How Astronomers View Education and Public Outreach: An Exploratory Study

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Over the past few years there have been a number of studies exploring the development of an interest in science and scientists' views on public outreach. Yet, to date, there has been no global study regarding astronomers' views on these matters. Through the completion of our survey of 155 professional astronomers online and in person during the 28th International Astronomical Union General Assembly in 2012, we explore how these individuals developed an interest in astronomy, the part outreach played in this and their views on the time constraints and budget restrictions associated with public outreach activities. We find that astronomers develop an interest in astronomy between the ages of four and six, but that the decision to undertake a career in astronomy often comes during late adolescence. We also discuss the claim that education and public outreach is regarded as an optional task rather than a scientist's duty. Our study reveals that many astronomers are of the opinion that a larger percentage of their research time should be invested in outreach activities, calling for a change in grant policies.

Introduction

In 2004, the European Union issued a major report addressing the need for more scientists and students to be involved in advanced studies of science and technology in order to achieve the desired economic growth (European Commission, 2004). The European Union is not the only body concerned by the decrease in the number of scientists and the associated effect on the economy. In 2005, the National Academies in the United States published a report discussing the condition of science and technology that emphasised the importance of science education to the economy. In 2006, during a speech following the publication of this report, the then President of the United States of America, George W. Bush, brought up the concern that corporations have about the imminent retirement of baby-boomer scientists over the next decade (Bush, 2006). Nowadays, the importance of science education and communication is recognised globally.

One approach to improve science education and communication, as well as developing methods that ignite interest and awareness amongst the public, is to understand scientists' perception of education and public outreach (EPO). In order to implement science education and outreach initiatives it is useful to identify what sparked the initial interest in science in working scientists. Many studies have reported that an interest in science is likely to develop at primary school age, but that the decision to become a scientist often comes towards the end of adolescence (Maltese & Tai, 2010).

Maltese and Tai (2010) investigated the importance of an early interest in science in developing scientists. Their survey received 116 responses from both practicing and retired physicists and chemists, as well as graduate students across the USA. The participants were asked about the moment when they first became interested in science and what initiated this interest. This survey concludes that for the majority (about 65% of the sample), an interest in science developed before or during primary school — up to the age of twelve — which is six times greater than the proportion who claim to have developed an interest for science at college age — between ages 16 and 18.

Additionally, in 2004, the Royal Society in England conducted an online survey with scientists and engineers where participants were asked when they first considered a prospective career in science (Royal Society, 2004). The majority (63%) of the respondents claimed that they had thought about becoming a scientist or an engineer by the age of 14. This is another piece of evidence that shows the importance of initiating an interest in science through education and public outreach at a young age.

A study conducted by Cleaves (2005) in the UK examined the factors that led students to pursue academic studies in science during college. A total of 69 students from six different schools were interviewed four times during a period of two years before entering college. The goal was to follow their thought processes regarding the decisions they took concerning their career choice. Surprisingly, many of the students who chose to continue studies in science, technology, engineering and mathematics (STEM) did not enjoy secondary school science. Their choices were mainly based on the idea of the career they wanted and the flexibility that science studies offer. On the other hand, students who did not plan on pursuing STEM studies also did not find secondary school science interesting, and they had been deterred from further science studies in college by their experience at school.

A study conducted by Lindahl (2007) investigated the factors influencing why students persist in advanced studies of science. This showed that these students claim that an interest in science is one of the most important factors in their decision to pursue a career in science. The survey was conducted with 70 Swedish students between the ages of 12 to 16, and consisted of a combination of interviews and questionnaires. It revealed that these students started considering a potential scientific career as early as the age of 12. Students also reported that the way science is taught in school was usually not representative of the natural world they experience on a daily basis and did not make them more engaged in classrooms. Consequently, their classroom experiences often affected their decisions to continue to study science. This highlights the importance of igniting an interest in science amongst children and younger teenagers both inside and outside of the classroom.

