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A Place for Space: The Shift to Online Space Education During a Global Pandemic

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The COVID-19 global pandemic has transformed the relationship between science and society. The ensuing public health crisis has placed aspects of this relationship in harsh relief; perceptions of scientific credibility, risk, uncertainty, and democracy are all publicly debated in ways unforeseen before the pandemic. This unprecedented situation presents opportunities to reassess how certain disciplines contribute to the public understanding of science. Space education has long provided a lens through which people can consider the intersection of the natural world with society. Space science is critical to understanding how human activity and pollution affect global warming, which in turn, inextricably links it to perceptions of the natural world, environmental change, science communication, and public engagement. The pandemic has caused a dramatic shift in how space education projects connect with public audiences, with participation pivoting to online engagement. This transition, coupled with the renewed societal examination of trust in science, means that it is an ideal time for the field of space education to reflect on its development. Whether it evolves into its own distinct field, or remains an area that straddles disciplinary boundaries, such as science education, communication, and public engagement, are crucial considerations when scientific trust, accountability, and responsibility are in question. This paper describes the current state of space education, recent advances in the field, and relevant COVID-19 challenges. The experience of an international space education project in adapting to online engagement is recounted, and provides a perspective on potential future directions for the field.

Keywords: space education, online learning, COVID-19, science communication, public engagement

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INTRODUCTION

Space education has had a longstanding role in human-centred knowledge and learning. This understanding of humankind's place in the cosmos has been central to philosophical interpretations of the world since antiquity (Lindberg, 1992; Grant, 2007). Space has been included in education, in some form, since natural philosophers raised their gaze to the night sky and shared their thoughts in the informal gatherings that predated schools (Evans, 1998;

Weinberg, 2015). In modern society, the role that space education plays in our comprehension of the natural world continues to be crucial, from understanding climate change and the type of planet that future generations will inherit (Cooke, 2012), to providing new tools and intellectual contributions that have the potential for "profound technological and political influence" (Courvoisier, 2017, p. 19). This coincides with advances in the field of space education, including new initiatives, projects, journals, and courses (Impey et al., 2015). The dramatic increase in the number of educational mobile applications (apps) for phones and smart devices (Pechenkina, 2017; Zack et al., 2018), has especially benefited the space education community with home-astronomy accessible across languages and the urban-rural divide (Fraknoi, 2011; Gill and Burin, 2013; Heafner, 2019). While online learning has long been significant to space education (Margoniner, 2014), the COVID-19 pandemic has caused the most substantial shift of global educational resources to digital tools that has been witnessed in recent memory (Amemado, 2020; Chen et al., 2020; Dhawan, 2020; Sun et al., 2020).

This paper examines the place of online space education in the context of a global pandemic. The current state of the field of space education is examined in terms of the published literature and the recent growth of international projects and initiatives. The ways in which science is communicated in the time of a global health crisis has blurred the boundaries between formal and informal science education. The Programme for International Student Assessment (PISA), coordinated by the Organisation for Economic Co-operation and Development (OECD), has demonstrated the challenges in assessing, not just informal science education, but all outside-school-time educational activities (Bray et al., 2020). The Teaching and Learning International Survey (TALIS), also coordinated by the OECD, has demonstrated, in conjunction with PISA, the diversity of challenges affecting schools in many parts of the world, for example, the US (Zhang et al., 2020), Latin America (Solano-Flores, 2019), and East Asia (Komatsu and Rappleye, 2017).

This paper highlights an international space education project, spaceEU, that was carried out in Europe where, despite the different circumstances across the continent, there is not the same complexity of issues facing education as there is in other parts of the world. The experience of spaceEU is described through the lens of a sudden shift to online education and the circumstances that caused a major change in the implementation of the project. It is hoped that these insights will help science communication researchers, practitioners, and educators to learn from the challenges and opportunities that arose during the pandemic and to start a discussion about the future directions of the field of space education. The pandemic has resulted in a global call for renewed trust in science and it is up to the researchers, educators, and policy-makers working in science around the world "to seize this opportunity to build on that trust" (Andrews-Fearon et al., 2020, p. 456).

