



Perceptions of the European Space Sector: Youth Engagement With Space Education Events

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OPEN ACCESS

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Specialty section:

This article was submitted to
STEM Education,
a section of the journal
Frontiers in Education

Received: 31 July 2021

Accepted: 04 November 2021

Published: 29 November 2021

Citation:

Roche J, Bell L, Hurley M, Jensen AM, Jensen EA, Owens B, D'Arcy G, González JR and Russo P (2021) Perceptions of the European Space Sector: Youth Engagement With Space Education Events. *Front. Educ.* 6:750952. doi: 10.3389/feduc.2021.750952

Space education not only plays a key role in helping young people understand the natural world and their impact on the planet but is also vital in ensuring that future generations can make meaningful contributions to the space sector at all levels. Positive perceptions of the space sector can lead young people to take roles where they can contribute to new knowledge, develop new technologies, and tackle societal challenges. As the relationship between science and society is tested by global events—such as climate change and the COVID-19 pandemic—scientific trust and accountability have become topics of frequent and public debate. The way in which young people engage with space education and perceive their potential involvement with the space sector is of greater importance now than ever before. This paper describes a two-year European space education project that was carried out before and during the COVID-19 global pandemic. An evaluation of the project activities showed that young people are generally enthusiastic about space, but their perceptions of the European space sector—and their connections to it—are less positive. Recommendations are made on the challenges facing the space sector and how it needs to adapt to better support the development of a more inclusive space education community.

Keywords: space education, science and society, social inclusion of youth, science communication, public engagement, informal learning, european space sector, community engagement

INTRODUCTION

Perceptions of science are affected by a myriad of background factors such as education, media, culture, and family life (Schibeci and Riley 1986; Bauer et al., 1994; Nisbet et al., 2002; Davies and Horst, 2016). These same background factors contribute to perceptions of space science and astronomy, and may affect how young people, in particular, self-identify and consider future careers (Jensen and Jensen, 2019; Anjos and Carvalho, 2020). Ideas about space are formed at a young age with children openly displaying curiosity about astronomical phenomena (Kallery, 2011). Through hobbyist participation in the form of amateur astronomy (Hayes et al., 2020) and citizen science (Cox et al., 2015), space education can be more accessible than some scientific disciplines, and with its presence in art (Milbrath, 1999; Carlson et al., 1999) and pop culture (Consolmagno, 1996) remains of interest to people regardless of age or cultural background (Selin, 2000; Nobes et al., 2003).

TABLE 1 | Recent international space education initiatives available to young people.

Initiative name	Host organisation	Activity type and reach	Website link
Universe Awareness (UN-AWE)	Leiden University	An initiative to use astronomy as a tool to inspire that ran from 2004–2013. Began in Europe and expanded to more than 45 countries. Funded €2 million from the European Commission from 2011–2013	www.unawe.org
International Year of Astronomy 2009 (IYA 2009)	International Astronomical Union (IAU) and UNESCO	A global programme of events and activities in 2009 that raised more than €18 million to reach 815 million people across 148 countries	www.astronomy2009.org
EU Space Awareness	Leiden University	A successor to UN-AWE that ran from 2015–2018 and reached more than 107,000 people across 68 countries	www.space-awareness.org
Our Space, Our Future	Cardiff University	Funded €1.2 million from the European Commission from 2018–2022 to promote careers related to space science. Aims to engage over 60,000 people with 5,000 students participating in workshops in four European countries	ourspaceourfuture.eu
spaceEU	Leiden University	Establishing a European space education community by combining a programme of public engagement activities, professional development for educators and advocacy. Funded €1 million from the European Commission from 2018–2020	www.space-eu.org

As space education is a field where perceptions can be shaped by comparing and contrasting personal experiences with contemporary scientific knowledge (Hannust and Kikas, 2007), longer term, repeated engagements are likely to deepen understanding and stimulate independent exploration and learning, as they do in other areas of science learning (Bevan et al., 2015). Although misconceptions about space are commonplace among children, as well as among the parents and teachers educating them (Dunlop, 2000; Schoultz et al., 2001), there is a long-held belief that giving young people the tools to investigate and test their own perceptions about space can be constructive: “by adopting a teaching strategy in which our pupils are given an opportunity to challenge their own explanations, much of the astronomical ignorance that appears to pass into adulthood can be avoided” (Baxter, 1995, p. 176).

