Educate & Inspire:

Summary of feedback relating to the Space Awareness educational resources

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"By providing such thorough background resources, as a teacher I felt more confident teaching the children about the subject. I was able to decide which information was relevant for them and use this to aid their learning and outcomes." (Primary school teacher, United Kingdom)

Executive Summary

The Space Awareness educational activities are designed to be run by teachers in their own classrooms, with all necessary information provided via the project website. **65 freely available activities were developed** as part of the Space Awareness project (21 at primary school level and 29 for secondary school pupils, with the remaining 15 being adaptable for students of all ages). The activities[1] are divided into four key thematic areas: *Our Wonderful Universe*; *Navigation Through the Ages*; *Our Fragile Planet* and *The Journey of Ideas*. A key part of their development involved teachers and educators throughout Europe and beyond testing and providing feedback on the resources; this report summarises the main findings.

The main evaluation tool was a 'Resource feedback form' which was based on the Space Awareness intended project outcomes (see Table 2 and Table 3). **Teachers were asked to complete the form after having implemented a particular resource or educational activity within their classroom.** For contextual purposes the feedback form also contained brief sections about the respondent's own background and experience, as well as their reactions to the activity; and how they felt their students reacted to it. The evaluation was implemented by a network of national dissemination nodes between December 2016 and July 2017, with each node aiming to recruit at least 20 teachers at national level.

In total, **212 feedback forms were received from teachers and other educators located throughout Europe and beyond**. These numbers were in general somewhat lower than the original aim; without any personal incentive for the teachers, recruitment proved more challenging than initially expected. However, they did encompass **feedback on 43 separate activities, and represented excellent breadth across central, eastern, northern and southern Europe**. Primary teachers were the most common respondents, representing approximately half of the cohort. Secondary school teachers were also well represented (41%), with a small number of contributions from informal educators (museum and science centre staff, astronomy club volunteers and the like, 4%) as well as other external roles (such as trainee teachers or university staff, 5%). The vast majority of respondents were STEM (science, technology, engineering and/or mathematics) specialists, though in line with the Space Awareness aims to encourage uptake of space science across the school curriculum it was pleasing to see respondents with language and other humanities (history, religion etc.) backgrounds involved.

The overall ratings for the evaluated resources were generally very positive: **half of the respondents gave a rating of 9 or 10 (Excellent)**, and more than 92% gave a rating of 7 or more. Breaking this down by the individual resources, it is clear that there is no consistent pattern for any particular resource – they all exhibit a range of ratings. Participants' ratings were thus likely dependent upon many external factors, rather than any one resource being particularly poor or outstanding. Primary-level activities were statistically more likely to receive higher rankings than those designed for secondary school students ($p=0.012$).

In terms of **"what worked well"**, a wide variety of themes emerged, most notably relating to the "hands-on" nature of the activities, the high quality of the background materials

[1] The full list of activities is provided in Annexe A.

(including the scientific content and images/visuals used), and the resources' success in explaining abstract or complex concepts. Respondents also highly valued opportunities to expand their students' involvement, for example encouraging collaborative learning, discussion/reflection of key issues, physical involvement (especially primary activities involving movement), independent learning and creativity. Finally, a handful of teachers highlighted more experiential elements relating to all three kinds of activities (MOOCs, Educational resources, teacher training), such as the opportunity to manipulate 'real' data, linking back to their existing knowledge, or simply having fun.

Regarding **potential improvements** to the resources, many of the respondents' suggestions (47 of 125 received) were very specific, detailing particular suggested modifications, or aspects they would do differently themselves next time. These formative feedback elements have fed into the final revision processes for the resource materials. There were two notable suggested improvements which were more generalised across multiple activities. The first related to requests for further support information and/or background materials, especially to assist those who are not specialists in space science. The second general improvement was that the indicated timings on some of the activities were unrealistic, and more time should be allowed for them to be completed within class.

The respondents were generally positive about the resources' impacts on their own emotional reactions, understandings, attitudes, skills, and behaviours. **At least three-quarters of the cohort agreed or strongly agreed with the majority of the teacher-related intended outcome statements**, rising to over 90% for aspects relating to the helpfulness of the content, extent of information provision, and whether individuals are likely to both use the resource themselves again in the future, or recommend it to colleagues. **The main exception was the statement relating to careers opportunities**: only around half of the respondents either agreed or strongly agreed with this statement, whilst 35% strongly disagreed that the activity had "helped me understand space career opportunities...". Statistical analysis suggested that **the educational resources were particularly effective in supporting primary teachers**. This is excellent news for the Space Awareness project, as primary teachers were a key intended audience. Similarly, resources linked to ICT, and/or within the *Navigation Through the Ages* thematic area, were statistically more likely to be intended to be used again in the future.

Moving now to consider the ***pupil* related statements, the responses were slightly less positive**: the proportion of respondents at least agreeing with each statement dropped to 60-80% in most cases. Of course, this is not necessarily a failure of individual specific resources – not all resources were designed to support ALL of the intended outcomes, so we would expect some of them to be less successful in achieving high scores on certain statements. Overall, respondents were most positive about the activities being interesting for their students (86% selecting "Agree" or "Strongly agree"), as well as teaching their students some content (84%). However, in both cases there was still around 14% of respondents who selected "Strongly disagree". **The weakest indicator when considered across all of the resources in aggregate related to IT skills**[2], where less than half of the respondents at least agreed that "The activity developed my students' IT skills" (46%), and over one-third selected "Strongly disagree" for this statement (34%). Likewise, there was

[2] Only 12 of the 65 activities targeted the use of ICT (see Annexe A), so this is not surprising.

strong overall disagreement with statements relating to encouraging equal participation from students of minority backgrounds (31%) and whether the activity "demonstrated how space research contributes to everyday life" (31%).

Taken individually however, many of the resources were judged to successfully achieve these more challenging goals. For example, for one activity "Know Your Planets", the levels of agreement relating to the development of IT skills and demonstrating the contributions of space science to everyday life were both 64%.

As with the teacher-related outcomes, primary school teachers agreed more strongly with all of the pupil indicator statements than their secondary school counterparts. Overall these responses suggest that **the activities were judged by the majority of participants (especially primary school teachers) to have been influential in achieving the intended pupil-oriented outcomes, though with some room for improvement**.

Table 1 provides a visual summary of **which priority intended learning outcomes were achieved within the Space Awareness educational resources**. The final column serves as a "traffic light" indicator of the extent to which the evidence gathered supported whether each outcome had been achieved[3]. It is clear from Table 1 that **there was strong evidence (albeit sporadic in places) of around half of the priority learning outcomes having been achieved** by the Space Awareness educational resources (11 of 23; green shading). There were however some notable areas where the **evidence of success was slightly weaker** (coloured amber or orange in Table 1): certainly, such outcomes were achieved for some individuals, but the effects were not consistent across the cohort. In particular this referred to (vi, xvii) **careers-related aspirations**, and (xxi) **connections to ICT usage**. Finally, there were seven intended outcomes for which we have no evidence either way as to whether they were successful (coloured grey in Table 4). These reflect lower-priority outcomes which were not explicitly mentioned within any of the indicator statements, and for which no mention was made within the open-response comments provided. It is possible that at least some of these outcomes were achieved for some individual respondents, however limitations within the evaluation processes mean we are unable to comment further.

In light of these findings a series of recommendations were produced to inform the development of similar projects in the future. For example, **factors contributing to teachers' "high quality" ratings were identified** (such as achieving high student engagement and/or interest and the provision of direct curriculum links). There were also some general suggestions regarding including **further support information and more realistic (extended) timings**, as well as methodological considerations such as the need to provide incentives to assist with recruitment of teachers to the feedback processes.

Overall these results are positive. There is evidence that most of the intended priority outcomes were achieved by the majority of the educational resources, and that they are likely to be perceived as a useful and valuable resource well after the lifetime of the Space Awareness project by teachers throughout Europe and beyond.

[3] In addition to teachers' self-reported responses to direct statements (see Figure 12 and Figure 13), these judgements have been based on a synthesis of qualitative comments received. The key to the colour scale used is included at the bottom of the table.

Theme	Priority intended learning outcome	Target* Audience	Rating
Feel	i. Find Space Awareness activities interesting	ES	
	ii. Enjoy learning/teaching about space	ES	
	iii. Feel confident teaching space topics	ES	
	iv. Feel inspired by space science	ES	
	v. Feel positive about space science	ES	
	vi. Aspire to space science careers	S	
Value	vii. Value the diverse contributions of many different cultures to space science	S	
	viii. Value the contributions made by both women and men to space science	ES	
	ix. Value trans-national European and Global citizenship	ES	
	x. Appreciate that space science contributes to everyday life	ES	
	xi. Appreciate that school science is relevant to space science	ES	
Understand	xii. Highlights of space science (Our Wonderful Universe, Our Fragile Planet and Navigation Through the Ages)	ES	
	xiii. Space science can be used for teaching in many disciplines including cross-disciplinary contexts and non-science subjects	E	
	xiv. Space science needs an interdisciplinary approach	ES	
Do	xv. Access and use Space Awareness activities confidently	E	
	xvi. Want to learn more about space science	ES	
	xvii. Choose or consider choosing, or encourage others, to study and pursue careers in space science and engineering or science and engineering more widely, especially girls and ethnic minorities	ES	
	xviii. Share their understanding of space science and technology with learners, peers, family and/or their community	ES	
Skills	xix. Learn how to carry out scientific or technical activities themselves	ES	
	xx. Develop inquiry-based skills for teaching/learning about space science	ES	
	xxi. Learn how to use IT to teach/learn about space science	ES	
	xxii. Learn how to be more inclusive while teaching, particularly for girls and minorities	E	
	xxiii. Develop skills involved in space-related careers	ES	

Strong evidence this outcome was achieved	*Strong but sporadic evidence this was achieved*	*Some evidence this outcome was achieved*	*Evidence this outcome was NOT achieved*	*No evidence either way*

Table 1- Summary of achieved learning outcomes. *Note that for the sake of brevity only the high priority outcomes identified in Table 2 have been included here. * Target audience refers to intended outcomes for educators (E) or students (S).*

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In compiling this report we wish to acknowledge the very important contributions of the various partners and nodes who managed the data collection processes at local level, as well as the teachers and other educators who willingly gave up their time to test the resources and provide feedback. Your efforts have been a tremendous help in ensuring that the final resources are a worthy contribution to space science teaching throughout Europe and beyond.