THE STATE OF THE FIELD OF SPACE EDUCATION

It has been more than two decades since Zeilik et al. (1997) shared their ideas for teaching astronomy concepts at higher education institutions in the US. In parallel to this work, Sadler (1992) investigated space education at post-primary level, and later developed the astronomy and space science concept inventory for high schools in the US (Sadler et al., 2010). At the same time, in Europe, Ottavianelli and Good (2002) described the "status quo of space education" where both post-primary schools and higher education institutions did not, at that time, consider space education as being important enough to play a role in the education of young people as preparation to face a rapidly changing society and uncertain career decisions (p. 125). Bailey and Slater (2003) highlighted how, despite the overall growing area of space and astronomy learning, not enough attention was being given to relating theory to practice in the field. This was reiterated by Pelton et al. (2004) who felt a clear connection "between the educational community (i.e. the primary and secondary schools as well as colleges and universities)" and a space research agenda "supported by the space industry" was a top recommendation for space policy (p. 197).

Pompea and Russo (2020) highlight the social responsibility of space education—that it should not only contribute to a more literate society, but to a more equal and inclusive society by "engaging students from diverse, underprivileged, and underreached communities and those who are underrepresented in the professional science enterprise" (p .348).

Efforts to integrate contemporary space science with space education research and practice are most obvious in the work of the space agencies and international societies. The US and European space agencies, NASA and ESA, are committed to public education and engagement through the NASA office of space science education and public outreach (Rosendhal et al., 2004) and ESERO—the European space education resource office (Clements and Mather, 2012). In terms of societies and associations, the International Astronomical Union (IAU), established in 1919 (Blaauw, 2012), remains the torchbearer for promoting research, education, and public engagement with space. While education is supported by more general astronomy societies, such as the Astronomical Society of the Pacific, the IAU leads the field of space education, even after the establishment of the European Association for Astronomy Education in 1995 (Reichen, 2006). This work has been supported by the establishment of academic and professional journals; in 2001 the "Astronomy Education Review" was launched (Fraknoi and Wolff, 2001), followed in 2007 by "Communicating Astronomy with the Public" (Christensen and Russo, 2007). In 2019, the IAU Office of Astronomy for Education was established at the Max Planck Institute for Astronomy in Heidelberg, Germany, with the goal of supporting professional astronomers and astronomy educators worldwide as they use astronomy for STEM (Science, Technology, Engineering and Mathematics) teaching and education from elementary to high school level (OAE, 2021). Large-scale studies of school students' perceptions of space have demonstrated the complexity of the relationship that young people have with space, and how it compares to other areas of science. In general, young people demonstrate clear enthusiasm for space science regardless of age or gender, although interest in pursuing a career in the space industry does follow traditional gendered patterns seen in other areas of the physical sciences (DeWitt and Bultitude, 2018).

INTERNATIONAL SPACE EDUCATION PROJECTS

A number of international space education projects, both ongoing and completed, have significantly advanced awareness of, and interest in, the field in the last 2 decades. Almost 420,000 people from 61 countries took part in "Universe Awareness" (UN-AWE) which was established in 2004 to help underserved children engage in astronomy and space science. The project received €2 million from the European Commission from 2011 to 2013 to inspire curiosity about the Earth and the universe, building on the "International Year of Astronomy 2009" (IYA 2009)—a landmark programme in space education that sought to raise awareness of the impact of astronomy in daily life, and to demonstrate how scientific knowledge can help bring about a more equitable society. An initiative of the International Astronomical Union (IAU) and the United Nations Educational, Scientific, and Cultural Organization (UNESCO), IYA2009 raised in excess of €18 million to fund activities around the world. More than 815 million people across 148 countries took part in activities at local, regional, and international levels. From 2015 to 2018, a follow-up project, "EU Space Awareness", conducted activities with over 107,000 people across 68 countries. The goal of EU Space Awareness was to provide free, high quality educational tools and resources to engage educators and children from 8 to 18 years of age in science, with a focus on space. In 2018, two new projects—"Our Space, Our Future" and "spaceEU"—received a combined €2.2 million from the European Commission's Horizon 2020 funding programme to foster interest in space in young students. Together, the two projects brought space and education expertise from partners in nine countries and sought to empower citizens and students to establish a space education community in Europe.

