
EYU VALUING INCLUSION: EVALUATION REPORT

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Executive Summary

Through long-term data capture from community engagement programmes across the Informal Science Learning sector, six inclusive outcome areas were identified by the Association for Science and Discovery Centres (ASDC) as part of the legacy of Explore Your Universe Phase 4 (EYU4), supported by STFC, part of UKRI. These outcome areas promote equity and inclusion in STFC engagement practice and are placed as key mechanisms to be prioritised if we are to unlock more diverse participation in STEM research, development, industry and innovation for the future.

Evaluation and research specialists in Informal Science Learning, science centre practitioners and community engagement specialists from youth and community groups, worked together to co-develop a quantitative instrument to measure these six inclusive participant outcome areas: Agency and ownership, Relevance, Belonging, Skills development, Social connection and Possible selves.

Data was collected from 13 science and discovery centres and museums (science centres) distributed across the UK. These science centres worked through their established community partnerships on grant-awarded projects that ran between February 2024 and May 2024, with each project providing evaluation data for at least two out of the six outcome areas.

Data collected reflected that the programmes and activities delivered by the science centres supported the six inclusive outcome areas. In the four science centres that collected both pre- and post-programme data, a notable increase was observed in positive responses for all 18 evaluation statements used. The statements 'I can be myself when doing science activities' and 'I feel my ideas are heard during science activities' under the Belonging outcome yielded a remarkable increase of over 20 percentage points. Additionally, six items relating to Possible Selves (3), Relevance (1), Social Connection (1) and Belonging (1) showed a boost of ten percentage points.

Among the 10 science centres that collected post-only data, 70% or more of participants reported feeling more comfortable in the project compared to their usual experiences with science and 73% agreed they were more interested in careers in science (possible selves). Over 90% indicated they had tried something new, learnt something new, and enjoyed doing science activities with friends and family.

These results are especially encouraging given the broad range of STFC science subjects covered and the diversity of participants, including youth groups, individuals with neurodivergence, those from low socioeconomic background, LGBTQ+ groups, and non-native English speakers. The success of these initiatives highlights the substantial impact inclusive informal science engagement

can have on young people's social and emotional outcomes, including broadening their aspirations and feeling more connected with science.

Beyond demonstrating impact, the project assessed the legitimacy of the six outcome areas used to evaluate inclusion in informal science learning contexts. This was done through a combination of quantitative analysis of audience responses and qualitative insights from discussions with science centres, community partners, and participants.

A Principal Components Analysis (PCA) was employed to explore associations between the 19 statements across the six outcomes, grouping related statements into overarching factors. These factors were then tested for internal consistency using Cronbach's alpha, revealing that the statements aligned well with their intended outcomes.

Instrument validation underscored the robustness of the process used to formulate and map appropriate statements to outcome areas. This process incorporated insights from existing literature, established instruments, expert researchers and ongoing consultations with practitioners.

In addition to revealing a positive impact on participants and showing the validity and reliability of the measures used, the evaluation also flagged areas that would benefit from further study. As science centres were given autonomy to choose which outcomes they measured, the ability to explore all possible correlations among outcomes was limited to some extent. Future studies should encourage science centres to capture particular outcomes data (e.g. related to Agency and Relevance) to permit further quantitative exploration of the relationships between outcome areas.

Additionally, while the 'Relevance' outcome demonstrated statistical reliability, qualitative data suggests it warrants exploratory reframing. Currently, it focuses on participants' perceptions of the relevance of the science subject matter or content. However, other data collected - as well as previous research - suggests that fostering a sense of personal connection with science is not only important but also requires that participants' experiences of engaging with science activities are themselves meaningful and relevant.

Our findings confirm that the six outcome measures effectively capture key components of equitable and inclusive practices in informal science education. However, concepts of enjoyment, interest, and curiosity also emerged as critical features supporting inclusive environments and thus seem to act as prerequisites to inclusive outcomes. Further exploration of the role of these factors in fostering inclusivity would contribute to further development of a robust Theory of Change.

Finally, qualitative observations and interviews with science centres and community partners suggest that the 'Social Connections' outcome could be expanded beyond participant-participant relationships to encompass practitioner-participant relationships. Practitioners played a vital role in fostering a welcoming environment, particularly conducive to the 'Belonging' outcome. Investigating how these relationships form and contribute to inclusivity within the Theory of Change would deepen our understanding of inclusive practices in informal science settings and the practitioner's role within this.

Introduction

The informal science learning sector lacks a shared language that can be used to articulate the impact of equality, diversity and inclusion endeavours. This absence potentially leaves audiences and science centres vulnerable to their efforts being undercut or their importance downplayed or dismissed.

A key challenge is that more qualitative measures of inclusion that go beyond diversity metrics can be viewed as lacking objectivity and rigour and seen as a ‘nice-to-have’ rather than ‘business essential’. In response, ASDC and STFC funded a number of science centres across the UK to devote time and resource to providing evidence around a series of inclusion metrics. Centres, with a dedicated community partner, engaged with audiences to deliver STFC science targeting the following six participant outcome areas:

- Possible Selves
- Agency
- Relevance
- Developing Skills
- Social Connection
- Belonging

Drawing on existing literature and measures, ASDC staff, science centres, community partners and expert evaluators worked together to co-develop a quantitative instrument that could measure these six areas. The purpose of this report is to summarise the findings from implementing this instrument and highlight the implications for equality, diversity and inclusion in informal science settings, in practice.

Instrument

The primary instrument for collecting data relating to the six participant outcome areas of Possible Selves, Agency, Relevance, Developing Skills, Social Connection and Belonging was a quantitative Likert-scale measure that was presented in a ‘postcard’ format. The postcard was tailored to each science centre and explained to respondents that they were sending a postcard to the team at the science centre they were working with to tell them about their experiences with science. An example postcard is provided in Appendix 1. Items for the measure were co-developed between ASDC, the evaluation team, evaluation experts, science centres and community partners at an ‘evaluation 101’ event and built on previous research in the field as well as earlier discussions.

The instrument comprised 19 statements to measure six participant outcome areas relating to inclusive science learning experiences. All outcome areas had three associated statements, apart from Possible Selves which had four. Some statements, due to their nature, were only suitable to be asked post-event. For example, it would not make sense to ask audiences if they ‘learnt something new’ prior to engaging in an activity or initiative. Although we could have asked about expectations (‘do you think you will learn something new?’), this is not a direct comparison and is a different sort of question. Additionally, it was important to keep the scales as short as possible.

For all statements, the response options were a 5-point Likert scale of agreement (strongly disagree, disagree, neither disagree nor agree, agree, strongly agree). All words marked in asterisks could be substituted with terminology more appropriate to centres' projects, for example:

- *science* - some centres were focusing on specific areas of science, for example space science, or big data science.
- *project* - centres were encouraged to replace this with either the name of their science centre or the name of the project, whatever term they felt their audience would be most familiar with.
- *friends and family* - it was important that this aligned with the audience groups the centres were working with, for example 'youth group' or 'classmates' may have been more suitable in some cases.

Further tweaks to wording were also permissible for intelligibility, but all were discussed with the evaluators.

Science centres were given two options for when to gather audience data: both before (pre) and after (post) their intervention, or just after (post). Decisions depended on the format and duration of interventions. For example, pre and post data collection is more suited to interventions that take place over multiple days/weeks, than to one-off events of an hour or two duration, or 'drop-in' events.

The outcome areas and their relevant statements and appropriate wording depending on when statements were posed to audiences (pre- or post-intervention) are summarised in Table 1.

TABLE 1 – OUTCOME AREAS AND ASSOCIATED STATEMENTS

Outcome	Statements		
	When Collecting Pre and Post Data		When only collecting Post Data
	Pre Statement	Post Statement	
Possible Selves	I would like to know more about careers involving *science*	I would like to know more about careers involving *science*	Since taking part in the *project*, I feel more interested in knowing about careers in *science*
	I think *science* will be useful to me in the future	I think *science* will be useful to me in the future	Since taking part in the *project*, I think *science* will be more useful to me in the future
	I could work with *science* in the future if I wanted to	I could work with *science* in the future if I wanted to	Since taking part in the *project*, I feel more able to work with *science* in my future
	/	[post-only] During the *project*, I heard about other *science* activities I can do at home or in my area	During the *project*, I heard about other *science* activities I can do at home or in my area
Agency	I feel able to contribute my ideas when doing science activities	I felt able to contribute my ideas during the *project*	Compared to my normal experiences doing *science* activities, I felt more able to contribute my ideas in the *project*
	I feel able to join in with science activities	I felt able to join in with the *project*	Compared to my normal experiences doing *science* activities, I felt more able to join in during the *project*
	I feel proud of myself when I do science activities	I felt proud of myself when doing the *project* activities	I felt proud of what I did during the *project*
Relevance	Science matters in my everyday life	The *science* we did in the *project* matters in my everyday life	The *science* we did in the *project* matters in my everyday life
	I can use science to understand the world around me	I can use the *science* we covered in the *project* to understand the world around me	I can use the *science* we covered in the *project* to understand the world around me
	Science feels relevant to me and things I care about	The *science* we did in the *project* felt relevant to me and things I care about	The *science* we did in the *project* felt relevant to me and things I care about

Developing Skills	I would like to develop my skills in science	I would like to develop my skills in *science*	Since doing the *project*, I am more interested in developing my skills in *science*
	/	During the *project*, I tried something I had not done before	During the *project*, I tried something I had not done before
	/	During the *project*, I learnt something new.	During the *project*, I learnt something new
Social Connection	I enjoy doing science activities with my *friends and family*	During the *project*, I enjoyed doing *science* activities with my *friends and family*	During the *project*, I enjoyed doing *science* activities with my *friends and family*
	I enjoy having conversations with my *friends and family* about science	During the *project*, I enjoyed having conversations about *science* with my *friends and family*	During the *project*, I enjoyed having conversations about *science* with my *friends and family*
	I feel connected to my *friends and family* when doing science activities together	During the *project* I felt connected to my *friends and family* when doing *science* activities together	During the *project*, I felt connected to my *friends and family* when doing *science* activities together
Belonging	I feel comfortable when doing science activities	I felt comfortable when doing the *project* activities	Compared to my normal experiences doing *science* activities, I felt more comfortable in the *project*
	I can be myself when doing science activities	I could be myself when doing the *project* activities	Compared to my normal experiences doing *science* activities, I felt more able to be myself in the *project*
	I feel my ideas are heard during science activities	I felt my ideas were heard during the *project* activities	Compared to my normal experiences doing *science* activities, I felt my ideas were heard more during the *project*

Data Collected

All 13 science centres collected evaluation data for at least two of the six outcome areas. Centres were encouraged to use all statements within each of the outcome measure they chose. Table 2 summarises which outcome areas were collected by which centre.