This project is funded the European Commission's Horizon 2020 Programme under grant agreement n° 638653.

1 Introduction

Space Awareness educational activities are designed to be run by teachers in their own classrooms, with the necessary resources and information provided online via the project website. 65 activities were developed as part of the Space Awareness project (21 at primary school level and 29 for secondary school pupils, with the remaining 15 being adaptable for students of all ages). They were selected following the most popular topics for space in the school curricula. These topics were decided based on results from a survey run as part of the Educational Framework work package (WP2), which was disseminated to educators in 10 European countries and South Africa in 2015.

The educational resources made freely available through Space Awareness are broken into four key themes: *Our Wonderful Universe*; *Navigation Through the Ages*; *Our Fragile Planet* and *The Journey of Ideas*. The full list of activities is provided in Annexe A[4]. In addition to Europe-wide distribution via key project partners and the project website, each project node was responsible for disseminating these educational resources within their own country. The Space Awareness dissemination nodes are national organisations ideally positioned to increase the project's outreach and to provide valuable input into the Space Awareness activities. They are an integral part of the exchange of expertise and material between educators in EU member states and throughout the world. Since the beginning of the project, the network of dissemination nodes continued to evolve and attract new members committed to the popularisation of space science and space careers. In October 2017, the Space Awareness network counted 14 national organisations acting as "formal" dissemination nodes, 6 national organisations acting as informal nodes and supporting the project on a volunteer basis, as well as 4 node organisations which are also project partners.

The dissemination nodes publicised the activities within their local, regional and national contexts, and in many cases assisted in translating the materials into local languages. Many also chose to incorporate the educational activities within teacher training courses they ran[5]. All dissemination nodes (formal, informal, and partner nodes) were expected to support the process of evaluation of resources. In particular, most (10 of the total 14) formal dissemination nodes were each expected to recruit around 20 teachers to implement resources in their classrooms and fill in a feedback form. This process was designed to ensure that all the activities were tested and improved by teachers and educators throughout Europe and beyond. This report summarises the feedback received.

The Space Awareness dissemination nodes were thus responsible for managing the evaluation data collection with their participating teachers, though the feedback form was also provided online via the website to encourage wider participation. Where possible the evaluation forms were provided electronically for ease of amendment, completion and submission, though some individual nodes did elect to distribute them in hardcopy where that was more suitable for local use.

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[4] The Journey of Ideas resources were not publicly available during the resource evaluation phase due to delays in the expert peer reviewing process for that content.

[5] See separate report for details of the evaluation of these workshops.

2 Data collection and analysis

2.1 Intended outcomes

The Space Awareness educational resources were intended to achieve a wide range of outcomes for participants (and their pupils), based on the wider Space Awareness intended outcomes. Table 2 provides a map of the intended outcomes, whilst Table 3 lists particular areas of focus for specific activities. From these tables, it is clear that the Space Awareness educational resources were designed to cover the majority of intended project outcomes for both educators and their students. The first three thematic areas (*Our Wonderful Universe*; *Our Fragile Planet* and *Navigation Through the Ages*) all had multiple resources focusing on developing skills related to use of ICT, and appreciation of global citizenship and diversity issues. The final thematic area, *The Journey of Ideas*, was entirely dedicated to improving awareness and appreciation of the diverse history of space science, in particular drawing on historical developments in Islamic science. Only three resources were intended to explicitly raise issues relating to careers in space science, though across all the resources the developers did attempt to connect the activities to careers as much as possible.

Educational Resources mapped to the Space Awareness Intended Outcomes **E = Educators; S = Students**	Primary Educational Resources		Secondary Educational Resources	
Priority outcomes are listed below; *Grey writing indicates additional outcomes of slightly lower importance*				
Feel ***Enjoyment, inspiration and creativity*** **= MAJOR PRIORITY CATEGORY**				
Find Space Awareness activities interesting	E	S	E	S
Enjoy learning/teaching about space	E	S	E	S
Feel confident teaching space topics	E	S	E	S
Feel inspired by space science	E	S	E	S
Feel positive about space science	E	S	E	S
Aspire to space science careers		S		S
Value ***Values and attitudes*** **= MAJOR PRIORITY CATEGORY**				
Value the diverse contributions of many different cultures to space science		S		S
Value the contributions made by both women and men to space science	E	S	E	S
Value trans-national European and Global citizenship	E	S	E	S
Appreciate that space science contributes to everyday life	E	S	E	S
Appreciate that school science is relevant to space science	E	S	E	S
Appreciate that people who work in space science are real people				
Understand ***Knowledge and understanding***				
Highlights of space science (Our Wonderful Universe, Our Fragile Planet and Navigation through the Ages)	E	S	E	S
The impact of space science on society and everyday life				
Space science can be used for teaching in many disciplines including cross-disciplinary contexts and non-science subjects	E		E	
Space science career opportunities are diverse, rewarding and highly accessible (particularly to girls and ethnic minorities)				
Space science needs an interdisciplinary approach	E	S	E	S
Space science is a global/European endeavour				
Career opportunities in space science and technology at all levels				
Relevant pathways to these career opportunities				
Do ***Action, behaviour and progression***				
Access and use Space Awareness activities confidently	E		E	
Create own content and additional activities on the same or related topics				
Want to learn more about space science	E	S	E	S
Choose or consider choosing, or encourage others, to study and pursue careers in space science and engineering or science and engineering more widely, especially girls and ethnic minorities	E	S	E	S
Share their understanding of space science and technology with learners, peers, family and/or their community	E	S	E	S
Skills				
Learn how to carry out scientific or technical activities themselves	E	S	E	S
Develop inquiry-based skills for teaching/learning about space science	E	S	E	S
Learn how to use IT to teach/learn about space science	E	S	E	S
Learn how to be more inclusive while teaching, particularly for girls and minorities	E		E	
Develop skills involved in space-related careers	E	S	E	S

Table 2 - Intended outcomes for the educational resources

Thematic Area	Use of ICT	Global citizenship and inclusion	Career dimension
Our Wonderful Universe	• Living in the Milky Way • The fibre optic class • Coma cluster of galaxies • How light pollution affects the stars • Star in a box: high school	• History of the Universe • Make a star lantern • Know your planets	
Our Fragile Planet	• A View from Above • The Climate in Numbers and Graphs • Valleys deep and mountains high	• Meet Our Home: Planet Earth • Blue Marble in Empty Space • Ocean Acidification • Global Warming of the Atmosphere • Transforming water into acid ... and back • Oceans on the rise • The big meltdown	• A View from Above • Valleys deep and mountains high
Navigation Through the Ages	• Navigation in the Ancient Mediterranean and Beyond • Navigate like a Viking – use the sun, not your phone! • The Quest for Longitude • Where on Earth Am I?	• What is a constellation? • Navigating with the Kamal	• Where on Earth Am I?
The Journey of Ideas		*ALL of the Journey of Ideas resources targeted these skills*	

Table 3 - Specific intended skills development for specific resources

2.2 Data collection tools

The evaluation data collection consisted of three main aspects (see Annexes B and C for the first two documents in this list):

1) *Instructions to nodes* – details for each of the node partners outlining how best to collect teacher feedback. This document introduced the activities themselves and provided instructions on how to select resources for feedback (to ensure wide coverage regarding which resources were tested), as well as specific advice regarding the questionnaire itself.

2) *Resource feedback form* – This is the questionnaire that teachers were asked to complete. It contained brief sections about the teacher and the students they tried the activity with (for context); what (if any) other associations the teacher previously had with the Space Awareness project (e.g. attending a training course or similar); the teacher's reactions to the activity; and how they felt their students reacted to it. The feedback form was strongly linked to the Space Awareness intended project outcomes outlined in Table 2. For ease of completion and to assist with comparison across different language backgrounds the majority of questions were quantitative in nature, though space was allowed for open-response comments where appropriate. There were also qualitative sections asking teachers to highlight any particular 'wow' moments, or conversely, how the activity could have been improved. The survey itself was translated into local languages where necessary.

3) *Reporting portal* – An online portal was provided for nodes to enter the data gathered locally. Where appropriate this was made available to teachers directly so that they could complete their feedback forms online, reducing the need for data entry by the nodes.

Node and teacher representatives from across Europe were invited to feedback on the questionnaire, which helped in refining its content and ensuring it was fit for purpose prior to distribution. As noted previously, each node was asked to recruit 20 local teachers[6] to test the various educational activities using the protocol, starting in September 2016, and feedback the results to the central evaluation team (UCL) for further analysis and synthesis of results by July 2017.

2.3 Analysis techniques

The feedback questionnaire data were exported from the online survey programme into the statistical analysis programme SPSS. Data summaries and graphs were produced using Microsoft Excel, whilst statistical analysis of key demographic patterns relating to aspects such as gender, participant teaching level (primary / secondary) and extent of previous teaching experience were conducted using SPSS. Open response comments within the surveys were grouped manually into emergent common themes.

[6] Ideally the request was for 20 different teachers to each test a different resource in order to get the broadest perspective possible. However, in reality most nodes recruited a much smaller number of teachers who each tested multiple resources.

3 Participant Backgrounds

To provide a context for the results described in sections 4 & 5, this section shows an overview of the people who provided feedback on the educational resources, starting with overall numbers involved, followed by a more detailed demographic breakdown.

In total 212[7] feedback forms were received from teachers and other educators located throughout Europe and beyond (Figure 1).