Nowadays, many scientists have a positive attitude towards science communication, EPO (Andrews, 2005; Poliakoff, 2007; Ecklund, 2012). However, there is still room for improvement in the number of scientists taking part in EPO and the amount of effort that they dedicate to these activities. Many studies have tried to investigate the motivating and inhibiting factors influencing scientists when deciding whether to undertake EPO initiatives. Ecklund's studies explored physicists' and biologists' views on science outreach and revealed that for many of the scientists who took part in the research, one of the most common factors acting against more public engagement was the time constraint. Many scientists already invest a lot of time in either research or teaching, leaving very little time for EPO. Other important inhibiting factors are disapproval by mentors and department heads, and the lack of career recognition associated with taking part in EPO activities.

A report published by the Wellcome Trust in 2000 on the role of scientists in society revealed similar results, stating that many scientists (23% of the participants) think that time constraints play a significant role in preventing them from participating in EPO activities. Sixty percent agreed that what was required from them each day left them with very little time for EPO initiatives. Participants also noted that EPO activities are not financially advantageous. Given this general perception of EPO initiatives, it can be rather difficult for scientists to meet the criteria that science communication guidelines suggest for effective outreach projects, and money and time constraints often discourage scientists from taking part in EPO activities.

While there are several studies regarding the development of an interest in science at an early age, its importance in developing scientists (Maltese & Tai, 2010; Cleaves, 2005; Lindahl, 2007; The Royal Society, 2004) and factors motivating or inhibiting EPO initiatives (Poliakoff, 2007; Ecklund, 2012), there is currently no global study addressing the role of an early interest in developing astronomers or their views on EPO. Most studies include data from former, current and future scientists from different fields, but we would like to examine current astronomers' opinions and see if they differ from other fields of science. Moreover, little published research has studied the amount of time, effort and money scientists invest in EPO.

We would like to answer the following questions:

- At what point in their lives did astronomers develop an interest in astronomy?
- Are EPO activities viewed as a hobby rather than a duty?
- How important are EPO activities according to astronomers?
- What do astronomers think of the budget allocated to EPO activities?

These results will then be compared to other studies in the literature and we will see whether astronomers' views differ from those of scientists working in other fields of science. This will also serve to pinpoint when and how an interest in astronomy starts.

Methods

The data collected for this analysis consisted of both quantitative and qualitative answers from a survey[1]. A questionnaire was designed to collect information on the development of astronomers' first interest in astronomy and their views on EPO. The target groups of participants for this study were future, current and retired professional astronomers. The groups therefore comprised, more specifically, astronomy students involved in either undergraduate or graduate studies, PhD candidates, postdoctoral fellows, faculty members and directors.

The International Astronomical Union, the largest association of astronomers across the globe, has 11 319 individual members. In August 2012, more than 3000 astronomers gathered at the 28th General Assembly in Beijing, China, to discuss, share, present and debate the most exciting discoveries about the Universe. Universe Awareness (UNAWE), in partnership with the IAU Office of Astronomy for Development, carried out individual interviews with 61 randomly selected astronomers attending the General Assembly in order to investigate when they first became interested in their field and their views on EPO. In addition, other potential participants were solicited by email through their Canadian Astronomical Society (CASCA) membership. A total of 94 responses were obtained from the online survey between 11 December 2012 and 24 January 2013.

In total, 155 responses were obtained for this study. Although these methods of sampling are, most of the time, the best option when searching for a representative sample, they restrict how far the results can be generalised as the solicited potential candidates were offered the choice of not participating in the survey.

The answers provided through the online survey and collected at the General Assembly of the IAU were combined and then a preliminary descriptive statistical analysis was made of each set of data to gather an overview of the distribution. Further statistical tests were applied to confirm or disprove the correlations between different variables and ascertain meaningful differences between groups of astronomers.

