Education and Heritage in the era of Big Data in Astronomy
Proceedings IAU Symposium No. 367, 2020
R. M. Ros, B. Garcia, S. R. Gullberg, J. Moldon & P. Rojo, eds.
doi:10.1017/S1743921321001058

Creation of a MOOC and an Augmented Reality application on exoplanets for the Exoplanets-A project

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Abstract. The European Exoplanets-A project aims to provide a comprehensive view of the nature of exoplanet atmospheres, through an interdisciplinary approach.

Exoplanets-A includes a knowledge server where we provide the scientific results and educational resources gathered and developed during the project. In this proceedings, we present two such educational resources: a MOOC and an augmented reality application.

Keywords. Exoplanets-A, MOOC, Augmented reality application

1. Introduction

The last twenty years have witnessed an exceptionally fast development in the field of extra solar planets (exoplanets). While the detection of exoplanets is an ongoing process, the characterization of their atmospheres has just begun and is developing very rapidly.

The European Exoplanets-A project(Pye *et al.* 2020) aims to provide a comprehensive view of the nature of exoplanet atmospheres, through an interdisciplinary approach, which includes the integration of state of the art models of the star-planet interaction, atmospheric chemistry and dynamics, and planet formation.

The Exoplanets-A knowledge server (www.explore-exoplanets.eu) provides scientific and educational resources through two main pages: the Science page and the Learning page. The science page includes a knowledge base with direct access to all of the project's scientific products, such as novel methods, tools, and databases for characterizing exoplanet atmospheres. The Learning page was designed for the general public with educational resources based on the science products: videos, online courses, serious games, etc.

Within the Exoplanets-A context, we have developed a MOOC (Massive Open Online Course) on exoplanets as well as an augmented reality (hereafter "AR") application about the Solar System, exoplanets, and the James Webb Space Telescope.

2. MOOC description

Our MOOC is located within the Learning page of the knowledge server under the Online courses section (cf. www.explore-exoplanets.eu/course/mooc-exoplanets).

Through this MOOC, we invite users to acquaint themselves with the surprising universe of exoplanets. They will discover at their own pace their diversity, detection

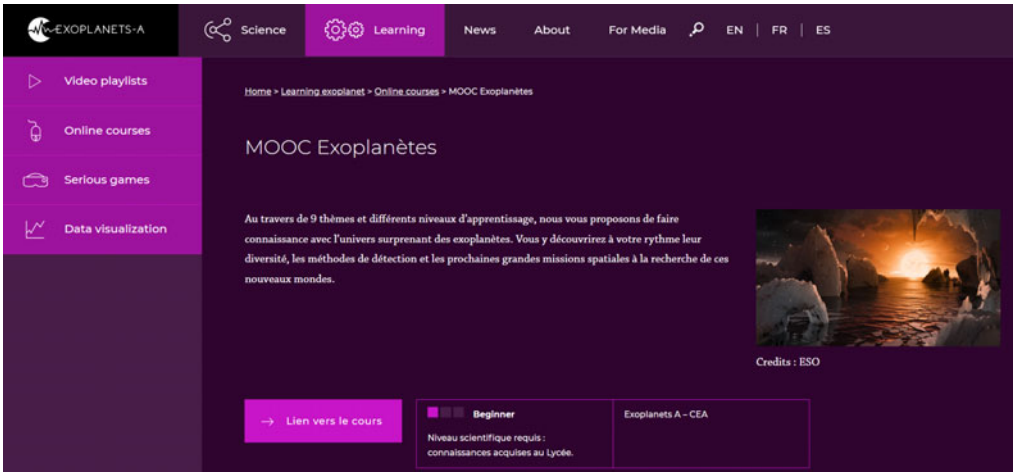

Figure 1. View of the MOOC page in the Learning/Online courses section.

methods, and the next major space missions searching for and analyzing these new worlds (cf. Figure 1). The MOOC is divided into 9 themes (or modules):

- Module 1 is the general introduction to MOOC and the topics covered;
- Module 2 compares the planets of our Solar System with exoplanets, illustrating the amazing diversity of exoplanets;
- Module 3 provides notions of astronomy: overview of the different objects in the Universe and the distances between them;
- Module 4 addresses the stars, including ours (the Sun), their diversity, and their evolution over time;
- Module 5 presents the instrument with which we observe the Universe: the telescope. Understanding how it works and its limits is essential to grasp the difficulty of detecting exoplanets;
- Module 6 is dedicated to exoplanetary atmospheres: how do we observe them and what is the point of studying them?
- Module 7 presents the concept of habitability / climate of exoplanets and therefore the essential duo: star-planet. We also discuss exobiology.
- Module 8 focuses on the Trappist-1 stellar system. This system acts as a practical case compared to the previous modules.
- Module 9 opens onto future space missions and the complexity of interstellar travel. The in-depth part is dedicated to the future large space telescope: the James Webb.

Each module is divided into two or three difficulty levels (cf. Figure 2). The first one contains the main notions that people should retain, as well as a quiz allowing the learner to test him/herself. The other difficulty levels include more details; the learner can thus go deeper into the subjects that interest him/her the most.

Each level systematically contains external resources, with links to other educational content. We propose a wide range of educational content from both national and international research institutions (e.g., NASA, ESA, CNRS, CNES, CEA), in several different formats for a more entertaining approach. For instance, there are videos, scientific articles, serious games, conferences, citizen science, etc. Therefore, the originality of this MOOC is to bring together and organize pre-existing educational content.

Finally, this MOOC is open and free, without any subscription needed. Everyone can use it to learn about exoplanets or to get access to teaching and outreach resources.