TABLE 2 – DATA COLLECTION FOR EACH SCIENCE CENTRE BY OUTCOME

Science Centre	N	Possible Selves	Agency	Relevance	Developing Skills	Social Connection	Belonging
Aberdeen Science Centre	35	✓		✓			✓
Armagh Observatory and Planetarium	18	✓	✓		✓	✓	
Cambridge Science Centre	7		✓			✓	✓
Catalyst	10	✓*	✓	✓	✓*		
Dundee Science Centre	48	✓					✓
Dynamic Earth	40	✓		✓	✓		
Jodrell Bank	97	✓					✓
National Space Centre	71	✓			✓	✓	✓
Royal Astronomical Society	137	✓			✓	✓	
Science Oxford	11			✓		✓	
Techniquet	146	✓		✓			
We the Curious	19			✓			✓
W5	23	✓	✓		✓	✓	

*only included two of the four statements for Possible Selves and two of the three statements for Skills.

From Table 2, it is apparent that only one centre (Catalyst, and see below) captured statements relating to both Relevance and Agency. This had implications for validation tests (see [Suitability of Tool](#)).

While results from Catalyst are provided in Table 3 and reported individually as a centre, their results are not included in full analysis as they were only able to provide average scores across all 10 participants for each statement, not individual responses. Table 3 summarises data collection across science centres by specific statements within each of the outcomes.

TABLE 3 – OVERVIEW OF DATA COLLECTED BY STATEMENT

	Statement	N (pre/post)	N (post only)	Centres
Possible Selves	I would like to know more about careers involving science	158/145	448	9
	I think science will be useful to me in the future	158/144	449	9
	I could work with science in the future if I wanted to	157/143	442	9

	During the project, I heard about other science activities can do at home or in my area [post-only]	-/96	447	8
Agency	I feel able to contribute my ideas when doing science activities	-	47	3
	I feel able to join in with science activities	-	47	3
	I feel proud of myself when I do science activities	-	46	3
Relevance	Science matters in my everyday life	55/34	204	5
	I can use science to understand the world around me	55/36	204	5
	Science feels relevant to me and things I care about	55/36	204	5
Developing Skills	I would like to develop my skills in science	110/90	170	5
	During the project, I tried something I had not done before [post-only]	-/90	171	5
	During the project, I learnt something new [post-only]	-/89	189	6
Social Connection	I enjoy doing science activities with my friends and family	71/61	194	6
	I enjoy having conversations with my friends and family about science	71/61	291	7
	I feel connected to my friends and family when doing science activities together	71/61	195	6
Belonging	I feel comfortable when doing science activities	118/108	119	5
	I can be myself when doing science activities	118/115	147	6
	I feel my ideas are heard during science activities	118/109	122	5

Suitability of Tool

A key objective of the evaluation was to assess the legitimacy of the outcome measures in terms of measuring inclusion in informal science learning contexts, and the appropriateness and cohesion of statements within each of the outcome areas. This was explored through quantitative analysis of audience responses to the outcome measures, and through qualitative discussions with centres, community partners and participants.

Reliability of Measurements

A Principal Components Analysis (PCA) was conducted to explore associations between the 19 statements across the six outcomes based on how audiences responded to these statements. As evident from Table 3, substantially more data was collected by centres post-intervention than pre-intervention and so we used post-data to run the PCA.

The PCA was initially computed to extract components with eigenvalues of 1 or greater. An eigenvalue describes the amount of variance (deviation from the mean) explained by each component (grouped variables/statements). An eigenvalue less than 1 means that the component explains less variance in the data than a single variable would.

Because science centres chose which outcomes they measured, we were unable to guarantee overlap of outcomes/statements for the PCA. As is evident from Table 2, no science centres measured statements relating to both Agency and Relevance (bar Catalyst, but see above). This meant that patterns in how participants responded to statements under these outcomes, could not be explored. Thus, the PCA could only be computed for statements relating to Possible Selves, Developing Skills, Belonging, Social Connection and Agency (not Relevance), OR for Possible Selves, Developing Skills, Belonging, Social Connection and Relevance (not Agency).

We report on both iterations, beginning with the PCA that included statements relating to Agency but not those relating to Relevance. This yielded four components with eigenvalues greater than 1 and produced the pattern matrix displayed in Figure 1. The values illustrate how much each statement ‘loads’ onto that component on a scale of 0-1, the closer to 1, the stronger that statement loads onto that factor. These loadings are based on how participants responded to the statements. The intended outcomes for each statement are displayed in closed brackets for reference.

FIGURE 1 – PATTERN MATRIX FOR PCA WITH STATEMENTS RELATING TO POSSIBLE SELVES, BELONGING, AGENCY, DEVELOPING SKILLS AND SOCIAL CONNECTION

Pattern Matrix^a

	Component			
	1	2	3	4
[Possible Selves 3] Since taking part in the project, I feel more able to work with science in my future	0.818			
[Possible Selves 1] Since taking part in the project, I feel more interested in knowing about careers in science	0.779			
[Possible Selves 2] Since taking part in the project, I think science will be more useful to me in the future	0.749			
[Possible Selves 4] During the project, I heard about other science activities I can do at home or in my area	0.533			
[Belonging 2] Compared to my normal experiences doing science activities, I felt more able to be myself in the project		-0.777		
[Belonging 1] Compared to my normal experiences doing science activities, I felt more comfortable in the project		-0.755		
[Belonging 3] Compared to my normal experiences doing science activities, I felt my ideas were heard more during the project		-0.701		
[Agency 1] Compared to my normal experiences doing science activities, I felt more able to contribute my ideas in project			0.900	

[Agency 2] Compared to my normal experiences doing science activities, I felt more able to join in during project			0.874	
[Agency 3] I felt proud of what I did during the project			0.690	
[Social Connection 3] During the project, I felt connected to my friends and family when doing science activities together				0.757
[Social Connection 1] During the project, I enjoyed doing science activities with my friends and family				0.748
[Developing Skills 3] During the project, I learnt something new				0.631
[Developing Skills 2] During the project, I tried something I had not done before				0.624
[Developing Skills 1] Since doing the project, I am more interested in developing my skills in science				0.568
[Social Connection 2] During the project, I enjoyed having conversations about science with my friends and family		-0.429		0.496

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 11 iterations.

The pattern matrix illustrates how Social Connection statement 2 ‘during the project, I enjoyed having conversations about science with my friends and family’ also loaded onto the component that otherwise described the Belonging statements. This is not surprising as intuitively we would expect the feeling of being involved in conversations with others, could also contribute to a sense of Belonging.

Furthermore, it is apparent that statements related to Possible Selves, Belonging and Agency all loaded into their own distinct components. However, statements relating to Developing Skills and Social Connection loaded onto a single component. Review of the language of these statements does little to offer an explanation of why these seemingly different statements loaded to a single component. One interpretation could be that the language across the statements involves ‘doing’ something in the project, for example, trying something they had not done before, having conversations about science. While these could describe a broader component of Active Participation, this could be considered akin to what the Agency outcome statements measure, which were grouped into a distinct component.

The PCA was then run to substitute the Agency statements for the Relevance statements. This produced a similar pattern matrix, with four components with eigenvalues greater than 1. This is displayed in Figure 2.

FIGURE 2 – PATTERN MATRIX FOR PCA WITH STATEMENTS RELATING TO POSSIBLE SELVES, BELONGING, RELEVANCE, DEVELOPING SKILLS AND SOCIAL CONNECTION

Pattern Matrix^a

	Component			
	1	2	3	4
Possible_selves_3 Since taking part in the project, I feel more able to work with science in my future	0.824			
Possible_selves_1 Since taking part in the project, I feel more interested in knowing about careers in science	0.793			
Possible_selves_2 Since taking part in the project, I think science will be more useful to me in the future	0.719			
Possible_selves_4 During the project, I heard about other science activities I can do at home or in my area	0.519			
Social_Connection_1 During the project, I enjoyed doing science activities with my friends and family		-0.774		
Social_Connection_3 During the project, I felt connected to my friends and family when doing science activities together		-0.767		
Skills_3 During the project, I learnt something new		-0.654		
Skills_2 During the project, I tried something I had not done before		-0.608		
Social_Connection_2 During the project, I enjoyed having conversations about science with my friends and family		-0.536	-0.388	
Skills_1 Since doing the project, I am more interested in developing my skills in science	0.301	-0.529		
Belonging_2 Compared to my normal experiences doing science activities, I felt more able to be myself in the project			-0.804	
Belonging_1 Compared to my normal experiences doing science activities, I felt more comfortable in the project			-0.760	
Belonging_3 Compared to my normal experiences doing science activities, I felt my ideas were heard more during the project			-0.678	
Relevance_3 The science we did in the project felt relevant to me and things I care about				0.848
Relevance_2 I can use the science we covered in the project to understand the world around me				0.762
Relevance_1 The science we did in the project matters in my everyday life				0.756

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 12 iterations.