ONLINE SPACE EDUCATION: THE SPACEEU EXPERIENCE

The spaceEU project was in the process of implementing an ambitious programme of space education events across ten European countries when the COVID-19 pandemic struck (Roche et al., manuscript in review)[1]. The pivot to digital engagement resulted in half of the school visits, teacher professional learning engagements, exhibitions, and workshops being reimagined as online space education events. The new programme of online events combined formats such as webinars, interactive workshops, and online competitions. Webinars focusing on the intersection between art and space science brought together astronauts, astronomers, and artists speaking their native languages, including Arabic, Dutch, and French. A series of "Space in the Classroom" events—wherein space professionals would visit schools to participate in discussions and share career experience and advice with students—were more easily adapted to the online environment through webinar software. Central to the spaceEU public engagement activities was a modular "Step into Space" exhibition. Although it was designed to be relatively low-cost and portable in comparison to more traditional science centre exhibits, the original format would still have required onsite installation by museum professionals. The pandemic adaptation resulted in a digital version of the exhibition that could be printed on a standard home colour printer. The exhibition was made publicly available as part of a toolkit, with easy-to-assemble instructions and a range of suggested educational activities (spaceEU, 2021a). A virtual reality version of the exhibition was also developed in a Greek school and was found to be more popular than the home assembly version for some students (spaceEU, 2021b). This was in keeping with the wider pattern of uptake in virtual and augmented reality exhibitions within the museum sector during the pandemic (Agostino et al., 2020; Natalia, 2020).

The pivot to online engagement was not without its challenges. Reflecting on the shift to digital engagement, project partners found that the biggest loss to the project was human interaction in a physical space. The difficulty of establishing rapport through distance learning has been a continual issue for educators, and reinforces the need to focus on social presence during virtual events (Gunawardena and Zittle, 1997; Cobb, 2009). For the spaceEU project, more emphasis was given to interactivity and dialogue during the online events. Project partners found that the younger, primary school aged students were highly capable of remote engagement despite the presence of screens in place of facilitators. However, the post-primary students were less willing to engage in the activities to the same extent that would be expected in person. In their final reflections on the project, spaceEU partners also highlighted that although online engagement allowed new groups to be reached, there were others who may have missed out, highlighting a persistent social inclusion challenge for online education (Notley, 2009). Additionally, the pandemic caused both formal and informal education (Tamir, 1991) to occupy the same kinds of digital roles in the lives of young people. Increased computer and device screen time for young people was already a health concern (Mark and Janssen, 2008) and only became more complicated with the onset of school closures caused by the pandemic (Nagata et al., 2020).

Despite these challenges, the shift to online events presented opportunities and unexpected benefits. The original intention, to augment the exhibitions in each location with student contributions was effectively reversed, with the exhibitions instead

[1]Roche, J., Bell, L., Hurley, M., Jensen, A. M., Jensen, E. A., Owens, B., et al. (2021). Perceptions of the European Space Sector: Youth Engagement with Space Education Events. manuscript in review.

becoming the creative backdrops for the students to explore co-creation and storytelling. With the closure of museums and galleries, spaceEU partners looked for new locations to present and support the downloadable exhibition. In Ireland, for example, efforts were concentrated on one geographical region—a remote island community in the northwest of the country and a nearby school on the mainland. In contrast to the rest of Ireland, where English is the primary language, this northwestern community represents a minority of the population (1.7%) where Irish is spoken on a daily basis and is the main language in schools (Central Statistics Office, 2016). While a local community centre was initially earmarked as a viable exhibition location earlier in the pandemic, the increasing restrictions resulted in a new location being chosen—the ferry that runs between the island and the mainland—where the school students and the rest of the local community would see the exhibition every day. Due to the geographically remote location, it would not have been feasible for the project team to engage such a community in person, while funding constraints would have seen school visits limited to the greater Dublin region. The online pivot meant that an underserved community—in this case a minority-language island community on the Atlantic coast of Europe, where engagement in space education is significantly less accessible—became the focus of the project team's efforts. Four online workshops were carried out with this same student group over the national Science Week (November 13–17th 2020) in an effort to ensure meaningful engagement. Having the freedom to include speakers and facilitators from any part of the world, rather than relying on in-person availability, also created unique opportunities. For example, in one of the "Space in the Classroom" webinars, a senior astronomer working in Canada—who was a past pupil of the northwestern Irish school and had a nephew in one of the classes—attended the session as a special guest. Involving such a space professional, who students identify with, can be invaluable in helping students consider potential career prospects in the space sector.