Sample

The sample consists of 155 astronomers from 31 different countries across the globe. This includes 102 males, 51 females and two individuals who did not disclose their gender. The ages of the participants vary from 23 to 72, with 55% in the age range of 25 to 45. The sample contains both students and professional astronomers. The majority of the sample are currently practicing astronomers, including 58 faculty members, 28 postdoctoral fellows and 29 PhD candidates.

Developing an interest in astronomy

The questionnaire revealed that 65% of the respondents had developed an interest in astronomy between the ages of four and twelve years old. Nearly 50% of all the participants first developed an interest between the ages of four and nine years old. These results are in agreement with other studies such as Lindahl (2007), Cleaves (2005), the Royal Society (2004) and Maltese & Tai (2010), which reported that scientists from other fields first established an interest in science during primary school and early adolescence.

As the data for the age at which astronomers were first excited about astronomy is not normally distributed as shown in Figure 1, the Maan–Whitney's U test, a non-parametric test, was used to assess whether there was a gender-related difference in when interest developed[2]. The analysis showed that there is no significant difference in the distribution (p) of the ages when interest in astronomy developed associated with gender ($p > 0.05$). This was expected as it agrees with the Maltese & Tai's (2010) studies on sources of early interest in science.

Whilst an interest in science is shown to occur at an early age, the decision to become a professional astronomer or to pursue studies to become an astronomer happens later. Over half of the participants claimed this decision was taken at the end of secondary school or during undergraduate studies. For many, taking an introductory course in astronomy during their undergraduate studies at university was the decisive factor. In a similar result to Lindahl (2007), this implies that even though the first interest in science often occurs at a fairly young age, if interaction with science during secondary school and the first years of university is not engaging, this can dissuade individuals from choosing a career in science. This implies, as might be expected, that decisions about an eventual career path occur later than childhood or early adolescence.

But what ignited the astronomers' interest in the subject to begin with? Over a quarter of our participants did not have a specific starting point, but those who did pointed to their inspiration from the night sky (42%) or their excitement after reading a popular science book (32%). In addition, looking through a telescope and following the Apollo missions appeared to be of great importance in initiating the first spark of interest in astronomy for many participants, as did being inspired by a family member or teacher. This shows that a first interest in science often happens outside the classroom, which is also in agreement with Lindahl (2007), who reported that participants found science, as taught in class neither particularly engaging nor representative of the natural world as experienced in everyday life. These results highlight the importance of both having EPO activities for children of primary school age outside the classroom and of ensuring that teenagers have an enjoyable experience of science within the classroom.

Views on education and public outreach

Many studies have revealed that most scientists have a positive attitude towards EPO initiatives (Poliakoff, 2007; Andrews, 2005; Ecklund, 2010). Our study showed similar results, as 79% of the respondents think that EPO initiatives are essential, and 19% claim that they are important. Another way of assessing scientists' views on EPO initiatives is to evaluate the amount of time and financial support scientists dedicate to EPO. Participants were