We again saw Social Connection statement 2 ‘during the project, I enjoyed having conversations about science with my friends and family’ load onto the Belonging component. However, this time

we also see that the Developing Skills statement 1 ‘since doing the project, I am more interested in developing my skills in science’ loaded onto the component that described the Possible Selves statements. Given that this statement is about developing, it could be considered a prospective future task and so it seems sensible that it would relate to the Possible Selves statements.

As with the previous PCA, statements relating to Social Connection and Developing Skills loaded onto a single component.

As we intended for these two outcome areas to be distinct, another PCA was run, this time forcing five components to be extracted. This meant that the fifth factor would have an eigenvalue less than 1. This yielded the pattern matrices in Figure 3 (without Agency statements) and Figure 4 (without Relevance statements)

With the PCA without Agency, this produced a pattern matrix as expected, with statements relating to Developing Skills and Social Connection loading onto separate components as apparent from Figure 3

FIGURE 3 – PCA [WITHOUT AGENCY] PATTERN MATRIX WITH FORCED 5 COMPONENT EXTRACTION

Pattern Matrix^a

	Component				
	1	2	3	4	5
[Possible Selves 3] Since taking part in the project, I feel more able to work with science in my future	0.820				
[Possible Selves 1] Since taking part in the project, I feel more interested in knowing about careers in science	0.804				
[Possible Selves 2] Since taking part in the project, I think science will be more useful to me in the future	0.728				
[Possible Selves 4] During the project, I heard about other science activities I can do at home or in my area	0.483				
[Relevance 3] The science we did in the project felt relevant to me and things I care about		0.841			
[Relevance 1] The science we did in the project matters in my everyday life		0.767			
[Relevance 2] I can use the science we covered in the project to understand the world around me		0.754			
[Belonging 1] Compared to my normal experiences doing science activities, I felt more able to be myself in the project			-0.822		
[Belonging 1] Compared to my normal experiences doing science activities, I felt more comfortable in the project			-0.761		
[Belonging 3] Compared to my normal experiences doing science activities, I felt my ideas were heard more during the project			-0.700		
[Social Connection 3] During the project, I felt connected to my friends and family when doing science activities together				0.831	

[Social Connection 1] During the project, I enjoyed doing science activities with my friends and family				0.815	
[Social Connection 2] During the project, I enjoyed having conversations about science with my friends and family			-0.301	0.605	
[Developing Skills 2] During the project, I tried something I had not done before					0.889
[Developing Skills 3] During the project, I learnt something new					0.654
[Developing Skills 1] Since doing the project, I am more interested in developing my skills in science	0.306				0.328

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 9 iterations.

However, for the PCA without Relevance, the separation of Social Connection and Developing Skills was less clear cut, as is apparent in Figure 4. Additionally, the Agency 3 statement ‘I felt proud of what I did during the project’, appeared to load with Developing Skills statements 2 and 3. This does not seem completely out of place as the two Developing Skills statements describe doing and learning new things, so a sense of pride in this could be expected.

FIGURE 4 – PCA [WITHOUT RELEVANCE] PATTERN MATRIX WITH FORCED 5 COMPONENT EXTRACTION

Pattern Matrix^a

	Component				
	1	2	3	4	5
[Possible Selves 3] Since taking part in the project, I feel more able to work with science in my future	0.824				
[Possible Selves 1] Since taking part in the project, I feel more interested in knowing about careers in science	0.791				
[Possible Selves 2] Since taking part in the project, I think science will be more useful to me in the future	0.755				
[Possible Selves 4] During the project, I heard about other science activities I can do at home or in my area	0.541				
[Belonging 2] Compared to my normal experiences doing science activities, I felt more able to be myself in the project		-0.769			
[Belonging 1] Compared to my normal experiences doing science activities, I felt more comfortable in the project		-0.760			
[Belonging 3] Compared to my normal experiences doing science activities, I felt my ideas were heard more during the project		-0.701			

[Agency 1] Compared to my normal experiences doing science activities, I felt more able to contribute my ideas in project			0.909		
[Agency 2] Compared to my normal experiences doing science activities, I felt more able to join in during project			0.877		
[Agency 3] I felt proud of what I did during the project			0.563		0.559
[Social Connection 3] During the project, I felt connected to my friends and family when doing science activities together				0.753	
[Social Connection 1] During the project, I enjoyed doing science activities with my friends and family				0.739	
[Developing Skills 1] Since doing the project, I am more interested in developing my skills in science	0.330			0.604	
[Social Connection 2] During the project, I enjoyed having conversations about science with my friends and family		-0.398		0.543	
[Developing Skills 3] During the project, I learnt something new					0.787
[Developing Skills 2] During the project, I tried something I had not done before				0.385	0.408

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 11 iterations.

Given the variety of PCA outputs, a number of different combinations of statements were tested for their internal consistency as a combined scale (component). This was measured through Cronbach's alpha tests. The Cronbach's alpha test is commonly used to test the reliability of scales comprising multiple items (questions/statements). It explores the extent to which the items within a given scale are measuring the same construct (or same underlying idea), assigning a value from 0 to 1. Values of 0.7 and above are considered to demonstrate high internal consistency¹.

Cronbach's alpha values of various combinations of statements are summarised in Table 4.

TABLE 4 – CRONBACH'S ALPHA TEST RESULTS FOR OUTCOME AREAS

Construct	Cronbach's Alpha	No. statements	Statements included in construct
Possible Selves as intended	0.779	4	<ul style="list-style-type: none"> • Since taking part in the *project*, I feel more interested in knowing about careers in *science* • Since taking part in the *project*, I think *science* will be more useful to me in the future • Since taking part in the *project*, I feel more able to work with *science* in my future • During the *project*, I heard about other *science* activities I can do at home or in my area

¹ DeVellis, R. F. (2003). Scale development: Theory and applications (2nd ed.). Thousand Oaks, CA: Sage Publications.

Agency as intended	0.778	3	<ul style="list-style-type: none"> Compared to my normal experiences doing *science* activities, I felt more able to contribute my ideas in the *project* Compared to my normal experiences doing *science* activities, I felt more able to join in during the *project* I felt proud of what I did during the *project*
Agency Revised	0.854	2	<ul style="list-style-type: none"> Compared to my normal experiences doing *science* activities, I felt more able to contribute my ideas in the *project* Compared to my normal experiences doing *science* activities, I felt more able to join in during the *project*
Relevance as intended	0.713	3	<ul style="list-style-type: none"> The *science* we did in the *project* matters in my everyday life I can use the *science* we covered in the *project* to understand the world around me The *science* we did in the *project* felt relevant to me and things I care about
Developing Skills as intended	0.590	3	<ul style="list-style-type: none"> Since doing the *project*, I am more interested in developing my skills in *science* During the *project*, I tried something I had not done before During the *project*, I learnt something new
Developing Skills Revised 1	0.709	4	<ul style="list-style-type: none"> Since doing the *project*, I am more interested in developing my skills in *science* During the *project*, I tried something I had not done before During the *project*, I learnt something new I felt proud of what I did during the *project*
Developing Skills Revised 2	0.636	3	<ul style="list-style-type: none"> During the *project*, I tried something I had not done before During the *project*, I learnt something new I felt proud of what I did during the *project*
Social Connection as intended	0.781	3	<ul style="list-style-type: none"> During the *project*, I enjoyed doing *science* activities with my *friends and family* During the *project*, I enjoyed having conversations about *science* with my *friends and family* During the *project*, I felt connected to my *friends and family* when doing *science* activities together
Social Connection Revised	0.784	4	<ul style="list-style-type: none"> During the *project*, I enjoyed doing *science* activities with my *friends and family* During the *project*, I enjoyed having conversations about *science* with my *friends and family* During the *project*, I felt connected to my *friends and family* when doing *science* activities together Since doing the *project*, I am more interested in developing my skills in *science*

Belonging as intended	0.740	3	<ul style="list-style-type: none"> • Compared to my normal experiences doing *science* activities, I felt more comfortable in the *project* • Compared to my normal experiences doing *science* activities, I felt more able to be myself in the *project* • Compared to my normal experiences doing *science* activities, I felt my ideas were heard more during the *project*
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It is apparent from Table 4 that five of the six outcome statements when grouped as intended areas demonstrated high reliability (0.7 or more). This meant the statements within each outcome were measuring the same construct. However, a low Cronbach’s alpha value was yielded for the Developing Skills outcome as intended. Results for the Agency construct also indicated that the Cronbach’s alpha score would increase for this scale if the statement ‘I felt proud of what I did during the project’ was removed. In response to these results, the statement ‘I felt proud of what I did during the project’ was removed from the Agency scale and added to the Developing Skills scale. This yielded the more favourable results where all constructs held Cronbach’s alpha values above 0.7.

Thus, the final arrangements of statements within each outcome are those highlighted in green in Table 4.

By reorganising statements in such a way, we can be confident the combined statements within each area are measuring the same underlying construct, as indicated by the Cronbach’s alpha values. It was decided that such a change did not warrant any changes to the names of the scales (outcomes) and that a sense of pride in what individuals did, fits the Developing Skills outcome label.

It is reassuring that few changes were necessary beyond the initial intended arrangement of outcomes and statements. This is indicative of the value of the process used in formulating these outcomes and questions – drawing on both existing literature and instruments, as well as multiple discussions with practitioners – and the relevant expertise of those involved in this process.

Suitability of Outcomes and Statements

Despite the positive results from the quantitative data and reliability analyses, qualitative feedback highlighted that the framework was not without its limitations.