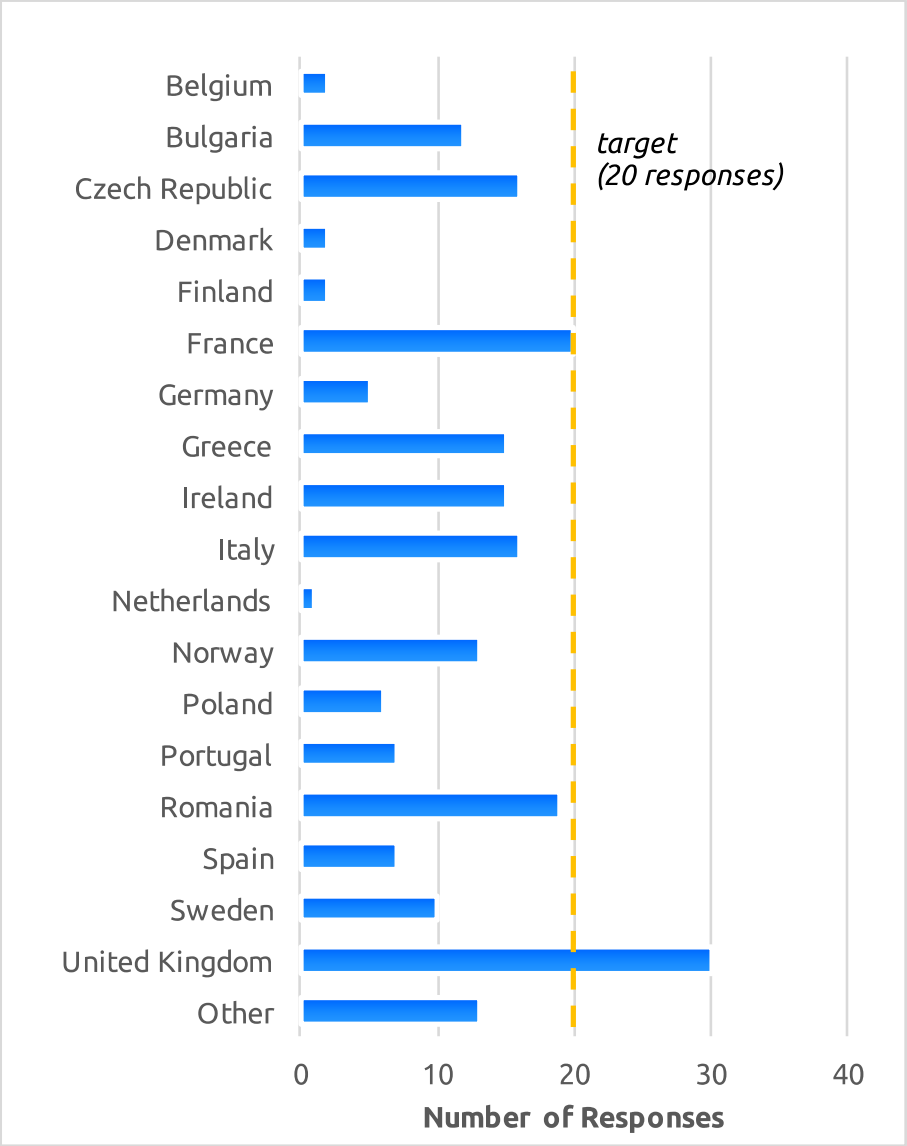

Figure 1 - Country of origin of feedback respondents [n=211]

[7] A total of 212 individual forms were received, however some respondents chose not to complete certain questions. For this reason the number of responses to each question are indicated in the captions for the relevant graphs.

Although the numbers were in general somewhat lower than the original aim (with the notable exception of the UK – Wales), they do represent excellent breadth across central, eastern, northern and southern Europe.

Coming back to the comparison with the intended targets, teacher recruitment proved more challenging than initially expected. With little personal incentive for the teachers, nodes relied on goodwill to encourage the requisite numbers of teachers to participate. Additionally, the original plan was that the educational resources would be tested as part of the wider teacher training workshops[8], also delivered by the Space Awareness dissemination nodes. The intention was that the teachers would be introduced to the resources at the workshop, then go back and try them in their classrooms, and report back on their experience afterwards. Whilst the resources were certainly *introduced* as part of the training workshops, workshop organisers reported difficulties in obtaining feedback from the participating teachers once the workshops were over. For future similar exercises further incentives for the teachers should be considered – perhaps a prize draw, or release of further resources and materials once the feedback form has been received.

The 212 responses received do provide a very useful perspective on the effectiveness of the educational resources, especially given that they encompass feedback on 43 separate activities[9]. They also represent a broad range of teacher backgrounds in terms of both level taught and subject specialism (Figure 2 and Figure 3).

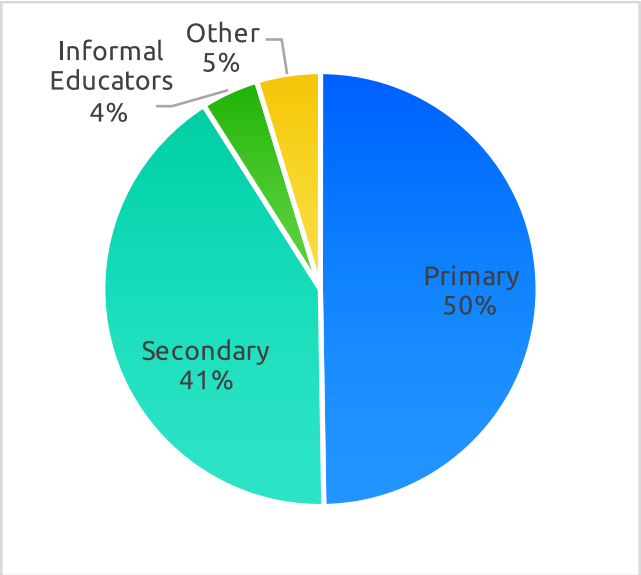

Figure 2 - Respondent teaching backgrounds [n=211]

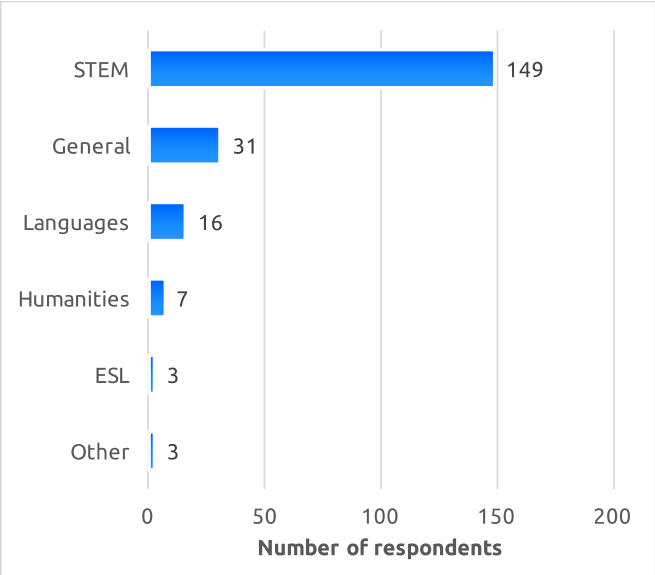

Figure 3 - Respondent subject specialisms [n=192] *(Note that some teachers specified multiple options)*

[8] See separate report for further details.

[9] Specific effort was made towards the end of the data collection period to actively seek feedback on resources that had not received any feedback by that stage.

Primary school teachers were the most common respondents, representing approximately half of the cohort. Secondary school teachers were also well represented (41%), with a small number of contributions from informal educators (such as museum and science centre staff or astronomy club volunteers, 4%) as well as other external roles (such as trainee teachers or university staff, 5%). The vast majority of respondents were STEM (science, technology, engineering and/or mathematics) specialists, as can be seen in Figure 3. In line with the Space Awareness aims to encourage uptake of space science across the school curriculum it is pleasing to see respondents with language and other humanities (history, religion etc.) backgrounds involved. A small number of English as a Second Language (ESL) staff were also involved (3), whilst 'General' refers to primary school teachers (who cover all subjects).

As shown in Figure 4, the feedback responses were mainly focused on activities from within the *Our Wonderful Universe* (45%) and *Our Fragile Planet* (41%) themes, though there were some responses for *Navigation Through the Ages* resources (13%). Only two (incomplete) responses were provided for *The Journey of Ideas* resources, in the main due to delays in making those resources publicly available.

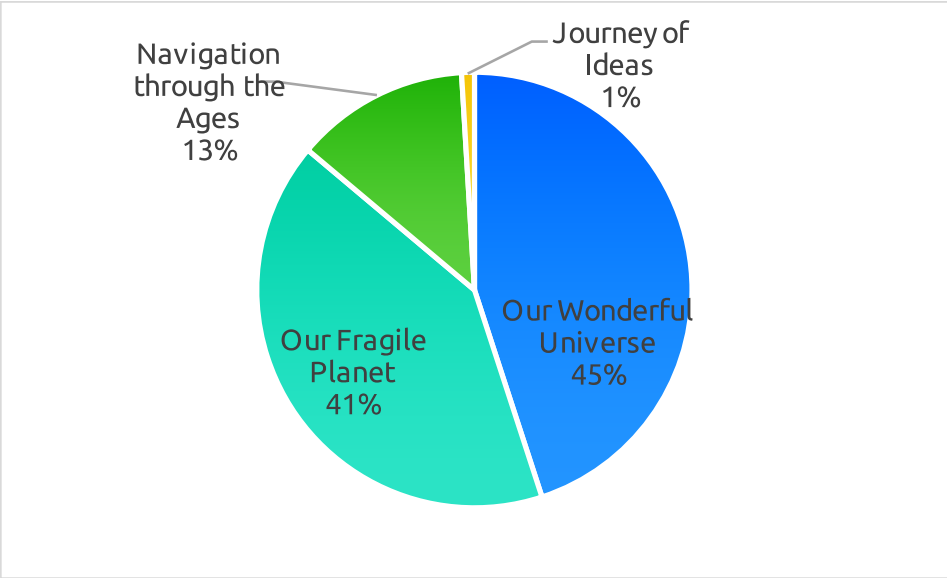

Figure 4 - Distribution of responses received according to thematic area [n=209]

To provide further background context, we asked respondents to indicate which (if any) other aspects of the Space Awareness programme they had been involved in (Figure 5).