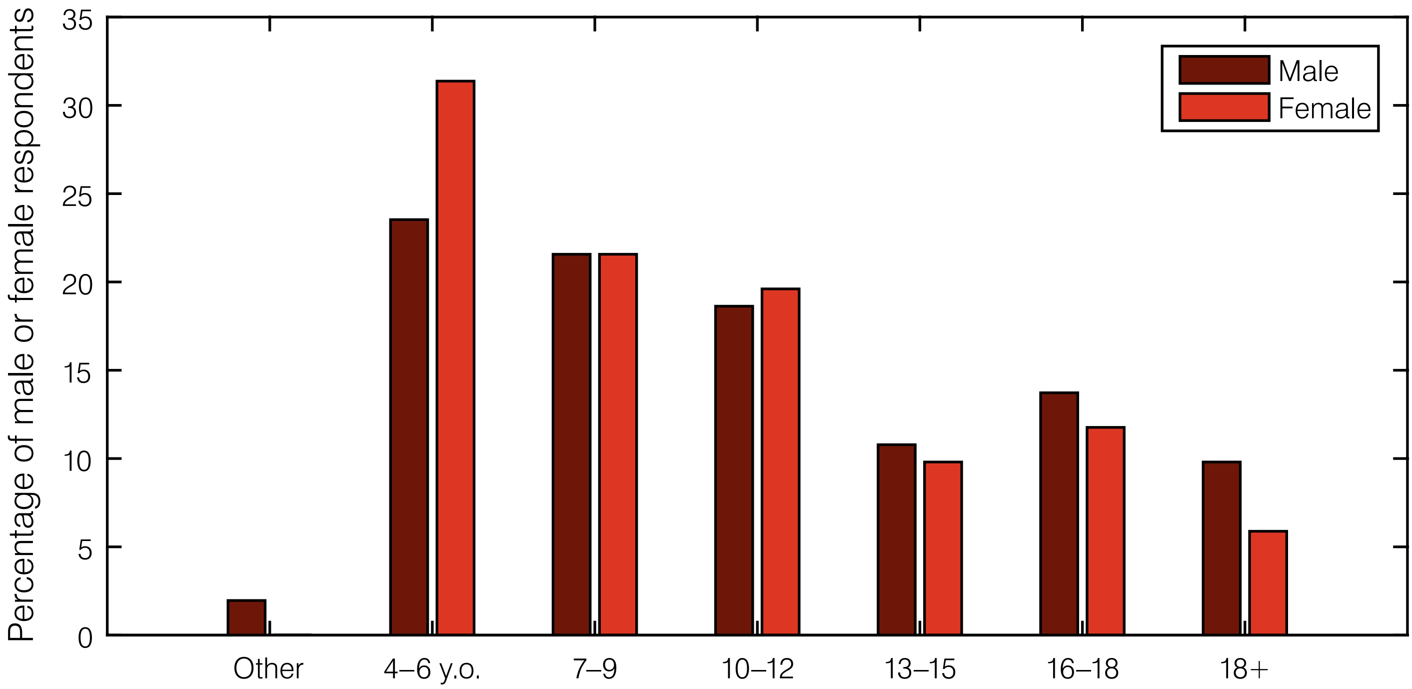

Figure 1. *Reported age at which astronomers first became interested in astronomy.*

given the option not to disclose answers to questions concerning the budget and time spent on outreach initiatives.

As previous studies showed that many scientists viewed EPO as a hobby rather than as part of their duty at work, the participants were asked for the amount of free time and working time spent on EPO activities (Poliakoff, 2007). The analysis of the data revealed no significant difference between the amount of free and working time allocated for EPO activities with a median of zero to two hours spent on EPO per week on average, as shown in Figure 2. After using the Spearman's ρ correlation, it was determined that scientists who claim to spend more time at work on EPO activities weekly also dedicate more time outside work. The analysis showed a moderate correlation between the two variables ($\rho = 0.46$; $p < 0.05$). Interestingly, this does not agree with Poliakoff's study, which reported that scientists considered EPO activities to be a hobby rather than a work duty. This implies that time constraints are not the main factor influencing astronomers when deciding to take part in outreach activities, and that other factors motivate them to invest both time at work and outside work to such projects.

Out of the 155 respondents, a quarter (56 participants) chose to not disclose the percentage of their research grant attributed to EPO. Among those who did answer the question ($N = 116$), 50 astronomers claimed that 0% of their grant money was allocated to EPO and 15 of them use between 0–2% for EPO activities. Hence, most of the respondents reported that less than 2% of their research grant went into EPO initiatives, which is less financial support than is suggested in many science communication guidelines (Brake, 2010; Bowater, 2013). As mentioned before, the 2000 Wellcome Trust report flagged this issue and showed that there was a lack of financial support for EPO.