Since the Apollo missions of the 1960s, there has been an ongoing commitment from the space sector to engage the public (Scott and Jurek, 2014). At the 2012 International Astronomical Union General Assembly, a survey of 155 participating professional astronomers found large-scale support for the importance of public engagement (Dang and Russo, 2015). In 2016, a survey of 2,587 members of the International Astronomical Union, 87% of participants reported regularly engaging with public audiences (Entradas and Bauer, 2019). In recent years, several international space education projects have attempted to provide such learning opportunities while simultaneously promoting careers in the European space sector (Roche et al., 2021a). During one such project, DeWitt and Bultitude (2018) carried out a large-scale study of perceptions of space careers among 8,000 school students (between the ages of 9–16) across 11 countries in Europe and found that young people expressed positive attitudes towards space careers regardless of age or gender. **Table 1** catalogues some of the recent large-scale space education initiatives that have originated in Europe.

While progress has been made in raising awareness of space science and its role in society, there remain challenges in how public audiences engage with space (Smith, 2003; Cominsky, 2018). Like many other areas of science (Bernard and Cooperdock, 2018), space education still has a long way to go to reach diversity goals (Sokol,

2016; Primas, 2019). This is particularly important for young people when it comes to realising their career aspirations (Goodkind, 2009) as well as identifying role models and overcoming barriers (Jacobs, 2005; Hazari et al., 2013). As with most areas of science, removing the inherent structural inequalities faced by those who have minority ethnic backgrounds or lower socioeconomic status is an enduring challenge (Dawson, 2018).

Given the increasing importance that the space sector will play over the coming decades in addressing the technological and sustainability challenges facing society (Metzger, 2016), it is important to understand young people’s perceptions of space-related career choices and any potential barriers they face. This paper shares summary results from a large-scale space education project called “spaceEU” (European Commission, 2021) which reveals the perceptions young people had about the space sector before and during the COVID-19 global pandemic.

METHODS

Despite the growing number of large-scale space education programmes (Roche et al., 2021a), there remains some debate over the theories of learning underpinning astronomy and space education in informal environments (Kovalenko, 2019; Anjos and Carvalho, 2020). Constructivism is one of the most common theories of learning that provides the theoretical foundation for events where public audiences engage with science (Stockmayer et al., 2010; McCauley et al., 2018), and for young people engaging in space and astronomy in informal learning environments, social constructivism—whereby learning is mediated through social interaction with teachers, educators, and peers—is often the learning theory that underpins the activities (Vygotsky, 1978; Kallery, 2011). The aim of the spaceEU project was to foster a space education community for young people in Europe and it set out to achieve this by implementing a programme of social constructivist activities designed to educate, engage, and encourage young people to better understand the role of European space science, including its benefits to society as well as potential career paths within the field.

The programme of activities focused on the inclusion of the arts within the more traditionally linked subjects of science, technology, engineering, and maths, which has become an emerging field of combined disciplines referred to as STEAM learning (Liao, 2016; Roche et al., 2021b; Mejias et al., 2021). From late 2018 until the end of 2020, the spaceEU project connected with people through 244 activities conducted in 10 countries across Europe, laying the foundations for an inclusive and diverse space education community in Europe. The activities highlighted the past and present contributions of women and minorities to the growth and development of the space sector and included exhibitions, workshops, debates, open calls, and informal conferences. The full list of activities is available as a publicly accessible and ready-to-use digital collection of space-centred activities (spaceEU, 2021a).

Surveys were chosen as the standardised research method for collecting quantitative and qualitative data (Jensen and Laurie, 2016) to help address the question of how young people perceive the European space sector. An evaluation framework was designed that combined the project outcomes being sought with best practice in the field, drawing on previous examinations of attitudes towards space (Smith, 2003; DeWitt and Bultitude, 2018) and the recent international space education projects shown in **Table 1**. The survey questions were selected by drawing on validated questions from previous studies of space education (Jensen and Jensen, 2019). While the survey parameters were being considered, feedback forums were established among the project partners so that all team members responsible for evaluating the spaceEU activities could report on their efforts and provide an overview of the scale of the evaluation task. This internal, continuous feedback mechanism ensured that the development of the research instrument was iterative and based on the needs of the participants and facilitators as well as being cognisant of the different contexts across countries.

After piloting, testing, and validating the survey with focus groups and field observations, the survey was made available for use across the project consortium. The spaceEU goal of fostering a European space education community was addressed by ensuring that any research instruments used by the project would be publicly accessible so that other space education researchers in the field could benefit from the spaceEU experience and integrate the tools into their own work. The final version of the spaceEU survey instrument is publicly accessible in the spaceEU “Impact Evaluation Toolkit” (spaceEU, 2021b) and includes general evaluation advice and a range of sample questions adaptable for different evaluation contexts.