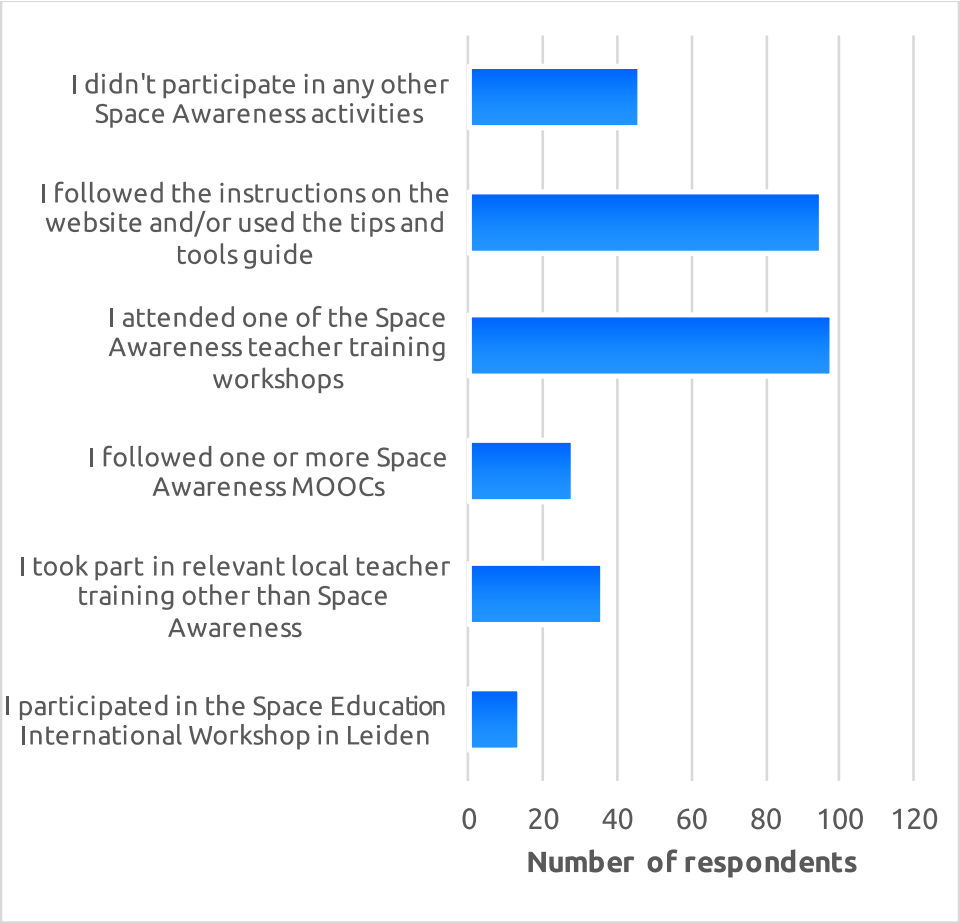

Figure 5 - Respondents' previous links to Space Awareness [n=203]
(Multiple options allowed)

As noted previously, the resource feedback was specifically integrated into the teacher training workshops, so it is no surprise that that response was the most common link chosen by respondents, representing just under half of the cohort. Respondents were also proactive in seeking information from the website and/or wider sources provided. However somewhat surprisingly, just over a fifth of respondents to the educational resources feedback survey reported having no previous links to the project at all. These teachers are in effect acting as "raw" participants, relying purely on the information provided, and thus provide a particularly useful testbed for judging the success of the resources in being transferred to classrooms throughout Europe and beyond.

The teachers' interest in space science was clearly strongly motivated by necessities relating to their role (Figure 6): over two thirds reported that they "have to teach it" within their national curriculum. Less than a quarter of respondents reported that space science is not part of their curriculum. These proportions were identical regardless of whether the respondent was a primary or secondary school teacher.

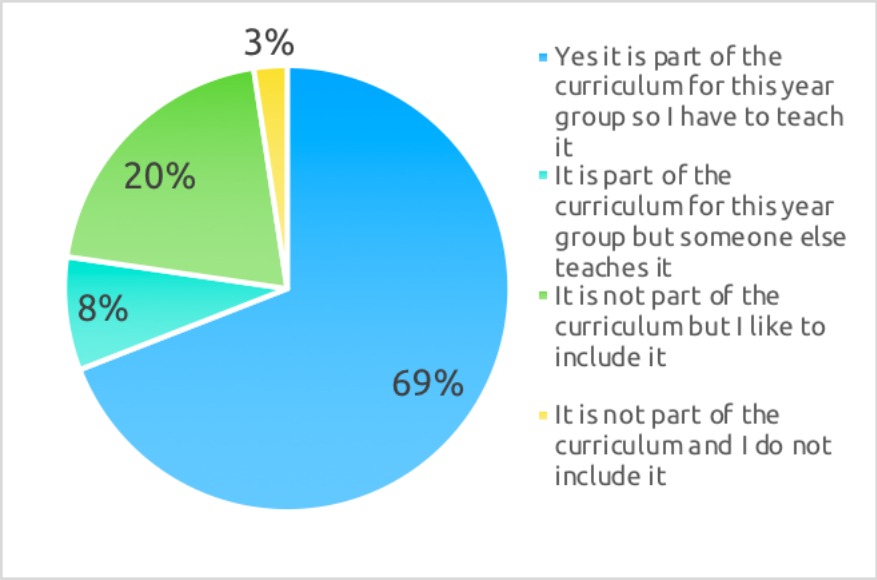

Figure 6 - Respondents' motivations related to curriculum links [n=207]

4 Quality assessment

Within the feedback form the participants were asked to rate the activity overall, on a scale of 1 (Poor) to 10 (Excellent). The results are shown in Figure 7, along with a more detailed breakdown per resource in Figure 8.

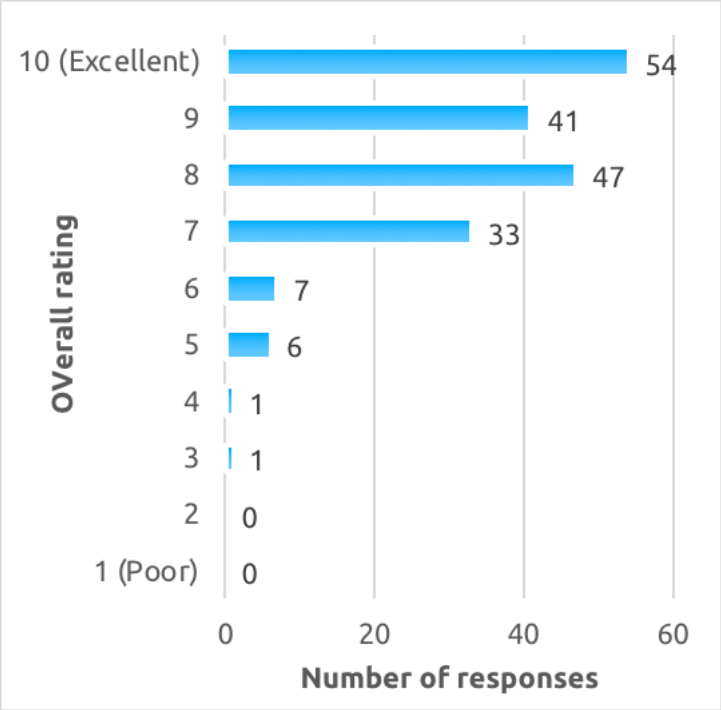

Figure 7 - Overall activity ratings [n=190]

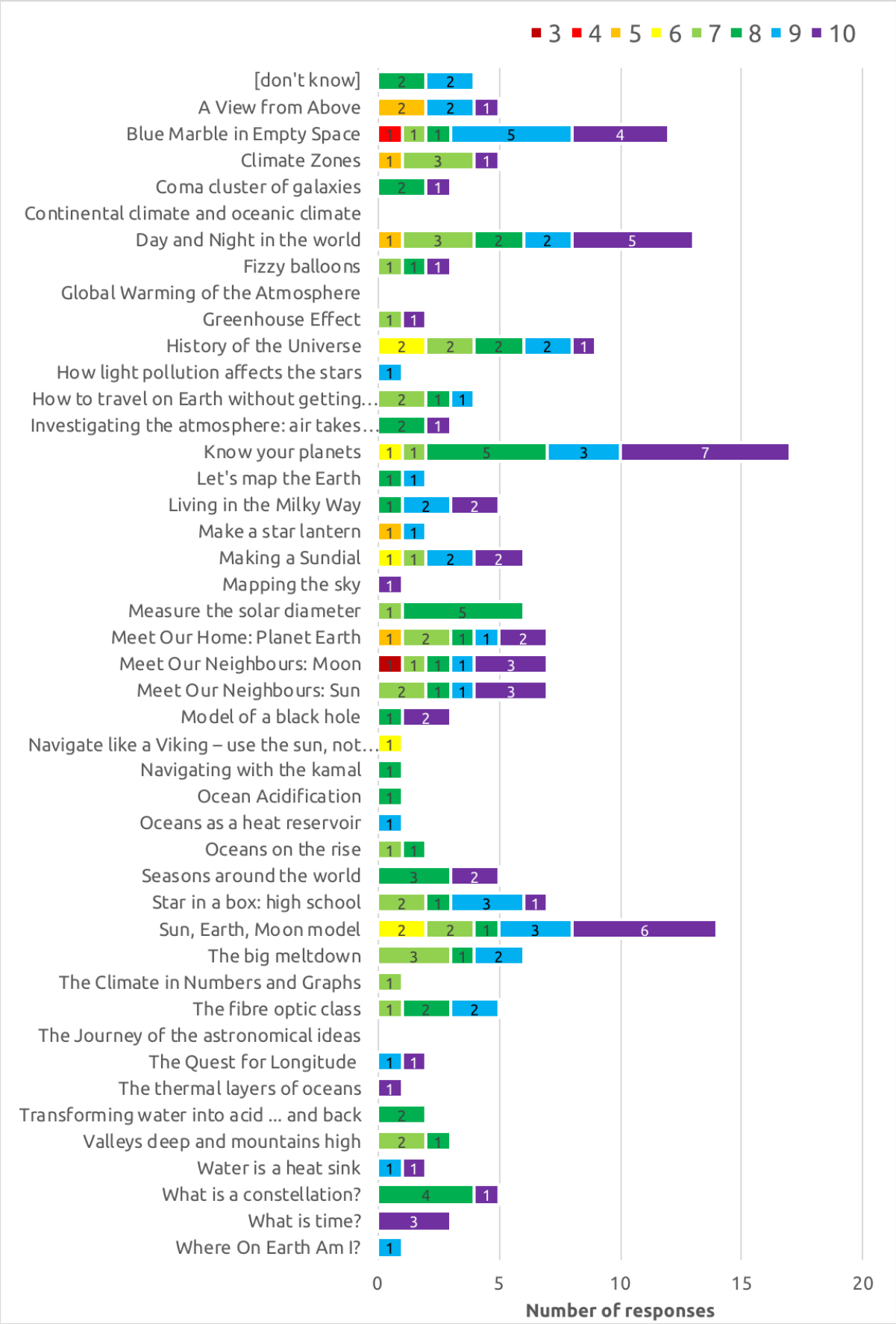

Figure 8 - Distribution of overall activity ratings by resource [n=190]

