolid (PID2022_125) and Junta de Castile y Leon (VA210P20) is gratefully acknowledged.

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