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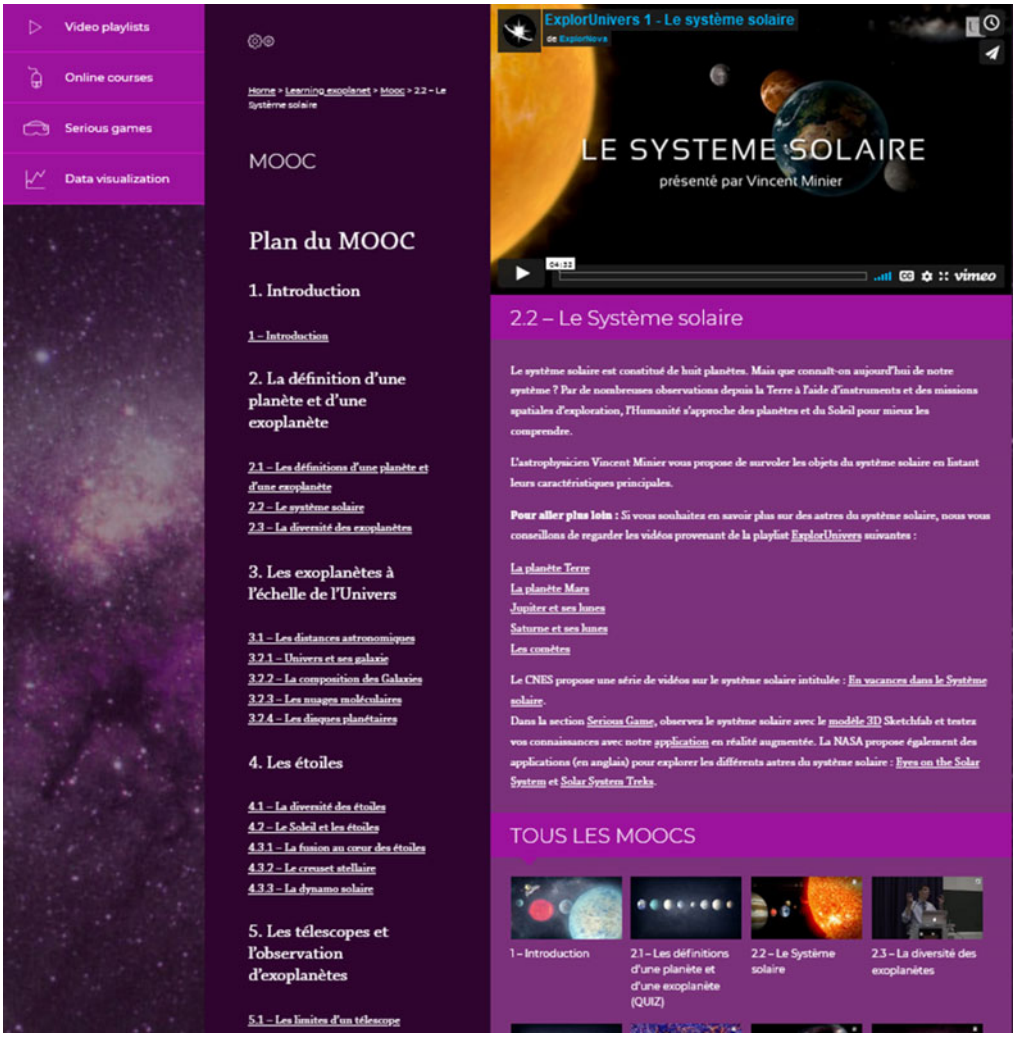

Figure 2. View of the MOOC outline.

To sum up, we propose a Massive (everyone can see it), Open (without registering or even leaving any contact), Online (on our knowledge server), Curated (resources has been curated and aggregated), Course (with learning outcomes and self-corrected quiz) : a MOOC^2.

In March 2021, an English and Spanish version will be also available.

3. AR application description

Within the Learning page, there is a section called "Serious games". A Serious Game is a tool using new technologies to teach in an entertaining way. Increasingly used, it is an excellent pedagogical tool.

With this intention, we developed an augmented reality application offering an interactive discovery of the diversity of exoplanets through 3D simulations (see www.explore-exoplanets.eu/game/augmented-reality-app/). The users can explore two extra-solar systems: 51 Pegasi, the first exoplanet system discovered, and Trappist-1, the famous 7-exoplanet system. There is also the possibility to explore the solar system

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Figure 3. Use of the Augmented Reality application during the 2019 summer tour of the SpaceBus France association (Credits: SpaceBus France).

for comparison (cf. Figure 3). Finally, the user can discover a future Space mission: the James Webb Space Telescope. Three levels of discovery are proposed:

• Exploration: users can go through 3D models of the Solar System, two exoplanetary systems, and the JWST. Each model includes clickable points of interest, which open a detailed description.

• Self-assessment quiz: users are then invited to evaluate their knowledge by answering quiz questions.

• Evaluation of these answers: finally users can check their answers by revisiting the 3D models.

This application is for the moment only available in French and for Android platform. The application and its image marker are downloadable on the Exoplanets-A website. The printed image marker allows to use the app and "anchor" the scene in the room.

Our augmented reality application was broadly used by the French scientific outreach association SpaceBus France. This association proposes several astronomy-themed activities presented by professional astronomers for the general public. In 2019, during its month-trip throughout France, SpaceBus France proposed this AR application to more than 7000 people. Thus, it has already successfully been tested with public of different ages and backgrounds.

4. Acknowledgment

The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement n° 776403.

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