To explore this shortfall in funds available for EPO, astronomers were asked what percentage of grant money should be invested in EPO. The response rate for this question was 83% (138 out of 155 participants). Interestingly, the results differed significantly from the previous question ($p < 0.05$) as shown in Figure 3. This time, only 13 respondents claimed that 0% of research grants should be invested into EPO activities. On average, astronomers suggested that 5–10% of research grants should be allocated to EPO activities, which is significantly greater than the amount actually used for outreach.

Given this result, a new question arises, do astronomers generally wish to spend more of their research grant on EPO than is currently offered? The Spearman rank correlation test revealed a correlation between respondents' current and suggested budget spent on EPO activities ($\rho = 0.59$; $p < 0.05$). This shows that in general in this survey, the participants suggested a higher portion of their research grant than is currently allocated to outreach initiatives. This implies that astronomers generally think there is a lack of financial support for EPO activities and suggests that policies on the distribution of their research grant should include a higher budget for EPO.

An interesting finding from Poliakoff's studies on factors predicting whether scientists would decide to participate in EPO activities was the indication from past behaviour. The research revealed that a scientist who has been involved in EPO projects in the past is more likely to participate again in the upcoming year. Consequently, taking part in outreach activities in the early stages of a research career increases the chance that a scientist will participate in EPO activities regularly at future career stages. However, Ecklund's studies on views concerning public engagement activities among scientists demonstrate that one of the participants' concerns was the lack of support from mentors for taking part in outreach activities. Deterring early career researchers through lack of support will therefore also affect their decision to take part in outreach projects at later stages in their careers. To address this,

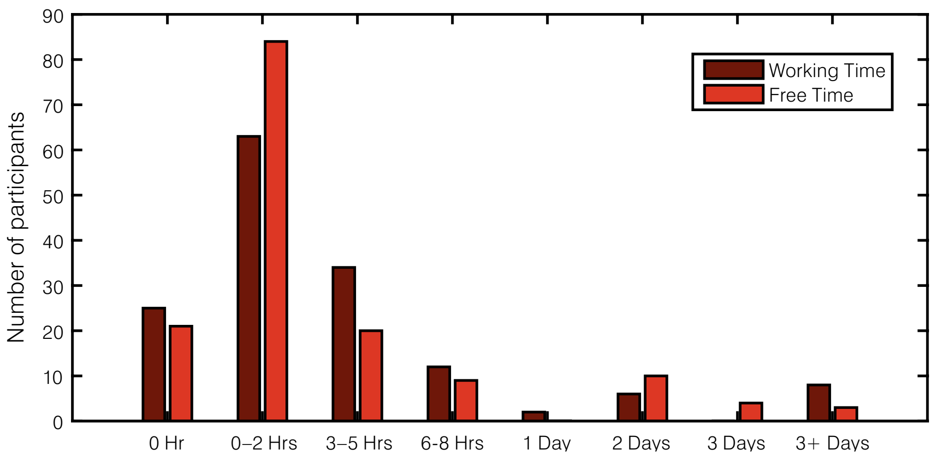

Figure 2. *Distribution of working and free time spent on EPO activities per week on average.*

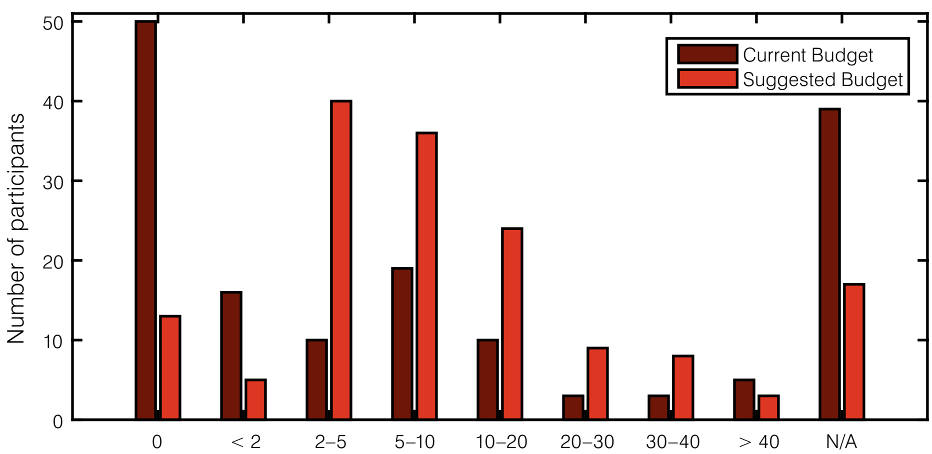

Figure 3. *Distribution of percentage of research grant that astronomers currently invest in EPO compared to the percentage they suggest allocating.*