The overall ratings were generally very positive: half of the respondents gave a rating of 9 or 10 (Excellent), and more than 92% gave a rating of 7 or higher. Breaking this down by the individual resources (Figure 8), it is clear that there is no consistent pattern for any particular resource – they all exhibit a range of ratings. The resources which received the lowest ratings (3, 4 or 5) also received scores of 9 or 10 from other respondents. Likewise, no resources consistently received scores of only 9 or 10. This suggests that participants' ratings were dependent upon many external factors, rather than any one resource being particularly poor or outstanding. To explore what such ratings were based on, statistical tests were run relating to aspects such as the respondent's demographics, or their responses to other questions within the feedback form. These showed that primary-level activities were statistically more likely to receive higher rankings ($p=0.012$). There was however no statistical difference depending on the thematic area or whether the age group involved when the respondent tried out the activity matched to the intended target audience. There was also no statistical relationship between overall ratings and whether the respondent had participated in any other Space Awareness activities. These results suggest that the activities were sufficiently capable of acting as stand-alone resources, without further insights or input from other aspects of the Space Awareness programme, and that there was some flexibility in suitable ages for their use.

The perceived overall quality was however statistically linked to three specific pupil outcomes. Respondents who gave a rating of 5 or lower were statistically more likely to *disagree* with the following statements:

- the activity was interesting for my students ($p=0.047$)
- the activity developed my students' inquiry skills ($p=0.044$)
- the activity promoted STEM careers ($p=0.044$)

The associations are comparatively weak (as indicated by the closeness of the p values to 0.05), however this may suggest that the overall perceived quality was particularly linked to the activity's success in meeting these three criteria.

To help gauge motivations and inform wider marketing and dissemination efforts, the respondents were also asked to indicate (from a pre-prepared list of suggested reasons) why they chose that particular activity to review (Figure 9). Likely student engagement, personal interest and direct curriculum links were all highly rated, with approximately half (or more) of the respondents selecting each of these options. Interestingly, primary school teachers were statistically more likely to be influenced by the opinions of others despite the last two options ("It was recommended by someone else" and "I was asked to review it") being relatively low priorities overall ($p=0.026$ and $p=0.035$ respectively).

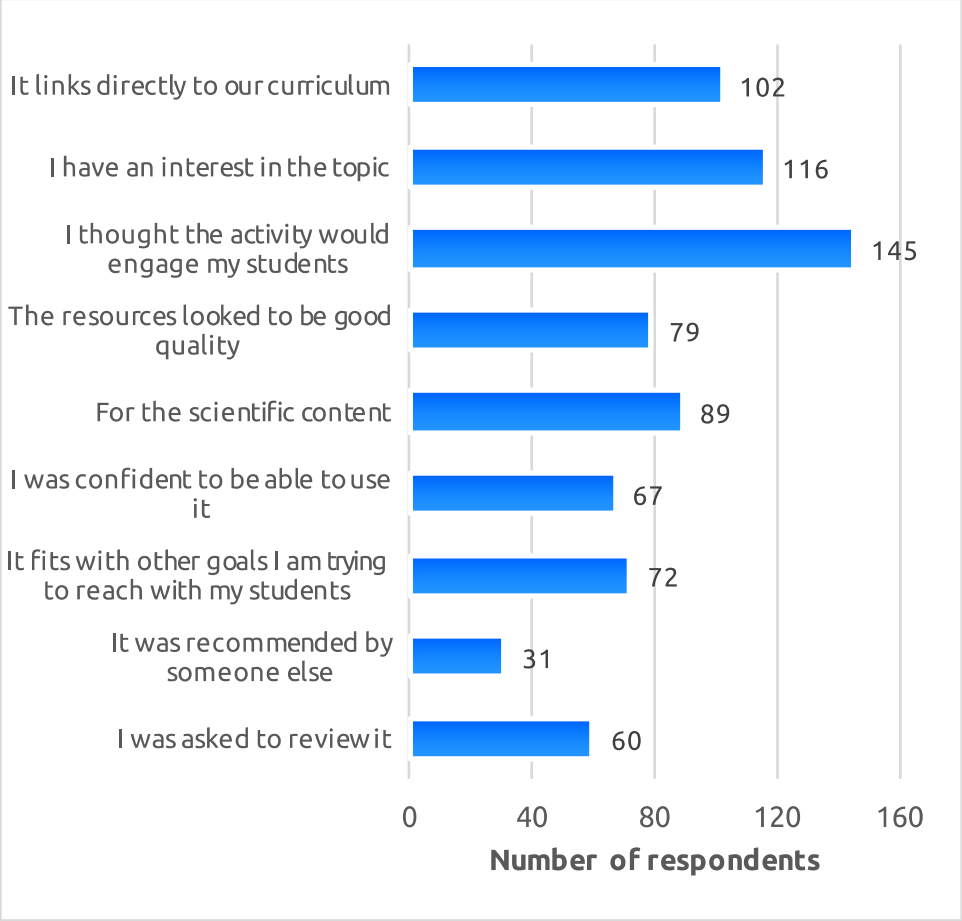

Figure 9 - Reasons why respondents chose that particular activity [n=212]

Open-response comments for "what worked well" were manually coded into common thematic categories (Figure 10). A wide variety of themes emerged, most notably relating to the "hands-on" nature of the activities, the high quality of the background materials (including the scientific content and images/visuals used), and the resources' success in explaining abstract or complex concepts. For example:

"By providing such thorough background resources, as a teacher I felt more confident teaching the children about the subject. I was able to decide which information was relevant for them and use this to aid their learning and outcomes." (Primary school teacher, United Kingdom)

"The combination of a rather easy experiment with just enough and hard enough curriculum." (Secondary school teacher, Norway)

"Practical investigation is a strong element of this activity. The variety of levels of background information provided for teachers is an additional strength of the resource that will support teachers teaching in a range settings and year groups with a range of subject knowledge." (Primary school teacher, United Kingdom)

"It was easy because it was well supported with notes and written with instructions which were step by step." (Secondary school teacher, Ireland)

It is noticeable within the above comments that the respondents explicitly made reference to the level of support provided, and the subsequent increase in confidence and associated ability to actively use such activities in the classroom.

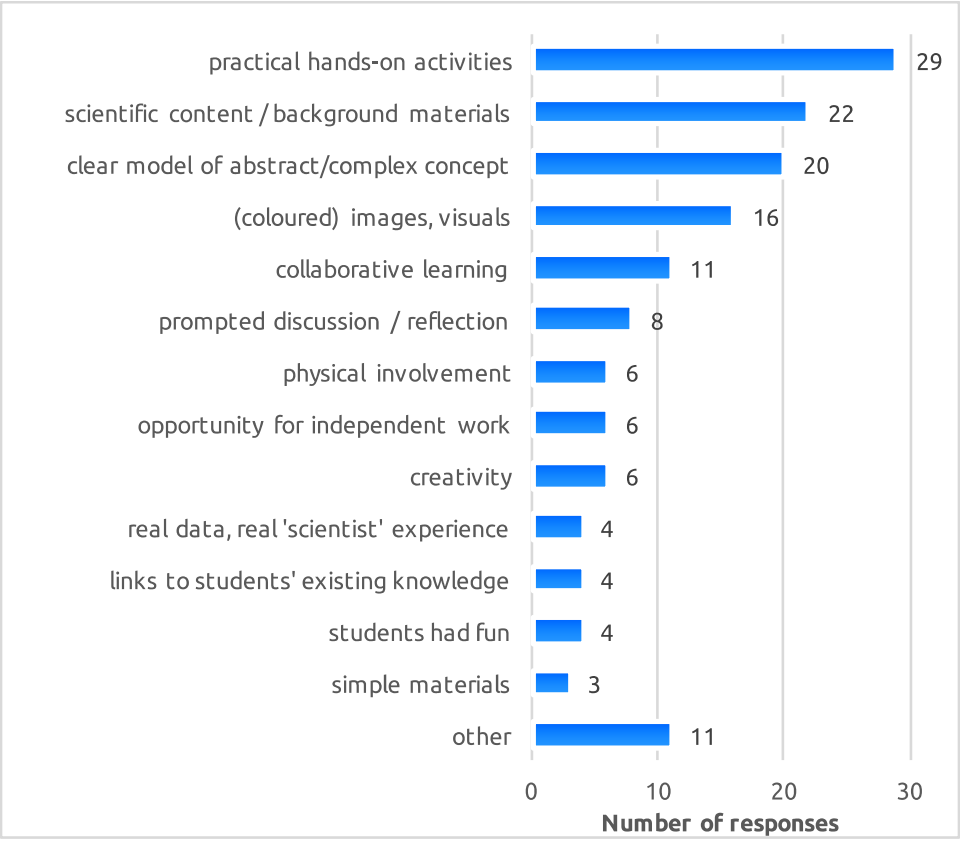

Figure 10 - What worked well [n=145]

Respondents also highly valued opportunities to expand their students' involvement, for example encouraging collaborative learning, discussion/reflection of key issues, physical involvement (especially primary activities involving movement), independent learning and creativity. Finally, a handful of teachers highlighted more experiential elements, such as the opportunity to manipulate 'real' data, linking back to their existing knowledge, or simply having fun:

"The conversation in which we talked about what they already knew (including their misconcepts). […] Some of the kids (mostly the girls also liked making the mobile and the idea that with the help of the mobile they could now explain it themselves to their (grand)parents, neighbours et cetera" (Primary school teacher, Netherlands)

"that the students were interacting with each other and that they had fun doing it" (Secondary school teacher, Ireland)

"children had fun, and they understood and reflected about things that they should notice every day (but they normally don't)" (Informal educator, Italy)

Regarding potential improvements to the resources, many of the respondents' suggestions (47 of 125 received, Figure 11) were very specific, detailing particular aspects within the activity that they either modified already themselves, or would do differently next time. These formative feedback elements have been incorporated into the final designs for the resource materials, and have thus contributed to improving and enhancing the educational activities as a legacy resource.