Exit interview discussions asked science centres and community partners to reflect on the suitability of outcome areas and associated statements in the context of their activities and intended impact on their audiences. Overall, it was apparent that the outcome areas were relevant to the aims and objectives of the science centres and their activities, and they found it useful to align their activities to such outcomes. Many reflected that the outcome areas aligned with their typical priorities and so they weren’t having to design drastically different programmes to their usual programmes. Indeed, it seemed to help them focus and refine their activities, and at times (e.g. with Aberdeen Science Centre), it challenged them to push their practice forward into areas they did not always typically focus on.

Nonetheless, while seemingly relevant and appropriate, there appeared to be different interpretations and definitions of the outcome areas as named, particularly for Possible Selves, Belonging and Agency. While centres and community partners highlighted that all of these were relevant to their activities and objectives, they would have perhaps labelled categories differently. For example, some may have described the process of being “able to contribute my ideas” as Belonging, rather than Agency as set out in the participant outcomes framework. However, the statements themselves resonated, so this should be taken more as a reminder to define the categories and/or use the statements as a means of providing those definitions to centres. This would, in turn, give the centres agency to choose the sets of statements that they feel best fit with their intended impact areas, regardless of label.

The Relevance outcome presented several challenges and is the outcome area most in need of reflection and refinement. These issues were particularly evident in the context of audiences from disadvantaged communities with very low socio-economic status. For example, it was perhaps not suitable to ask children who are experiencing poverty or other domestic challenges whether science – particularly something like astronomy or space science – “is relevant to their everyday life”, or “relevant to them and things they care about”. Furthermore, when comparing the language of the statements across outcomes, Relevance was the outcome which focuses on a particular subject matter (e.g. science, space science, etc), rather than an experience within a context of science/space science etc. The limitation of such a difference was apparent in observations of the implementations. Whilst many topics of science may not feel relevant to many children in terms of their “everyday life”, the process and experience of engaging with science can be. For instance, in Aberdeen, while some connections to daily life were made (e.g. around air pressure in the vacuum of space, compared with air pressure on Earth), these were more about connections to experiences that are common to any person (e.g. gravity), rather than being specific to the local neighbourhoods, schools and daily challenges faced by participants. Thus, while connections could be made, most of the science content did not actually address something they needed in their daily lives (e.g. to have enough food in their cupboards). At the same time, the experience of engaging with the science was highly relevant – it gave them food (in Supper and Science), valued them as individuals who could engage with science, supported their interests in science (sending a message to them that even with all the challenges in their lives, it was ‘allowable’ to be curious and interested in something distant and awe-inspiring). Moreover, in the process of doing various activities, practitioners from Aberdeen Science Centre (and others) also made efforts to remind participants of connections to things they already knew and/or to their daily lives, such as science involved in cooking (e.g. states of matter). A further perspective on relevance was brought by young people in Edinburgh, where they felt that the science they were learning was not relevant to their lives at the moment, but it might be in the future, when they were adults and might need it for their jobs. Thus they still saw the value and relevance of learning such topics, even if not ‘relevant’ in that given moment.

In their exit interview, We the Curious also highlighted the challenge in disentangling actual change across outcome areas, with the consequence of increased confidence to share more honest and candid responses following positive engagements with the interventions. This was raised in the context of the Relevance statements, in particular “the science we did in the project matters to my

everyday life”. For their interventions, We the Curious posed the question ‘should we research things just because we are curious?’. This prompted discussions among children about the global challenges we face (e.g. global warming). Many held the view that research should prioritise and focus on global challenges, not simply ‘things we are curious about’, such as space exploration. We the Curious felt that the very experience of having positive engagements in the activities and engaging in discussions and debate, helped the children to feel sure of their views and more confident in expressing them. In terms of their responses to the outcome statements, such a circumstance would lead them to respond more negatively about the relevance of certain science topics to their everyday life, thus indicating a negative result when in reality, increased confidence to express views, particularly related to science, is a positive outcome, even more so because many of these young people did not speak English as a first language. Overall, this complexity could explain why just 47.4% of participants from We the Curious’ agreed or strongly agreed that the science they talked about mattered in their everyday life. Again, if the Relevance statements had been focused on the process and the experience more than the subject matter, the results here may have been different.

Is the Framework Comprehensive?

A key question for science centres and community partners, and an area of focus for observations of interventions, was whether the framework of six outcomes encompassed all aspects of inclusive informal science learning, or if any key factors related to audience engagement were missing. In observations, we were looking for indicators of engagement or lack of, that could not be captured or described by the six outcomes.

Several centres and community partners were of the view that audience enjoyment and interest/curiosity is crucial to their activities and to audience inclusion. They reflected that enjoyment and interest is fundamental to all activities and that the other six outcomes were unlikely if a basic level of enjoyment – which supports engagement – is not present. Indeed, one Year 5 child (age 10/11) participating in the National Space Centre’s ‘Space Mile Science Club’ put this quite eloquently when he said that he felt comfortable and belonged because Josh and Lucy ‘make it into fun games’. Another child participating in the science club run by Cambridge Science Centre likewise remarked that she felt comfortable because the practitioners ‘make sure everyone is happy’. Such practices seem to signal to participants that these experiences and places are for ‘people like them’, where they can enjoy themselves and be themselves.

However, in terms of implications for the theory of change, enjoyment and interest are less suited as outcomes than as a context or input that surrounds the intervention. The six outcome areas therefore sit within or are contingent upon this broader enjoyable experience.

Overall Results

This section reports on the overall results of centres’ intervention as per the outcomes and associate statements. Four centres collected both pre and post data, and 10 centres collected post-data only. Aberdeen Science Centre are counted twice as they collected pre- and post- data for one audience group, and post-data only for other audience groups.

Responses on the Likert-scales were condensed from a 5-point scale to a 3-point scale. Strongly disagree and disagree were combined (D/SD), neither disagree or agree remained the same (NE) and agree and strongly agree (A/SA) were combined.

Centres who collected both pre and post data, and centres who collected post-only data are reported separately in the following sub-sections.

Pre and Post Data Results

For centres who collected pre and post data we report on responses on both pre and post occasion according to the percentage who agreed or strongly agreed (A/SA) on each occasion, and the difference in percentage points (pp), these are summarised in Table 6. Three statements yielded an increase of 20 percentage points or more from pre to post (highlighted in green), and six statements yielded an increase of 10 percentage points or more (highlighted in blue).

TABLE 6 – SUMMARY OF PRE- AND POST-DATA COLLECTED

	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Possible Selves	I would like to know more about careers involving science	158	145	69.6%	81.4%	+11.8%
	I think science will be useful to me in the future	158	144	76.6%	90.3%	+13.7%
	I could work with science in the future if I wanted to	157	143	65.0%	77.6%	+12.6%
	[Post only] During the project, I heard about other science activities I can do at home or in my area	-	96	-	87.5%	-
Agency	I feel able to contribute my ideas when doing science activities	-	-	-	-	-
	I feel able to join in with science activities	-	-	-	-	-
Relevance	Science matters in my everyday life	55	34	54.5%	70.6%	+16.1%
	I can use science to understand the world around me	55	36	69.1%	72.2%	+3.1%
	Science feels relevant to me and things I care about	56	36	42.9%	72.2%	+29.3%
Developing Skills	I would like to develop my skills in science	110	90	80.9%	86.7%	+5.8%
	[Post only] During the project, I tried something I had not done before	-	90	-	91.1%	-
	[Post only] During the project, I learnt something new	-	89	-	97.8%	-

	I feel proud of myself when I do science activities	-	-	-	-	-
Social Connection	I enjoy doing science activities with my *friends and family*	71	61	91.5%	98.4%	+6.9%
	I enjoy having conversations with my *friends and family*	71	61	85.9%	96.7%	+10.8%
	I feel connected to my *friends and family* when doing science activities together	71	61	85.9%	95.1%	+9.2%
Belonging	I feel comfortable when doing science activities	118	108	88.1%	99.1%	+11.0%
	I can be myself when doing science activities	118	115	69.5%	91.3%	+21.8%
	I feel my ideas are heard during science activities	118	109	61.9%	88.1%	+26.2%

It is promising to see that for all statements where pre- and post-data was collected, there was an increase in audience agreement, following the interventions. The statements that yielded the biggest increase related to Belonging (two statements) and Relevance (one statement). We anticipate that the reason for high agreement with the Relevance statement is due to respondents reflecting on the relevance of the experiences they were having, more than the specific science they were doing.

Post Data Only Results

Table 7 summarises the responses to statements for the 10 centres who collected post-data only. Here, we report on the percentage of responses that fell into the condensed categories of strongly disagree or agree (SD/D), neither disagree nor agree (NE), and agree or strongly agree (A/SA). Three statements yielded agreement among 90% or more of participants and are highlighted in green and related to Developing Skills (two statements) and Social Connection (one statement).