RESULTS

The COVID-19 global pandemic drastically impacted the number of participants who could complete the evaluation survey. As the spaceEU activities underwent a rapid shift from in-person to online events (Roche et al., 2021a), the event organisers and facilitators had to prioritise redesigned versions

of the events going ahead in the midst of a public health crisis rather than reminding participants to complete the evaluation survey. Evaluation of public engagement events can be limited even with long lead-in times and appropriate resources (Jensen, 2014), and while the spaceEU evaluation approach followed best practice in survey research, the reduced sample size was the main legacy of the pandemic.

Once the data were cleaned, the final sample, $N = 283$, represented just under 5% of the 5,942 potential participants. While the survey sample size was representative of the overall participants, there were some inherent biases. As more space education events took place in Portugal than other countries, 58% of all respondents were resident there (**Table 2**). The survey respondents were almost gender balanced (53% identified as girls) and most of the participants (81%) were younger than 18, directly addressing the project goal of involving more young women in space education activities. The respondents were also balanced in terms of participants who had or had not attended a science event in the past 12 months (46% reported they had) and, while limited, the sample provided a valuable insight into youth perceptions of the European space sector during a global pandemic.

In general, respondents reported positive attitudes when queried on their perceptions of the space sector. The majority found the space education activities they engaged in interesting (93%). Most respondents (89%) also reported some degree of familiarity with the space sector and, as shown in **Table 3**, chose positive sentiments to describe their feelings towards the idea of working in the space sector, such as “stimulating” (88%), “fascinating” (89%), and “interesting” (91%). The statement “women can help advance the space sector” was met with 90% agreement. Analyses were carried out to determine if there was any relationship between these perceptions and the demographic categories of the participants and no statistically significant trends emerged.

Despite these strong perceptions, several results clearly showed that there is still work to be done in improving perceptions of the European space sector and how it connects with young people. 25% of respondents either disagreed or felt neutral towards the statement “European society today benefits from the space programme”. Although this result demonstrates that the majority of participants held positive sentiments, a quarter of participants feeling neutral or negative is higher than the space sector should be comfortable with if it is striving to be inclusive and welcoming to all European citizens. Similarly high minorities were evident in terms of how the respondents described their personal connection to the space sector.

36% either agreed with or felt neutral towards the statement “Space professionals are not people like me”. A 23-year-old female who took part in spaceEU activities in Bulgaria provided a follow-up explanation for why she felt space professionals are not like her: “It seems that they have been passionate about space more than I am”. An 11-year-old male who took part in spaceEU activities in the Netherlands commented “I have been working on this topic for 2 months and my knowledge cannot be compared to professionals, because they have trained and gained certain knowledge”.

Only 51% of respondents felt the space sector in general has some relevance to their daily lives (30% stated they were unsure,

TABLE 2 | Demographic background of spaceEU survey respondents (N = 283).

Country of residence	Portugal (58%), Austria (8%), Poland (6%), Spain (5%), Ireland (5%), Germany (4%), Netherlands (2%), Hungary (1%), France (1%), the United Kingdom (1%), Romania (1%), Belgium (1%), other (7%)
Age	Under-18 (81%), 25–38 (5%), 18–24 (4%), 39–45 (3%), 46–52 (3%), 53–59 (2%), 60–66 (1%), 67–73 (1%)
Gender	Female (53%), Male (47%), Other (0%)
Education level	Secondary/High School (51%), Primary/Elementary (23%), Postgraduate (17%), Undergraduate (9%)

TABLE 3 | Attitudes towards working in space careers. This table shows the distribution of answers indicating the degree to which respondents felt working in a space career would be Interesting/Uninteresting (n = 229, mean = 2.27, mode = 3, SD = 1.35, variance = 1.83), Stimulating/Dull (n = 222, mean = 2.09, mode = 3, SD = 1.16, variance = 1.34), and Fascinating/Boring (n = 224, mean = 2.21, mode = 3, SD = 1.27, variance = 1.62).

	3	2	1	0	-1	-2	-3	-
Interesting (91%)	148	46	13	8	4	5	5	Uninteresting (6%)
Stimulating (88%)	105	70	21	20	3	1	2	Dull (3%)
Fascinating (89%)	130	57	13	10	9	2	3	Boring (6%)

TABLE 4 | Capability of being a space professional. This table demonstrates how participants responded to the question “Do you feel capable of being a space professional if you wanted to?” This result was analysed to check if any significant statistical relationships existed between demographic categories, but no differences or trends were identified on the basis of gender (DF = 2, $\chi^2 = 0.87$, $p = 0.65$), education (DF = 8, $\chi^2 = 0.24$, $p = 1.0$), or current status as a student (DF = 2, $\chi^2 = 2.23$, $p = 0.33$).