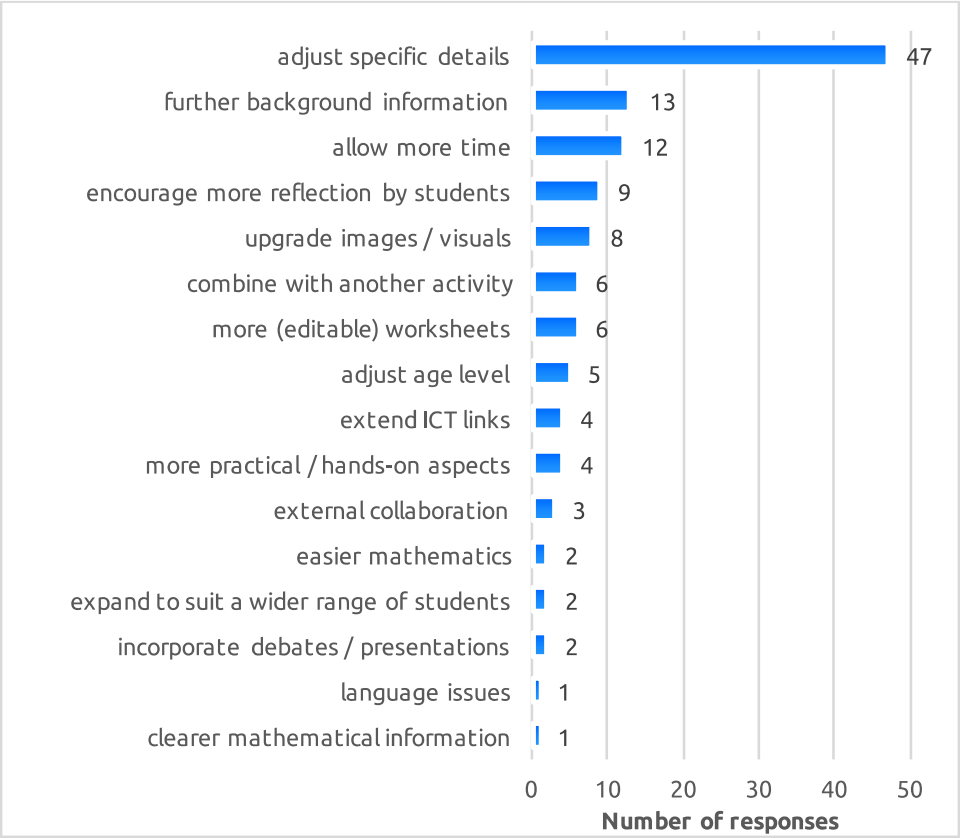

Figure 11 - Suggested improvements [n=125]

There were two notable suggested improvements which were more generalised across multiple activities. The first related to requests for further support information and/or background materials, especially to assist those who are not specialists in space science. The second general improvement was that the indicated timings on many of the activities were somewhat unrealistic, and more time should be allowed for them to be completed within class. The remaining suggestions in the main related to extending aspects that for other activities had been highlighted as particular strengths (Figure 10), for example more hands-on opportunities and encouraging more student reflection, or improving the quality and extent of the images, worksheets and other support materials provided.

"I feel that the time recommended for the activity is not necessarily long enough- particularly when working with younger children." (Primary school teacher, United Kingdom)

"Some questions to pose to students which would make them think at a deeper level. Say, five questions to promote thinking using Blooms taxonomy" (Secondary school teacher, Ireland)

5 Evaluation of outcomes

We move now to the main evaluation focus for this work: determining what changes occurred for the participating teachers and their students as a result of their use of a particular educational resource. Within the feedback form we asked respondents to rate how strongly they agreed or disagreed with a variety of indicator statements relating to the intended outcomes for the educational resources (see Table 2 for details). The first set of statements (explored in section 5.1) referred to changes relating to the teachers themselves – whether internal (such as their confidence, understanding, or emotional associations), or action oriented (relating to what actions they took or planned to take). The second set of statements (section 5.2) more specifically focused on the participants' students, and whether any changes were noticeable relating to their understanding, attitudes, skills, behaviours or emotional reactions.

5.1 Teacher outcomes

Figure 12 summarises the participants' responses to the teacher outcome indicator statements. Overall these results are fairly positive: at least three-quarters of the cohort agreed or strongly agreed with the majority of the statements, rising to over 90% for aspects relating to the helpfulness of the content, extent of information provision, and whether individuals are likely to both use the resource themselves again in the future, or recommend it to colleagues.

The main exception is the statement relating to careers opportunities: only around half of the respondents either agreed or strongly agreed with this statement, whilst 35% strongly disagreed that the activity had "helped me understand space career opportunities...". Exploring this further, resources within the *Our Fragile Planet* theme were statistically *more* likely to elicit agreement than others to this statement ($p=0.010$), whilst resources within *Navigation Through the Ages* were statistically *less* likely to demonstrate agreement ($p=0.013$). *Our Fragile Planet* resources therefore appear to have been slightly better aligned to space careers opportunities (though still exhibiting much weaker agreement than the other statements), and *Navigation Through the Ages* activities less so. In some respects this is rather disappointing, given that there are three separate intended outcomes relating to careers targeted by the educational resources (Table 2). However, as noted in Table 3 there are in fact only three resources explicitly target careers dimensions, corresponding to only 11 of the 211 activity feedback forms. It is therefore unsurprising that the majority of respondents did not report an increased understanding of space career opportunities, given that it was not a target feature of the resources they reviewed.

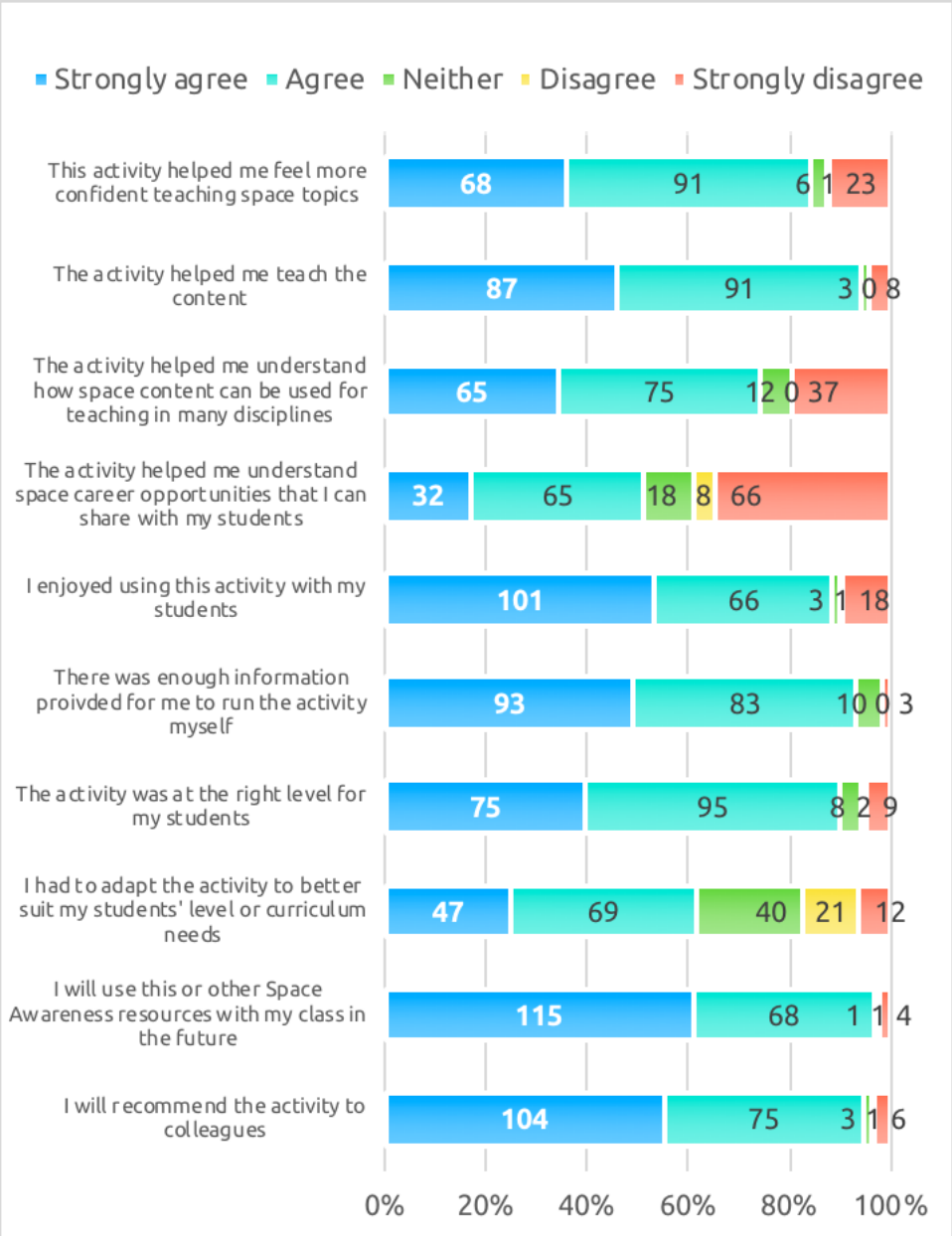

Figure 12 - Participants' reactions to the teacher-related outcome indicators [n=189]

We also explored demographic patterns within these data in order to identify potential trends that might require further attention within the resource revision process. Primary school teachers were more likely to agree with the majority of the teacher indicator statements than their secondary counterparts, with the exception of the statements relating to multidisciplinary teaching and space career opportunities. In particular, primary school teachers were statistically more likely to agree with the following statements (p values indicated in brackets):

- This activity helped me feel more confident teaching space topics (p=0.002)
- The activity helped me teach the content (p<0.001)
- There was enough information provided for me to run the activity myself (p=0.001)
- The activity was at the right level for my students (p=0.002)
- I will use this or other Space Awareness resources with my class in the future (p<0.001)
- I will recommend the activity to colleagues (p=0.027)

The large number of statements here, as well as the very low p values in most cases, suggest that the educational resources were particularly effective in supporting primary school teachers. This is excellent news for the Space Awareness project, as primary school teachers were a key intended audience for the programme.