DISCUSSION AND CONCLUSION

Online learning has been a mainstay of modern education for decades (Harasim, 2000). Schools and universities have been advised to provide more online education opportunities for their students to engage in real-time, synchronous learning, as well as offline, asynchronous learning, since long before the onset of the pandemic (Nieuwoudt, 2020). The arrival of the pandemic, however, heralded a new era in online science engagement. This was especially apparent in the field of space education, which has grown dramatically in recent years through the spread of pan-European projects engaging young people. The pandemic resulted in a dramatic shift in how these kinds of projects can be implemented, with almost all activities taking place virtually rather than in more traditional forms of public engagement. Given this shift towards online engagement, the field of space education is at a critical phase of development. It is clear that both formal and informal education can play important roles in how young people engage with space science and astronomy (Anjos and Carvalho, 2020). The blurring of the boundaries between formal and informal education, caused by the pandemic, presents the field of space education with an opportunity to consider its future development. With the growth in projects, initiatives, and funding, space education might have reached a critical mass where it can now be recognised as its own distinct discipline—a field of research as well as practice. This would bring the benefit of being able to tackle specific challenges faced by the field, such as removing the "intangible barriers that stand in the way of inclusion" (Russo et al., 2019, p. 19). Alternatively, retaining its ability to transcend disciplinary boundaries could see the field of space education offer more potential accessibility for public engagement with science, which might be critical in helping to foster societal trust in science through a continuing public health crisis. Either way, the future of space education in a post-pandemic landscape is likely to be intertwined with developments in the field of online engagement.

An instructive analogue for space education, and how it might adapt to a post-pandemic environment, is the development of the field of citizen science. Citizen science has existed in some form or other as long as space education (Roche et al., 2021b) and its transdisciplinary nature has caused wide-ranging challenges for its integration into formal education (Roche et al., 2020). The tipping point for the evolution of modern citizen science was its early adoption of online engagement, which transformed it from a niche field of research and practice to a global phenomenon engaging millions (Bonney, 2014). In the case of the spaceEU project, shifting to an online setting meant it became easier to identify and involve space professionals around the world. With appropriate planning and consideration of time zones, event organisers were not limited to local or national expertise. The reduction in travel requirements allowed the project team to shift the focus of some events to more underserved communities and to include more languages. As is the case with citizen science, language accessibility is vital in any large-scale online science engagement as the terminology will be greatly affected by cultural contexts (Eitzel et al., 2017).

While online engagement can help students feel that there is some normality in their learning experience—invaluable to those struggling with mental health issues exacerbated by the pandemic—it can also cause problems for students who may not have easy access to reliable broadband infrastructure, or even consistent access to a computer. As has long been the case with online engagement—students with the greatest learning needs are likely to be the ones who face the biggest challenges in gaining equal access (Barraket and Scott, 2001). For space education to fulfil its potential to strengthen the relationship between science and society, it will have to overcome the digital divide and ensure a socially inclusive field of online engagement (Ramsetty and Adams, 2020). The space education community, like every public engagement field that was transported online in a public health crisis, faces new responsibilities in how to communicate science in uncertain times. The first challenge is how to provide better, more equitable, learning access and support for those who need it most (Retrê et al., 2019).

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

JR led the conceptual design of the manuscript, while LB, MH, and JR wrote the initial drafts. GD, BO, AJ, and JG contributed to subsections of the manuscript while EJ and PR provided critical guidance on the text. PR and JG co-led the conceptual design of the intervention. All authors reviewed the manuscript and provided comments and feedback.

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