astronomers were asked whether they recommended or encouraged their students to get involved with EPO projects. For the most part (70% of the participants), the answer was positive, as opposed to 2% who answered negatively. The majority of the 43 participants who did not answer the question were either Masters/PhD students or postdoctoral fellows for whom the question was not applicable. This was unexpected since many scientists claimed a factor inhibiting the participation in EPO initiatives was disapproval by mentors and department heads (Ecklund, 2012). This could mean that encouragement to participate in outreach projects is more present in the community of astronomers than other sciences. However, the way the question was posed was biased towards a positive response. A more accurate way to measure this would have been to give the respondents an ordinal scale rather than only the option to answer either positively or negatively when they were asked whether they encourage their students to participate in EPO initiatives.

Conclusion

Astronomers' interest in astronomy is shaped from a very young age (4 to 6 years old). As expected, despite the gender imbalance in the astronomical field, there is no evidence of a difference between genders in the age at which an interest in astronomy develops. The decision to undertake a career in astronomy only comes later, at the end of adolescence or during early adulthood, which shows the importance of nurturing an interest in astronomy up to this age.

Most astronomers claim to have a positive attitude towards EPO and those in authority encourage their students to participate in outreach. However, other studies have shown that although scientists have a positive view of EPO, some of them do not participate due to disapproval from their mentors and department heads, which is not consistent with our results.

The results show that astronomers allocate less time to EPO on average than the amount recommended by practical guides for science communication. Some science communication books explain this by making the assumption that science communication projects are initiatives that researchers would only undertake if they have extra time beside their other duties in academia. However, this study also disproves the theory that EPO activities are viewed as a hobby rather than a duty, as no significant difference between the time astronomers put into EPO during work time and free time was found. Interestingly, the analysis showed that those who claimed to spend more working time on EPO activities also invested as much of their free time. This implies that there must be some factors other than their views on their responsibility as scientists which motivates working on EPO projects both at work and outside of work.

Another finding from the study is that the percentage of their research grants that astronomers allocate to EPO does not align with the amount that they would suggest is optimal. In general, most of them suggest a higher amount than is currently assigned to EPO activities. This indicates that astronomers would like to invest a larger ratio of their grants towards EPO and therefore, calls for a change in grant policies.

Limitations and future work

The collection of data did not keep track of the number of solicited astronomers who chose not to participate in the survey, so this prevented us from obtaining a response rate to evaluate whether the sample was a good representation of the target group. In addition, online surveys also imply a certain level of self-selection bias; which is a limitation of this study.

Some questions about the value of EPO and the encouragement given to take part of EPO activities were asked in a manner biased towards a positive answer.

The data obtained revealed some interesting insights, but it is not complete. A more detailed study about the views of astronomers would allow us to tackle the motivating and inhibiting factors for public outreach initiatives. It would also give more insight into the changes that need to be made in order to increase the number of astronomers participating in EPO and how these changes can be implemented. The next goal is to explore astronomers' points of view on different aspects of their attitude towards engagement initiatives, their level of confidence in taking part in EPO activities, their perception of the public and their peers and the value of EPO at their institution.

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Notes

[1] The source data files used in this paper are available on an open repository: https://github.com/unawe/research/

[2] More information on the Mann–Whitney *U* test: https://en.wikipedia.org/wiki/Mann%E2%80%93Whitney_U_test

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