Interestingly, resources that were specifically linked to ICT (Table 3) were statistically *more* likely to be used again in the future (0.048) or recommended to colleagues (p=0.032). This suggests that effective ICT tools are sought after by European teachers, and act as an additional hook during decisions relating to ongoing use of particular resources.

Similarly, teachers who used resources from within the *Navigation Through the Ages* thematic area were statistically more likely to report having enjoyed the experience (p=0.005), plan to use it again in the future (p=0.008) and recommend it to colleagues (p=0.027). No other trends were observed for the remaining thematic areas. Hence the *Navigation Through the Ages* resources appear to have been particularly successful in becoming embedded within the respondents' ongoing practice.

5.2 Pupil outcomes

Moving now to consider the *pupil* related statements, Figure 13 summarises the respondents' ratings in each case. Though positive overall, the responses here are slightly less effusive than the teacher-related statements outlined in section 5.1: the proportion of respondents at least agreeing with each statement has dropped to 60-80% in most cases. Of course, this is not necessarily a failure of individual specific resources – none of the resources were designed to support ALL of the intended outcomes, so we would expect some of them to be less successful in achieving high scores on certain statements. Overall, respondents were most positive about the activities being interesting for their students (86% selecting "Agree" or "Strongly agree"), as well as teaching their students some content (84%). However, in both cases there was still around 14% of respondents who selected "Strongly disagree".

The weakest indicator when considered across all of the resources in aggregate related to IT skills, where less than half of the respondents at least agreed that "The activity developed my students' IT skills" (46%), and over one-third selected "Strongly disagree" for this statement (34%). Likewise, there was strong overall disagreement with statements relating to encouraging equal participation from students of minority backgrounds (31%) and whether the activity "demonstrated how space research contributes to everyday life" (31%).

Taken individually however, many of the resources were judged to successfully achieve these more challenging goals. For example, for one activity "Know Your Planets" [10], the levels of agreement relating to the development of IT skills and demonstrating the contributions of space science to everyday life were both 64% (Figure 14). Drilling down further into the data, it is noticeable that as with the overall ratings for individual resources (Figure 8), the responses to these indicator statements did show wide variation at individual resource level.

[10] This resource was chosen as it had the largest number of responses (n=14), however the trends discussed here were generally true across most of the individual resources.

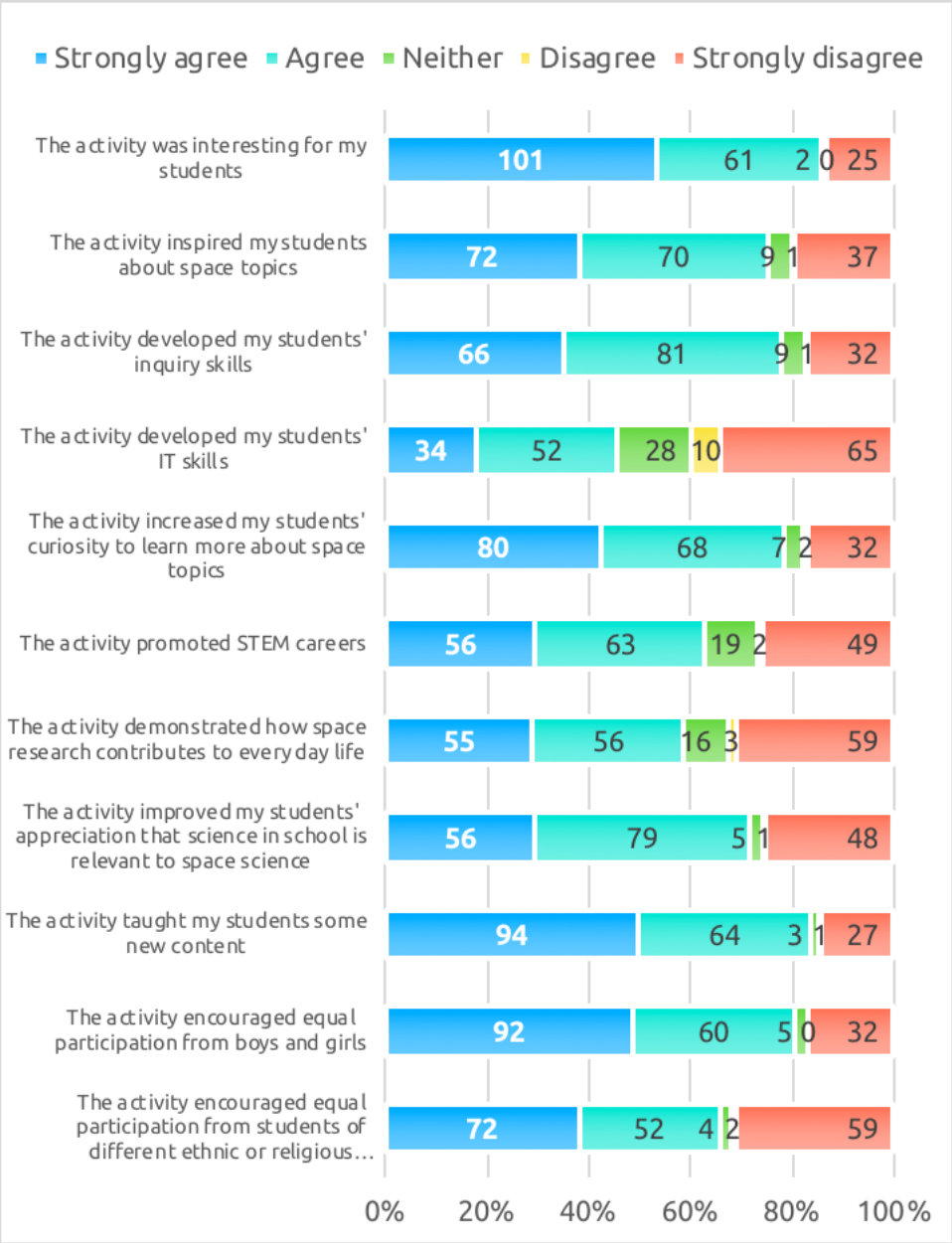

Figure 13 - Participants' reactions to the pupil-related outcome indicators [n=189]

Exploring Figure 14 from a holistic perspective suggests that the responses to the pupil-related outcome indicator statements also showed wide variation. The overall pattern is remarkably similar to that shown in Figure 13, and again suggests that factors relating to an individual teacher's priorities and situation were more likely to influence their responses. None of the individual resources were particularly poor or outstanding (in comparison to the others) when it came to achieving the intended pupil-related impacts.

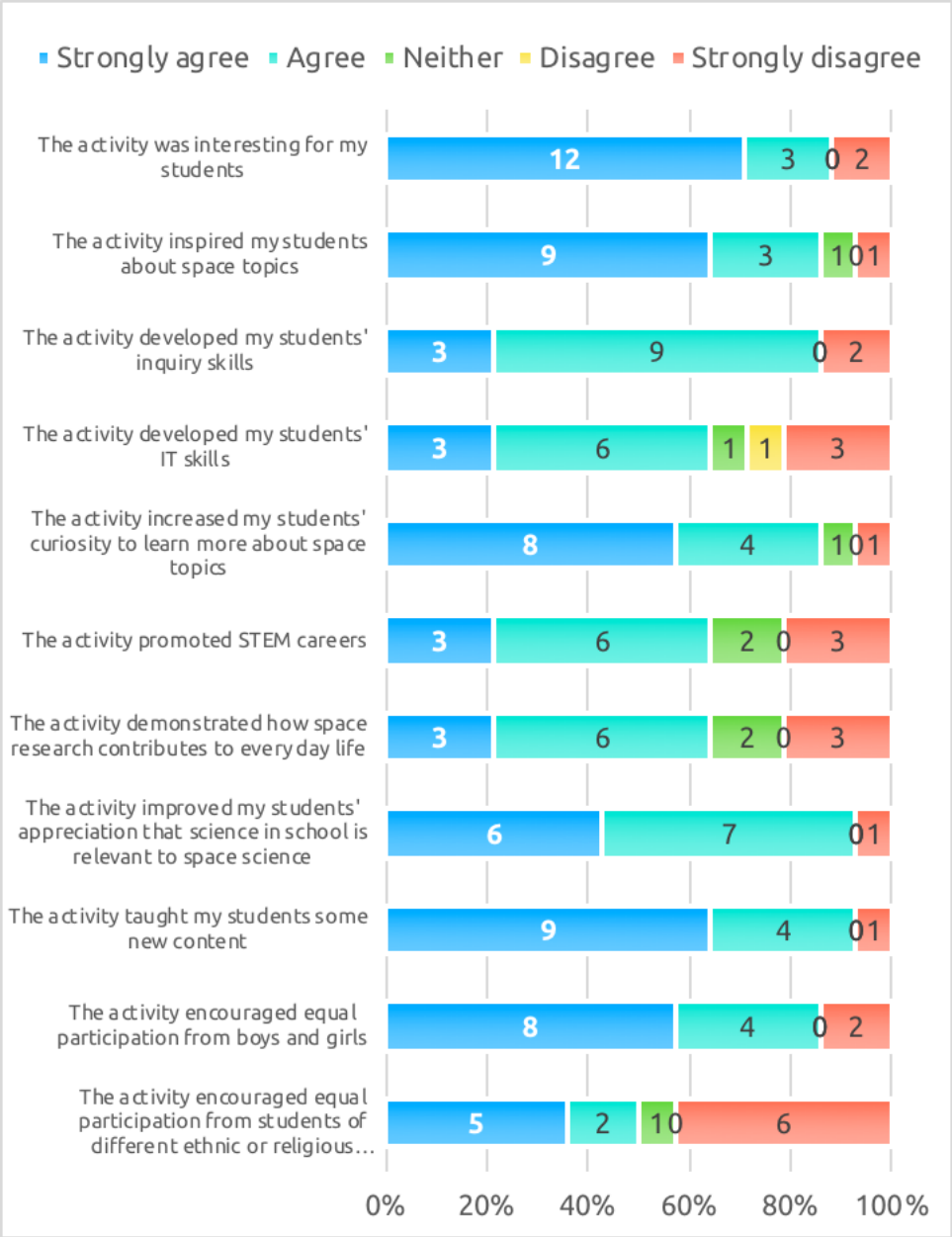

Figure 14 - Participants' reactions to the pupil-related outcome indicators - "Know Your Planets" resource only [n=14]