TABLE 7 – SUMMARY OF RESULTS FROM CENTRES WHO COLLECTED POST-DATA ONLY

	Statement	N	SD/D	NE	A/SA
Possible Selves	Since taking part in the project, I feel more interested in knowing about careers in science	448	8.3%	18.8%	73.0%
	Since taking part in the project, I think science will be more useful to me in the future	449	6.9%	29.6%	63.5%
	Since taking part in the project, I feel more able to work with science in my future	414	12.8%	23.4%	63.8%
	During the project, I heard about other science activities I can do at home or in my area	447	17.2%	14.5%	68.2%
	I could work with science in the future if I wanted to*	28	10.7%	7.1%	82.1%
Agency	Compared to my normal experiences doing science activities, I felt more able to contribute my ideas in project	47	8.5%	29.8%	61.7%
	Compared to my normal experiences doing science activities, I felt more able to join in during project	47	10.6%	19.1%	70.2%

Relevance	The science we did in the project matters in my everyday life	204	14.7%	30.4%	54.9%
	I can use the science we covered in the project to understand the world around me	204	7.8%	20.6%	71.6%
	The science we did in the project felt relevant to me and things I care about	204	7.8%	21.6%	70.6%
Developing Skills	Since doing the project, I am more interested in developing my skills in science	170	4.7%	12.4%	82.9%
	During the project, I tried something I had not done before	171	2.9%	5.3%	91.8%
	During the project, I learnt something new	189	1.1%	4.2%	94.7%
	I felt proud of what I did during the project	46	6.5%	15.2%	78.3%
Social Connection	During the project, I enjoyed doing science activities with my friends and family	194	2.1%	7.2%	90.7%
	During the project, I enjoyed having conversations about science with my friends and family	291	4.8%	15.1%	80.1%
	During the project, I felt connected to my friends and family when doing science activities together	195	4.6%	15.9%	80.0%
Belonging	Compared to my normal experiences doing science activities, I felt more comfortable in the project	119	9.2%	20.2%	70.6%
	Compared to my normal experiences doing science activities, I felt more able to be myself in the project	147	10.2%	25.2%	64.6%
	Compared to my normal experiences doing science activities, I felt my ideas were heard more during the project	122	15.6%	24.6%	59.8%

*Only one science centre collected data for this statement and was intended for pre-data collection.

The three statements with the highest proportion of participants disagreeing or strongly disagreeing (highlighted in orange) related to Possible Selves, Relevance, and Belonging (one statement for each outcome), though no statements yielded disagreement among more than 18% of respondents and overall, all of such statements still prompted more than 50% agreement from participants.

As PCA and reliability tests confirmed that individual statements could be combined to create a scale for each of the six outcomes, the mean scores for these six scales were calculated. This was done through adding the responses of 1-5 for each statement within each scale and dividing by the number of statements within that scale. Results are summarised in Table 7 where it is apparent that the scale for Social Connection received the highest mean score, and the scale for Belonging received the lowest. It is possible that comparisons with 'normal experiences doing science activities' is contributing to the lower agreement, as some people completing the survey may have had positive or relatively positive previous experiences. It is also problematic in that we do not know what previous experiences were like and there is likely to be variability, so the comparison or question is not consistent across respondents. Nonetheless, all mean scores were above 3.0, thus indicating a positive mean response.

TABLE 7 – MEAN SCORES FOR EACH OUTCOME SCALE FOR POST-ONLY DATA COLLECTION

Post-only	N	Mean (SD)
Possible Selves	411	3.92
Agency	47	3.90
Relevance	204	3.88
Developing Skills ²	21	4.21
Social Connection	192	4.46
Belonging	116	3.78

Table 8 reports the mean scores for each outcome scale but according to each of the science centres.

TABLE 8 - MEAN SCORES FOR EACH OUTCOME SCALE FOR POST-ONLY DATA COLLECTION BY CENTRE

Science Centre*	Post Mean (SD)					
	Possible Selves	Agency	Relevance	Developing Skills	Social Connection	Belonging
AOP	4.00 (0.83)	4.17 (1.16)			4.51 (0.89)	
WTC			3.49 (0.84)			4.18 (0.57)
RAS	4.43 (0.68)				4.55 (0.62)	
ASC	4.19 (0.71)		4.07 (0.84)			
W5	4.04 (0.69)	3.56 (1.08)		4.24 (0.69)	3.95 (0.92)	
TQ	3.89 (0.81)		3.84 (0.86)			
JB	3.21 (0.80)					3.71 (0.83)
CSC		4.23 (0.64)			3.76 (0.46)	3.76 (0.71)
SO			4.51 (0.64)		4.76 (0.40)	

*AOP=Armagh Observatory and Planetarium, WTC=We the Curious, RAS=Royal Astronomical Society, ASC=Aberdeen Science Centre, TQ=Techniquest, JB=Jodrell Bank, CSC=Cambridge Science Centre, SO=Science Oxford

Results by Centre

In the following sections, we report on results by science centre. Here, we have included the language amendments that each centre used. For centres that collected post-only data, statements yielding agreement from 80% of respondents or more are highlighted in green, and statements that yielded 50% agreement or less are highlighted in orange.

For centres that collected pre- and post-data, statements that received an increase in agreement of 20 percentage points or more from pre- to post-occasion are highlighted in green. Any that saw an increase in disagreement are highlighted in orange.

All results are reported in percentages; however, we urge caution for some centres where numbers are low (less than 20 responses). Where possible, we have drawn on qualitative data from observations and interviews to add further comments for each centre in order to aid interpretation of the questionnaire responses.

² Where we moved one of the statements originally under Agency to Developing Skills, this substantially reduced the number of data points for the combined Developing Skills scale. This is because centres would have needed to have collected data for statements relating to both Agency and Developing Skills outcomes.

Aberdeen Science Centre

Aberdeen Science Centre collected both pre- and post-data from one of their audience groups, and post-only data from three audience groups. Both are reported here. We urge caution in interpreting percentages for the pre- and post-data comparisons, given that total N is low.

It is notable that the scores for relevance are so high, given the particularly challenging life circumstances of many of their participants. However, it is possible that the participants interpreted the question as referring to the overall experience of the workshops, rather than specifics of the content covered. It is also possible that the efforts of the ASC practitioners to highlight connections between the activities and participants' lives also contributed to this.

TABLE 9 – ABERDEEN SCIENCE CENTRE RESULTS FOR PRE AND POST MEASUREMENTS

	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Possible Selves	I would like to know more about careers involving science	16	7	56.3%	85.7%	+29.4%
	I think science will be useful to me in the future	16	7	62.5%	85.7%	+23.2%
	I could work with science in the future if I wanted to	16	7	37.5%	85.7%	+48.2%
	During the project, I heard about other science activities I can do at home or in my area	-	7	-	85.7%	-
Relevance	The science we did in the workshops matters in my everyday life	16	7	50.0%	85.7%	+35.7%
	I can use the science we covered in the workshops to understand the world around me	16	7	75.0%	85.7%	+10.7%
	The science we did in the workshops felt relevant to me and things I care about	16	7	31.3%	85.7%	+54.4%
Belonging	I feel comfortable when doing science activities	16	-	75.0%	-	-
	I can be myself when doing science activities	16	7	43.8%	85.7%	+41.9%
	I feel my ideas are heard during science activities	16	-	43.8%	-	-

TABLE 10 – ABERDEEN SCIENCE CENTRE RESULTS FOR POST-ONLY MEASUREMENTS

Post-Only Data					
	Statement	N	SD/D	NE	A/SA
Possible Content	Since taking part in the project, I feel more interested in knowing about jobs involving science	28	3.6%	28.6%	67.9%
	Since taking part in the project, I think science will be more useful to me in the future	28	0.0%	25.0%	75.0%
	During the project, I heard about other science activities I can do at home or in my area	28	7.1%	10.7%	82.1%

	I could work with science in the future if I wanted to	28	10.7%	7.1%	82.1%
Relevance	The science we did in the project matters in my everyday life	28	7.1%	25.0%	67.9%
	I can use the science we covered in the project to understand the world around me	28	3.6%	21.4%	75.0%
	The science we did in the project felt relevant to me and things I care about	28	7.1%	14.3%	78.6%
Belonging	Compared to my normal experiences doing science activities, I felt more able to be myself in the project	18	0.0%	14.3%	85.7%

Armagh Observatory and Planetarium

We urge caution in interpreting percentages for Armagh Observatory and Planetarium, given that total N is low. Armagh worked with neurodivergent youth groups, and targeted communities who had never visited the planetarium. Many youths came with their parents who commented to Mark ‘oh, we came here as kids and now we get to come with our kids’. As reported in the exit interview, parents further reflected on how this was not an experience they expected to be able to share with their children because they thought the observatory and planetarium would be inaccessible to their child’s needs and thought ‘maybe it’s not for them’. This positive shared experience between the parents and their children is reflected in the positive responses to the statements relating to Social Connection.

TABLE 11 – ARMAGH OBSERVATORY AND PLANETARIUM RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	SD/D	NE	A/SA
Possible Selves	Since taking part in the activities at AOP, I feel more interested in knowing about careers in science	18	0.0%	22.2%	77.8%
	Since taking part in the activities at AOP, I think science will be more useful to me in the future	18	0.0%	33.3%	66.7%
	Since taking part in the activities at AOP, I feel more able to work with science in my future	18	11.1%	22.2%	66.7%
	During the activities at AOP, I heard about other science activities I can do at home or in my area	18	38.9%	11.1%	50.0%
Agency	Compared to my normal experiences doing science activities, I felt more able to contribute my ideas during the activities at AOP	18	11.1%	11.1%	77.8%
	Compared to my normal experiences doing science activities, I felt more able to join in during activities at AOP	18	11.1%	5.6%	83.3%
Skills	During the visit to AOP, I learnt something new	18	22.2%	5.6%	83.3%
	I felt proud of what I did during the activities at AOP	18	0.0%	16.7%	83.3%

Social Connection	During the activities at AOP, I enjoyed doing science activities with my classmates, friends and family	18	0.0%	11.1%	88.9%
	During the project, I enjoyed having conversations about science with my classmates, friends and family	18	5.9%	11.8%	82.4%
	During the project, I felt connected to my classmates, friends and family when doing science activities together	18	5.6%	11.1%	83.3%

Cambridge Science Centre

We urge caution in interpreting percentages for Cambridge Science Centre, given that total N is extremely low. Moreover, the young people participating had been coming for varying lengths of time, and this particular set of club sessions was being held in a new community space. In addition, focus group data highlighted that some of the participating young people felt comfortable with science in any environment and/or were a bit frustrated that they did need to behave in the club, which could have contributed to some scores being a bit lower than might be expected.