	N	%
Yes	124	58
No	30	14
Unsure	59	28

with a further 19% believing the sector has no relevance to their lives). 56% of respondents indicated they had no known connection to a space professional and only 58% felt generally capable of being a space professional (Table 4).

DISCUSSION AND CONCLUSION

Public perceptions of European research can vary by country and context (Roche et al., 2017), and so pan-European comparative international research studies can offer the best solution to obtaining accurate insights. The generally positive perceptions of space encountered during the spaceEU project are not surprising. The activities showed that young people generally harbour positive attitudes towards space, consistent with previous studies (DeWitt and Bultitude, 2018). The priority of the spaceEU project was to reach audiences and community groups that have been underserved in the past, and it succeeded in showing that space education events can result in extremely high levels of interest and curiosity being reported by young people, regardless of the demographic categories of the participants. However, even with the emphasis on reaching new audiences, 46% of the

spaceEU survey respondents reported having attended a science event in the past 12 months. This demonstrates a persistent challenge facing most areas of public engagement with science—reaching beyond those audiences who are already engaged (Bultitude, 2014; Kennedy et al., 2018).

The future of the European space sector is bright, but it is not without its pitfalls. The scale of work needed to change public perceptions was revealed by the high proportion of spaceEU participants who were uncertain about the space sector having relevance to their daily lives, having no known connection to a space professional, and not believing themselves capable of being a space professional. While the establishment of a space education community is already underway, the shift to online engagement demanded by the pandemic resulted in both opportunities and challenges. Feedback was collected from the spaceEU project partners throughout the project and while they highlighted the success of the pivot to online engagement making it possible to reach new audiences in remote locations, prevailing failures of public engagement were also mentioned. The persistent challenge of conscientious social inclusion in space education was made more difficult through online education as the digital divide caused by unequal access to reliable Internet infrastructure undoubtedly exacerbated existing inequities (Notley, 2009).

The key focus for space education, and public engagement in science in general, remains reaching new audiences and connecting with underserved communities (Russo et al., 2019; Pompea and Russo, 2020). Progress is being made to better support diversity, equity, and inclusion in informal learning initiatives (Brestovanský et al., 2018); from the museum sector (Ng et al., 2017; Brown et al., 2020) to citizen science (Eitzel et al., 2017; Roche et al., 2020), and the space sector should capitalise on its unique position “to stimulate science engagement with marginalized communities” (Joubert, 2019, p. 131). Recent advancements include the first International Astronomical Union symposium tackling “Astronomy for Equity, Diversity and Inclusion” in 2019 (Primas, 2019, p. 1077) and space education activities, such as the Astroaccessible project, being accessible to people with intellectual, sensorial, and motor disabilities (Pérez-Montero, 2019). This kind of work must continue for the field of space education to thrive and for perceptions of the space sector to be further transformed.

Increasing resources, training, and rewards at institutional level for space professionals’ public engagement efforts would help to strengthen the field of space education, while international projects and collaborations are needed for regions with less available resources (McBride et al., 2018; Entradas and Bauer, 2019; Pompea and Russo, 2020). Such initiatives can increase participation of minorities and provide mentorship to youth from

underprivileged backgrounds (Lucatello and Diamond-Stanic, 2017). A society coping with diminishing resources needs sustainable and inclusive solutions and now is a more pressing time than ever to build international collaborations that support the participation of minority, marginalised, and indigenous communities in astronomy (Kewley, 2019; Venkatesan et al., 2019). Only when all structural barriers to inclusion have been removed can the European space education community hope to reflect the diversity of society. An important first step is for all pan-European work in space education to be reported and, as in the case of spaceEU, any resources and toolkits developed be made freely available (spaceEU, 2021a). This will allow future projects to build towards the goal of fostering a truly inclusive and creative space education community in Europe.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The study received approval from an ethics

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committee at Trinity College Dublin. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JR led the conceptual design of the manuscript, while LB, MH, AJ, and JR wrote the initial drafts. GD'A, BO, 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.

FUNDING

This work was made possible with funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 821832.

ACKNOWLEDGMENTS

The authors are grateful for the support of the spaceEU project team and all the project participants.

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