There were some interesting patterns within these data, for example that on average, primary school teachers agreed more strongly with all of the pupil indicator statements than their secondary counterparts. Importantly, primary school teachers were statistically more likely to agree with the following statements regarding their pupils' experiences of using the resources (p values indicated in brackets):

- The activity was interesting for my students (p=0.004)
- The activity inspired my students about space topics (p=0.019)
- The activity increased my students' curiosity to learn more about space topics (p=0.022)
- The activity encouraged equal participation from boys and girls (p<0.000)
- The activity encouraged equal participation from students of different ethnic or religious backgrounds (p=0.004)

What is noticeable here is that the ratings from primary school teachers tended to demonstrate statistically significant differences in the case of emotional reactions (interest, enjoyment, curiosity), as well as with regards to the two statements relating to differential participation (by gender or minority status). However, statements reflecting changes in values, attitudes and skills were not so devolved from those of secondary school teachers. This may simply reflect normal differences in primary/secondary school student behaviour (for example that primary school pupils are more likely to react emotively).

There were however some differences by thematic area which are less easy to explain by participant background. In particular, participants who used the *Navigation Through the Ages* resources were *more* likely to agree that "The activity developed my students' inquiry skills" (p=0.032) whilst those who used the *Our Wonderful Universe* resources were *less* likely to agree with the same statement (p=0.005). It appears that development of inquiry skills was therefore judged to be more effective within the *Navigation Through the Ages* resources than those associated with the *Our Wonderful Universe* theme.

Overall these responses to the pupil-indicator statements suggest that the activities were judged by the majority of participants to have been influential in achieving the intended pupil-oriented outcomes, though with some room for improvement.

6 Conclusions

This section compares the observed results reported in section 5 with the originally intended outcomes as described in section 2.1[11]. 212 feedback forms covering 43 activities were received in total, submitted by teachers throughout Europe and beyond. They represented a good range of teaching levels (both primary and secondary schools) and geographical spread. Although weighted towards STEM specialisms, the respondents did include around 30 individuals who reported at least some expertise within languages, humanities or other non-STEM subjects.

The overall ratings were generally very positive: half of the respondents gave a rating of 9 or 10 (excellent), and more than 92% gave a rating of 7 or more. Where multiple respondents tested the same resource the ratings tended to be quite varied, suggesting that participants' ratings were dependent upon many external factors, rather than any one resource being particularly poor or outstanding. Primary school activities were statistically more likely to receive higher ratings than secondary school resources, and lower ratings appear to have been linked to resources which were perceived to be lacking in interest, inquiry skills and/or the promotion of STEM careers.

Participants particularly appreciated activities which were "hands on", contained high quality background materials (both in terms of the scientific content and the images/visuals used), and/or were able to explain abstract or complex concepts. The respondents also provided a range of specific adjustments and feedback rating to individual resources, which have been incorporated into the final versions where possible. In addition, more generally they were interested in further support information (especially to assist those who are not

[11] For a broader summary of this report overall see the Executive Summary at the start.

specialists in space science), and recommended that the indicated timings on many of the activities should be extended.

Table 4 provides a visual summary of which priority intended learning outcomes were achieved within the Space Awareness teacher educational resources. The final column serves as a "traffic light" indicator of the extent to which the evidence gathered supported whether each outcome had been achieved[12].

It is clear from Table 4 that there was strong evidence (albeit sporadic in places) of around half of the priority learning outcomes having been achieved by the Space Awareness educational resources (11 of 23; green shading). It is clear that participating teachers (and their students) (i) found the Space Awareness activities interesting, and gained a variety of positive emotions from the experience, including (ii) enjoyment, (iii) confidence, (iv) inspiration, and (v) general positive attitudes to space science. They also gained (xii) content knowledge and (xiii) an appreciation of the relevance of space science to multi-disciplinary teaching. Educators were able to (xv) confidently implement the resources, and (xviii) expressed a strong intent to recommend the resources to other colleagues. Likewise, the survey respondents felt that both they and their students (xvi) wanted to learn more about space science, and had (xx) developed inquiry-based skills as a result of their involvement.

There were however some notable areas where the evidence of success was slightly weaker (coloured amber or orange in Table 4): certainly, such outcomes were achieved for some individuals, but the effects were not consistent across the cohort. In particular this referred to (vi, xvii) careers-related aspirations, and (xxi) connections to ICT usage. Additionally, there were some values (x and xi) that were explicitly explored within the evaluation survey, but again the evidence of their success was limited within the cohort. Of course, these issues can in part be explained by the fact that not all resources were expected to achieve ALL of the intended outcomes. Additionally, these elements are likely to have been implicit within the various educational resources (rather than explicitly highlighted), and may have benefitted from more overt mention within the instructions and/or support materials in order to make teachers and/or pupils more aware of the likelihood of those outcomes being achieved.

Finally, there were seven intended outcomes for which we have no evidence either way as to whether they were successful (coloured grey in Table 4). These reflect lower-priority outcomes which were not explicitly mentioned within any of the indicator statements, and for which no mention was made within the open-response comments provided. It is possible that at least some of these outcomes were achieved for some individual respondents, however limitations within the evaluation processes mean we are unable to comment further.

Overall these results are positive. There is evidence that most of the intended priority outcomes were achieved by the majority of the educational resources, and that they are likely to be perceived as a useful and valuable resource well after the lifetime of the Space Awareness project by teachers throughout Europe and beyond.

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[12] In addition to teachers' self-reported responses to direct statements on these aspects (see Figure 12 and Figure 13), these judgements have been based on a synthesis of qualitative comments received. Note that the key to the colour scale used is included at the bottom of the table.

Theme	Priority intended learning outcome	Target* Audience	Rating
Feel	xxiv. Find Space Awareness activities interesting	ES	
	xxv. Enjoy learning/teaching about space	ES	
	xxvi. Feel confident teaching space topics	ES	
	xxvii. Feel inspired by space science	ES	
	xxviii. Feel positive about space science	ES	
	xxix. Aspire to space science careers	S	
Value	xxx. Value the diverse contributions of many different cultures to space science	S	
	xxxi. Value the contributions made by both women and men to space science	ES	
	xxxii. Value trans-national European and Global citizenship	ES	
	xxxiii. Appreciate that space science contributes to everyday life	ES	
	xxxiv. Appreciate that school science is relevant to space science	ES	
Understand	xxxv. Highlights of space science (Our Wonderful Universe, Our Fragile Planet and Navigation Through the Ages)	ES	
	xxxvi. Space science can be used for teaching in many disciplines including cross-disciplinary contexts and non-science subjects	E	
	xxxvii. Space science needs an interdisciplinary approach	ES	
Do	xxxviii. Access and use Space Awareness activities confidently	E	
	xxxix. Want to learn more about space science	ES	
	xl. Choose or consider choosing, or encourage others, to study and pursue careers in space science and engineering or science and engineering more widely, especially girls and ethnic minorities	ES	
	xli. Share their understanding of space science and technology with learners, peers, family and/or their community	ES	
Skills	xlii. Learn how to carry out scientific or technical activities themselves	ES	
	xliii. Develop inquiry-based skills for teaching/learning about space science	ES	
	xliv. Learn how to use IT to teach/learn about space science	ES	
	xlv. Learn how to be more inclusive while teaching, particularly for girls and minorities	E	
	xlvi. Develop skills involved in space-related careers	ES	

Strong evidence this outcome was achieved	*Strong but sporadic evidence this was achieved*	*Some evidence this outcome was achieved*	*Evidence this outcome was NOT achieved*	*No evidence either way*

Table 4- Summary of achieved learning outcomes. *Note that for the sake of brevity only the high priority outcomes identified in Table 2 have been included here. * Target audience refers to intended outcomes for educators (E) or students (S).*

6.1 Recommendations

This section summarises key recommendations from the evaluation of the Space Awareness educational resources which may be relevant for the development of future similar initiatives.

- To be perceived as high quality by teachers, educational resources need to be likely to achieve high student engagement and/or interest, and contain direct curriculum links. Hands-on aspects, high quality images and scientific content, and successful explanation of an abstract or complex concept were also strong characteristics.
- There were two notable general suggested improvements: further support information and/or background materials (especially to assist those who are not specialists in space science); and to extend the indicated timings for many of the activities to be more realistic.
- Though key areas of intended impact, careers aspirations and ICT skills were judged by these participating teachers to be less well supported by the resources than aspects relating to knowledge or emotional reactions. These elements are likely to have been implicit within the various educational resources (rather than explicitly highlighted), and may have benefitted from more overt mention within the instructions and/or support materials to help both teachers and students recognise the focus on those skills.
- Teacher recruitment to participate in the evaluation of the educational resources proved very challenging in most countries. For future similar exercises further incentives for the teachers should be considered – perhaps a prize draw, or release of further resources and materials once the feedback form has been received.
- The ratings scores here varied wildly; multiple teachers rated the same resource in very different ways. There were few clear patterns in these ratings at individual resource level – clearer labels (e.g. regarding the difference between a 7 or an 8) may help to normalise such ratings in the future.

7 Appendices

Annexe A: Full list of activities

Annexe B: Instructions to nodes

Annexe C: Resource feedback form

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