TABLE 12 – CAMBRIDGE SCIENCE CENTRE RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	SD/D	NE	A/SA
Agency	Compared to doing science outside of Science Club, I felt more able to contribute my ideas in Science Club	7	0.0%	14.3%	85.7%
	Compared to doing science outside of Science Club, I felt more able to join in during Science Club	7	0.0%	28.6%	71.4%
Developing Skills	I felt proud of what I did during Science Club	6	33.3%	0.0%	66.7%
Social Connection	During Science Club, I enjoyed doing science activities with other club members	7	14.3%	14.3%	71.4%
	During Science Club, I enjoyed having conversations about science with other club members	7	0.0%	28.6%	71.4%
	During Science Club, I felt connected to other club members when doing science activities together	7	14.3%	42.9%	42.9%
Belonging	Compared to doing science outside of Science Club, I felt more comfortable in Science Club	7	14.3%	42.9%	42.9%
	Compared to doing science outside of Science Club, I felt more able to be myself in Science Club	7	14.3%	14.3%	71.4%
	Compared to doing science outside of Science Club, I felt my ideas were heard more during Science Club	7	0.0%	28.6%	71.4%

Catalyst

Due to a technical glitch, Catalyst were only able to provide mean scores for their responses rather than individual responses by participant, we can only provide the mean scores for each individual statement. Mean scores of 4.5 or higher are highlighted in green. Catalyst were also one of the centres that collected additional evaluation data (beyond the outcome measures) which will be of additional value to their understanding of the activities they delivered.

The highest mean score was yielded for the statement relating to being able to join in (highlighted in green). In the exit interview, the community partner, Glow, a youth group for the LGBTQ+ community highlighted that many of the young people they work with had never visited Catalyst, despite it being ‘on their doorstep’. They emphasised how Catalyst ensured that they felt welcome and made them feel like important guests. When LGBTQ+ groups so often feel like outcasts or misplaced in social situations, it was valuable to have a safe space where their opinions were valued, and they could be themselves.

While some of the lowest mean scores were for the statements relating to possible selves, Catalyst staff emphasised that while these areas are important, it was hard to develop them over a short time frame. They emphasised that to build a sense of empowerment among these young people required regular, ongoing engagement with them.

TABLE 13 – CATALYST RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	Mean
Possible Selves	Compared to your normal experiences doing science activities, did you feel... [much less able to much more able], to work with science in my future	10	3.6
	During our Explore Your Universe project, I heard about other science activities I can do at home or in my area	10	3.7
Agency	Compared to your normal experiences doing science activities, did you feel... [much less able to much more able], to contribute my ideas in project	10	4.2
	Compared to your normal experiences doing science activities, did you feel... [much less able to much more able], to join in with this project	10	4.6
Relevance	During our Explore Your Universe project, the science we did matters in my everyday life	10	4.0
	During our Explore Your Universe project, I can use the science we covered to understand the world around me	10	4.1
	During our Explore Your Universe project, the science felt relevant to me and things I care about	10	3.9
Developing Skills	During our Explore Your Universe project, I tried something I had not done before	10	4.4
	During our Explore Your Universe project, I learnt something new	10	4.3
	During our Explore Your Universe project, I felt proud of what I did during the project	10	4.2

Dundee Science Centre

Dundee Science Centre’s programme involved a week-long camp which provided a lot of opportunities for confidence-building and, especially, the staff really getting to know the children, which supported a strong sense of belonging. Evident from the table below is the increase in the audience’s sense of possible selves. This lends to the point raised by Catalyst about the difficulty in building these sentiments among young people and how this longer engagement between Dundee Science Centre and their audiences enabled them to foster this confidence.

TABLE 14 – DUNDEE SCIENCE CENTRE RESULTS FOR PRE AND POST MEASUREMENTS

	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Possible Selves	I would like to know more about careers involving science	31	48	67.7% (21)	87.5% (42)	+19.8%
	I think science will be useful to me in the future	31	47	77.4% (24)	89.4% (42)	+12.0%
	I could work with science in the future if I wanted to	31	48	54.8% (17)	77.1% (37)	+22.3%
Belonging	I feel comfortable when doing science activities	31	47	83.9% (26)	97.9% (46)	+14.0%
	I can be myself when doing science activities	31	47	64.5% (20)	89.4% (42)	+24.9%
	I feel my ideas are heard during science activities	31	48	54.8% (17)	85.4% (41)	+30.6%

Dynamic Earth

In the workshops delivered by Dynamic Earth, space-related careers were discussed quite a bit, particularly in one of the workshops. The decrease in interest in learning about careers involving science in this instance may reflect that their curiosity about space careers had been satisfied. In contrast, references to science industries (e.g. space port) near Edinburgh may also have contributed to increased feelings of relevance about science. At the same time, relatively low agreement to relevance statements could also represent that space science and jobs in space science felt interesting but distant to the lives of these children, with one saying that science might be useful when they grew up, but not now.

TABLE 15 – DYNAMIC EARTH RESULTS FOR PRE AND POST MEASUREMENTS

	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Possible Selves	I would like to know more about careers involving science	40	29	55.0% (22)	51.7% (15)	-3.3%
	I think science will be useful to me in the future	40	29	70.0% (28)	86.2% (25)	+16.2%
	I could work with science in the future if I wanted to	39	27	66.7% (26)	70.4% (19)	+3.7%
	[Post-only] During the Dynamic Earth workshops, I heard about	/	28	/	75.0% (21)	/

	other science activities can do at home or in my area					
Relevance	Science matters in my everyday life	39	27	56.4% (22)	66.7% (18)	+10.3%
	I can use science to understand the world around me	39	29	66.7% (26)	69.0% (20)	+2.3%
	Science feels relevant to me and things I care about	40	29	47.5% (19)	69.0% (20)	+21.5%
Developing Skills	I would like to develop my skills in science	39	29	69.2% (27)	72.4% (21)	+3.2%
	[Post only] During the Dynamic Earth workshops, I tried something I had not done before	/	29	/	86.2% (25)	/
	[Post only] During the Dynamic Earth workshops, I learnt something new	/	28	/	92.9% (26)	/

Jodrell Bank

Given the efforts of Jodrell Bank to connect young people to scientists, the low scores on possible selves are perhaps disappointing. Feedback from one of the youth workers involved highlights that a more structured session with the scientist may have helped, which is something Jodrell could consider for future sessions.

TABLE 16 – JODRELL BANK RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	SD/D	NE	A/SA
Possible Selves	Since taking part in the visit, I feel more interested in knowing about careers in astronomy	96	16.7%	24.0%	59.4%
	Since taking part in the visit, I think astronomy will be more useful to me in the future	97	17.5%	45.4%	37.1%
	Since taking part in the visit, I feel more able to work with astronomy in my future	96	28.1%	33.3%	38.5%
	During the visit, I heard about other astronomy activities I can do at home or in my area	97	36.1%	28.9%	35.1%
Belonging	Compared to my normal experiences doing science activities, I felt more comfortable on the visit	96	9.4%	22.9%	67.7%
	Compared to my normal experiences doing science activities, I felt more able to be myself on the visit	95	13.7%	29.5%	56.8%
	Compared to my normal experiences doing science activities, I felt my ideas were heard more during the visit	97	19.6%	25.8%	54.6%

National Space Centre

While increases from pre to post are relatively small, that they occurred across all items is noteworthy. That social connection and belonging are particularly high - and a belonging statement had the greatest increase - may also be a reflection of the inclusive, welcoming and fun environment created by the NSC staff delivering the club. They had a clear rapport with the children, as well as

demonstrating flexibility and responsiveness which likely made the young people feel welcome and comfortable.

TABLE 17 – NATIONAL SPACE CENTRE RESULTS FOR PRE AND POST MEASUREMENTS

	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Possible Selves	I would like to know more about careers involving science	71	61	81.7% (58)	90.2% (55)	+8.5%
	I think science will be useful to me in the future	71	61	83.1% (59)	93.4% (57)	+10.3%
	I could work with science in the future if I wanted to	71	61	74.6% (53)	80.3% (49)	+5.7%
	[Post-only] During the project, I heard about other science activities can do at home or in my area	/	61	/	93.4% (57)	/
Developing Skills	I would like to develop my skills in science	71	61	87.3% (62)	93.4% (57)	+6.1%
	[Post only] During the project, I tried something I had not done before	/	61	/	93.4% (57)	/
	[Post only] During the project, I learnt something new	/	61	/	100% (61)	/
Social Connection	I enjoy doing science activities with my friends and/or family	71	61	91.5% (65)	98.4% (60)	+6.9%
	I enjoy having conversations with my friends and/or family	71	61	85.9% (61)	96.7% (59)	+10.8%
	I feel connected to my friends and/or family when doing science activities together	71	61	85.9% (61)	95.1% (58)	+9.2%
Belonging	I feel comfortable when doing science activities	71	61	93.0% (66)	100% (61)	+7.0%
	I can be myself when doing science activities	71	61	77.5% (55)	93.4% (57)	+15.9%
	I feel my ideas are heard during science activities	71	61	69.0% (49)	90.2% (55)	+21.2%

Royal Astronomical Society

The Royal Astronomical Society worked with Slough Museum to target underserved families in the Slough area, in particular, families who were new to Slough and for whom English was not their first language.

As is evident from Table 18, they yielded very high levels of agreement from their audience across all three of their outcome measures. While the focus of their programme was the Herschel family, their activities were multidisciplinary. Although brother and sister William and Caroline Herschel are famous for their significant contributions to astronomy, the activities also drew attention to the family's additional successes in music and mathematics. All activities took place at Slough Museum and involved combinations of performing arts, science demonstrations, and arts and

crafts. These varied points of engagement could well have helped towards offering something to everyone who attended.

However, the community partner was doubtful of the validity of using the quantitative methods to evaluate such events and felt that people’s responses were too biased by the opportunity for a novel and free experience. She was concerned that quantitative measures do little to delve into the meaningful experiences that individuals had beyond something they had not done before and were able to access without any cost. Such a concern highlights the added value and additional insight that qualitative methods can offer which cannot be as readily inferred from quantitative measures.

TABLE 18 – ROYAL ASTRONOMICAL SOCIETY RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	SD/D	NE	A/SA
Possible Selves	Since taking part in the Astronomy Through The Herschels workshop, I feel more interested in knowing about careers in astronomy	137	3.6%	14.6%	81.8%
	Since taking part in the Astronomy Through The Herschels workshop, I think astronomy will be more useful to me in the future	137	2.2%	13.9%	83.9%
	Since taking part in the Astronomy Through The Herschels workshop, I feel more able to work with astronomy in my future	135	1.5%	13.3%	85.2%
	During the Astronomy Through The Herschels workshop, I heard about other astronomy activities I can do at home or in my area	137	7.4%	5.9%	86.7%
Developing Skills	Since doing the Astronomy Through The Herschels workshop, I am more interested in developing my skills in astronomy	137	5.1%	8.0%	86.9%
	During the Astronomy Through The Herschels workshop, I tried something I had not done before	137	2.9%	2.9%	94.2%
	During the Astronomy Through The Herschels workshop, I learnt something new	137	0.0%	3.6%	96.4%
Social Connection	During the Astronomy Through The Herschels workshop, I enjoyed doing astronomy activities with my friends and family	136	0.7%	4.4%	94.9%
	During the Astronomy Through The Herschels workshop, I enjoyed having conversations about astronomy with my friends and family	137	0.7%	9.5%	89.8%
	During the Astronomy Through The Herschels workshop, I felt connected to my friends and family when doing astronomy activities together	137	4.4%	13.1%	82.5%

Science Oxford

We urge caution in interpreting percentages for Science Oxford, given that total N is low. They were also not directly involved in the Valuing Inclusion project but agreed to try the postcards as part of their Mindsets and Missions project.

TABLE 19 – SCIENCE OXFORD RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	SD/D	NE	A/SA
Relevance	The science we did in the visit matters in my everyday life	11	0.0%	9.1%	90.9%
	I can use the science we covered in the visit to understand the world around me	11	0.0%	0.0%	100.0%
	The science we did in the visit felt relevant to me and things I care about	11	0.0%	18.2%	81.8%
Social Connection	During the visit, I enjoyed doing science activities with my friends and family	11	0.0%	9.1%	90.9%
	During the visit, I enjoyed having conversations about science with my friends and family	11	0.0%	9.1%	90.9%
	During the visit, I felt connected to my friends and family when doing science activities together	11	0.0%	0.0%	100.0%

Techniquest

Techniquest teamed up with staff from the School of Physics and Astronomy at Cardiff University and Space Forge, a small Cardiff-based enterprise specialising in in-space manufacturing. Their implementations involved staff from Techniquest, Cardiff University and Space Forge visiting underserved primary schools in Merthyr Tydfil for a full day, and then schools visited Techniquest on a separate occasion.

In the exit interview, the community partner, a primary school teacher and liaison for a network of primary schools in the Merthyr Tydfil area highlighted the value of the project and its applications to the new ‘Curriculum for Wales’ that emphasises the importance of developing skills for ‘real life’ and for future career pathways. He stipulated that meeting staff from Techniquest, Cardiff University and Space Forge was a novel experience for the children. Many of them had never left their hometown and only hear about these jobs from their teachers. Meeting ‘real’ space scientists and interacting with them broadened their horizons. This could go towards explaining why over 70% of the pupils indicated that they were more interested in knowing about careers involving space science having participated.

In deprived areas of low socioeconomic status, staff emphasised that the action of Techniquest going to the schools ‘made a real difference’ and the project would not have worked had schools been required to go to Techniquest. Indeed, although a visit to Techniquest was part of the delivery, not all schools were able to do this. While entrance to Techniquest was free for participating schools, some schools/parents could not afford to fund the travel there.

TABLE 20 – TECHNIQUEST RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	SD/D	NE	A/SA
Possible	Since taking part in the Techniquest project, I feel more interested in knowing about careers involving space science	146	10.3%	16.4%	73.3%

	Since taking part in the Technquest project, I think space science will be more useful to me in the future	146	7.5%	34.9%	57.5%
	Since taking part in the Technquest project, I feel more able to work with space science in my future	142	15.5%	23.9%	60.6%
	During the Technquest project, I heard about other space science activities I can do at home or in my area	146	14.4%	13.7%	71.9%
Relevance	The space science we did in the Technquest project matters in my everyday life	146	16.4%	32.9%	50.7%
	I can use the space science we covered in the Technquest project to understand the world around me	146	7.5%	24.0%	68.5%
	The space science we did in the Technquest project felt relevant to me and things I care about	146	8.9%	21.9%	69.2%

We the Curious

We urge caution in interpreting percentages for We the Curious, given that total N is low. Despite this small N, the low agreement that the science in the project matters in their everyday lives stands out. However, the project workshops revolved around the question of whether we/scientists should research things just out of curiosity, with some young people concluding that they should not - that research needs to have clear value in people's lives. Such conclusions could very easily have influenced the way in which young people responded to this item, especially combined with their evidenced sense of comfort and feeling heard.

TABLE 21 – WE THE CURIOUS RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	SD/D	NE	A/SA
Relevance	The science we did in the project matters in my everyday life	19	21.1%	31.6%	47.4%
	I can use the science we covered in the project to understand the world around me	19	21.0%	5.3%	73.7%
	The science we did in the project felt relevant to me and things I care about	19	5.3%	31.6%	63.2%
Belonging	Compared to my normal experiences doing science activities, I felt more comfortable when doing the project activities	18	5.6%	0.0%	94.4%
	Compared to my normal experiences doing science activities, I felt more able to be myself when doing the project activities	17	5.9%	23.5%	70.6%
	Compared to my normal experiences doing science activities, I felt my ideas were heard during the project activities	18	0.0%	16.7%	83.3%

W5

W5 worked with a youth group in the Belfast area and focused heavily on Developing Skills and the uses of big data. In the exit interview, Matt at W5 highlighted the importance they placed not just on developing 'hard skills', such as coding, but also the importance of 'soft skills' in science, such as

resilience, analytical thinking and problem solving. Ciarán, the community partner, praised W5 on how they embedded skill development in the activities without placing any real pressure on the audience to engage. There was encouragement to ‘have a go’ and to hop in and out of different activities when they were happy to do so. It is heartening that this gentle encouragement yielded positive responses in terms of the Developing Skills outcome area.

The community partner also emphasised the value of contact time between the children and the W5 team, highlighting how ‘the kids built up a great relationship with the W5 facilitators and this was key to the programme’s success’. As with Aberdeen, this highlights the importance not only of social connections with family and peers, but with the practitioners.

TABLE 22 – W5 RESULTS FOR POST-ONLY MEASUREMENTS

	Statement	N	SD/D	NE	A/SA
Possible Selves	Since taking part in Explore Your Universe, I feel more interested in knowing about careers involving Big Data	23	0.0%	21.7%	78.3%
	Since taking part in Explore Your Universe, I think Big Data will be more useful to me in the future	23	0.0%	26.1%	73.9%
	Since taking part in Explore Your Universe, I feel more able to work with Big Data in my future	23	0.0%	39.0%	60.9%
	During Explore Your Universe, I heard about other Big Data activities I can do at home or in my area	23	8.7%	17.4%	73.9%
Agency	Compared to my normal experiences doing science activities, I felt more able to contribute my ideas in Explore Your Universe	23	9.1%	50.0%	40.9%
	Compared to my normal experiences doing science activities, I felt more able to join in during Explore Your Universe	22	13.6%	27.3%	59.1%
Developing Skills	Since doing Explore Your Universe, I am more interested in developing my skills in Big Data	22	4.5%	40.9%	54.5%
	During Explore Your Universe, I tried something I had not done before	23	4.3%	17.4%	78.3%
	During Explore Your Universe, I learnt something new	23	0.0%	8.7%	91.3%
	I felt proud of what I did during Explore Your Universe	22	4.5%	18.2%	77.3%
Social Connection	During Explore Your Universe, I enjoyed doing Big Data activities with my friends and family	22	9.1%	22.7%	68.2%
	During Explore Your Universe, I enjoyed having conversations about Big Data with my friends and family	23	13.0%	21.7%	65.2%
	During Explore Your Universe, I felt connected to my friends and family when doing Big Data activities together	22	0.0%	36.4%	63.6%

Results by Outcome Areas

This section summarises the results by outcome area in terms of quantitative data. Qualitative data is incorporated where possible to describe processes or features of the experiences that may have help support these outcome areas among audiences. Relevant further reflections on the items themselves which emerged during discussions with practitioners are also included.

Possible Selves [All centres, except Cambridge, Oxford, & We the Curious]

TABLE 23 – POSSIBLE SELVES RESULTS FOR PRE- AND POST-DATA

Data Collected Pre- and Post-Intervention						
	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Possible Selves	I would like to know more about careers involving science	158	145	69.6%	81.4%	+11.8%
	I think science will be useful to me in the future	158	144	76.6%	90.3%	+13.7%
	I could work with science in the future if I wanted to	157	143	65.0%	77.6%	+12.6%
	[Post only] During the project, I heard about other science activities I can do at home or in my area	-	96	-	87.5%	-

TABLE 24 – POSSIBLE SELVES RESULTS FOR POST-DATA ONLY

Data Collected Post-Intervention Only					
	Statement	N	SD/D	NE	A/SA
Possible Selves	Since taking part in the project, I feel more interested in knowing about careers in science	448	8.3%	18.8%	73.0%
	Since taking part in the project, I think science will be more useful to me in the future	449	6.9%	29.6%	63.5%
	Since taking part in the project, I feel more able to work with science in my future	414	12.8%	23.4%	63.8%
	During the project, I heard about other science activities I can do at home or in my area	447	17.2%	14.5%	68.2%
	I could work with science in the future If I wanted to*	28	10.7%	7.1%	82.1%

The possible selves outcome area, which might also be termed ‘science in my future’, ‘broadening horizons’ or similar, looks forward to how participants might relate to or participate in science in the future – whether at home/locally or in work, and whether they feel confident or able to do so. The questions themselves seemed to be quite understandable to participants, including the three post-

only items which asked respondents to compare their views and feelings with how they felt or thought prior to participating. While how they felt prior would certainly have varied by person, there is still opportunity to move forward from almost any position. With regard to the two work/careers-related questions in particular, some science centres explicitly discussed science-related jobs in their activities, which was often met with enthusiasm, though this may not always have been reflected in responses. This disparity also highlights the added value that qualitative data can bring to our understanding of quantitative results.

Agency [Armagh, Cambridge, Catalyst, W5]

No science centres collected data around the Agency outcome both pre- and post-interventions so we can only report on post-only data here.

TABLE 25 – AGENCY RESULTS FOR PRE- AND POST-DATA

Data Collected Post-Intervention Only					
	Statement	N	SD/D	NE	A/SA
Agency	Compared to my normal experiences doing science activities, I felt more able to contribute my ideas in project	47	8.5%	29.8%	61.7%
	Compared to my normal experiences doing science activities, I felt more able to join in during project	47	10.6%	19.1%	70.2%

While included as an outcome area, agency is more of an experiential outcome or proximal outcome than a distal outcome or longer-term impact on participating individuals. That is, it is applicable to the experience of participants during the activity, rather than a longer-term change in an individual. However, experiencing agency – being able to contribute ideas and join in – is an important aspect of inclusive and equitable experiences and can be considered a type of outcome. Perhaps unsurprisingly (due to being based on instruments from existing research), the question cores (about contributing ideas and joining in) were well understood. However, making comparisons to ‘my normal experiences doing science activities’ were more problematic in that although it is likely respondents thought of school, we cannot be sure. Further complicating matters, individuals could be at a range of comparison points – from having had very positive, inclusive experiences to having very negative ones. This difference muddies interpretation of the data. As we are primarily interested in whether individuals experienced agency in the activities provided, we would encourage dropping the first part of these two items (‘Compared to my normal experiences...’).

Drawing on the qualitative data, Cambridge had young people working on a mini-research project about living on the Moon. Young people were able to set the direction of the research (choose their questions and how to address the challenge set), which seemed to support a sense of agency. As one girl from the Science Club (run by CSC) put it, contrasting it with school, ‘You can choose what kind of question you can do’. The youth also remarked on the way in which the facilitators encouraged them to join in, further supporting their agency in the club.

Relevance [Aberdeen, Catalyst, Dynamic Earth, Science Oxford, Techniquet, We the Curious]

TABLE 26 – RELEVANCE RESULTS FOR PRE- AND POST-DATA

Data Collected Pre- and Post-Intervention						
	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Relevance	Science matters in my everyday life	55	34	54.5%	70.6%	+16.1%
	I can use science to understand the world around me	55	36	69.1%	72.2%	+3.1%
	Science feels relevant to me and things I care about	56	36	42.9%	72.2%	+29.3%

TABLE 27 – RELEVANCE RESULTS FOR POST-DATA ONLY

Data Collected Post-Intervention Only					
	Statement	N	SD/D	NE	A/SA
Relevance	The science we did in the project matters in my everyday life	204	14.7%	30.4%	54.9%
	I can use the science we covered in the project to understand the world around me	204	7.8%	20.6%	71.6%
	The science we did in the project felt relevant to me and things I care about	204	7.8%	21.6%	70.6%

These questions referred to the content or subject matter addressed in the various activities or projects. Discussions with practitioners and participants suggested that, although the questions were generally understandable, they were somewhat off the mark in terms of what should or could be aimed for with relevance. That is, for many of the audiences the science centres were working with, aspects of STFC science (e.g. astrophysics) are not directly applicable or relevant to issues in their daily lives (e.g. unemployment, substance abuse, poverty, housing). However – and as noted previously – the experience of engaging with STFC science can be incredibly relevant and powerful and thus we encourage the consideration of a shift in language of the items to focus more on the experience of engaging with the science than the detail of the content itself. At the same time, when connections can be made between the science and participants' lives and interests (e.g. when Aberdeen Science Centre referred to oxygen all around us, or states of matter for water), these can only serve to reinforce feelings of connection to science and relevance of engaging with science more broadly. In addition, some of the parents interviewed in Aberdeen described their hopes that their children would 'gain knowledge' from sessions with the science centre, so the opportunity to do so was clearly valued and relevant to their aspirations for their children's futures.

Developing Skills [Armagh, Catalyst, Dynamic Earth, National Space Centre, Royal Astronomical Society, W5]

TABLE 28 – DEVELOPING SKILLS RESULTS FOR PRE- AND POST-DATA

Data Collected Pre- and Post-Intervention						
	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Developing Skills	I would like to develop my skills in science	110	90	80.9%	86.7%	+5.8%
	[Post only] During the project, I tried something I had not done before	-	90	-	91.1%	-
	[Post only] During the project, I learnt something new	-	89	-	97.8%	-
	I feel proud of myself when I do science activities	-	-	-	-	-

TABLE 29 – DEVELOPING SKILLS RESULTS FOR POST-DATA ONLY

Data Collected Post-Intervention Only					
	Statement	N	SD/D	NE	A/SA
Developing Skills	Since doing the project, I am more interested in developing my skills in science	170	4.7%	12.4%	82.9%
	During the project, I tried something I had not done before	171	2.9%	5.3%	91.8%
	During the project, I learnt something new	189	1.1%	4.2%	94.7%
	I felt proud of what I did during the project	46	6.5%	15.2%	78.3%

Discussions with science centre practitioners and with participating young people suggested that these questions were easily understood. They are also useful because they can cover a wide range of skills and activities and we encourage their continued use in their current format. If resources allow, qualitative data could also be collected to gain additional insight into which skills participants felt they had gained. Relatedly, other research suggests that reflecting on activity – such as on skills gained – can help reinforce learning as well as self-confidence. Thus, we would encourage practitioners focusing on this outcome (and even those who are not!) to try to reference explicitly the skills that participants are using during the activities.

Social Connection [Armagh, Cambridge Science Centre, National Space Centre, Royal Astronomical Society, Science Oxford, W5]

TABLE 30 – SOCIAL CONNECTION RESULTS FOR PRE- AND POST-DATA

Data Collected Pre- and Post-Intervention						
	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Social Connection	I enjoy doing science activities with my *friends and family*	71	61	91.5%	98.4%	+6.9%
	I enjoy having conversations with my *friends and family*	71	61	85.9%	96.7%	+10.8%
	I feel connected to my *friends and family* when doing science activities together	71	61	85.9%	95.1%	+9.2%

TABLE 31 – SOCIAL CONNECTION RESULTS FOR POST-DATA ONLY

Data Collected Post-Intervention Only					
	Statement	N	SD/D	NE	A/SA
Social Connection	During the project, I enjoyed doing science activities with my friends and family	194	2.1%	7.2%	90.7%
	During the project, I enjoyed having conversations about science with my friends and family	291	4.8%	15.1%	80.1%
	During the project, I felt connected to my friends and family when doing science activities together	195	4.6%	15.9%	80.0%

This outcome area emphasises the connections individuals make in the context of science activity, which can support both enjoyment and a sense that this activity is for ‘people like me/us’. Fortunately, fostering social connections is an area in which science centres often excel, as is also reinforced by how well many did in this area. Qualitative data collected in this project also reflect that the questions themselves were understood by participants, and observations contain multiple examples of families and friends/peers having animated conversations about the science activities in which they were engaged in during the sessions, such as one about blocking radiation (Roots Club, Dynamic Earth).

Belonging [Aberdeen, Cambridge Science Centre, Dundee, Jodrell Bank, National Space Centre, We the Curious]

TABLE 32 – BELONGING RESULTS FOR PRE- AND POST-DATA

Data Collected Pre- and Post-Intervention						
	Statement	N (pre)	N (post)	A/SA (pre)	A/SA (post)	Difference (pp)
Belonging	I feel comfortable when doing science activities	118	108	88.1%	99.1%	+11.0%
	I can be myself when doing science activities	118	115	69.5%	91.3%	+21.8%
	I feel my ideas are heard during science activities	118	109	61.9%	88.1%	+26.2%

TABLE 33 – BELONGING RESULTS FOR POST-DATA ONLY

Data Collected Post-Intervention Only					
	Statement	N	SD/D	NE	A/SA
Belonging	Compared to my normal experiences doing science activities, I felt more comfortable in the project	119	9.2%	20.2%	70.6%
	Compared to my normal experiences doing science activities, I felt more able to be myself in the project	147	10.2%	25.2%	64.6%
	Compared to my normal experiences doing science activities, I felt my ideas were heard more during the project	122	15.6%	24.6%	59.8%

Belonging was another outcome area in which science centres often excelled. Discussions with practitioners and participants that occurred as part of qualitative data collection highlighted that the ideas of feeling comfortable, being yourself, and having your ideas heard were understandable to participants. As with the agency items, however, efforts to compare these experiences to ‘normal experiences doing science activities’ are problematic, as baselines will vary by individual and in some cases, will already have been positive. Thus, as belonging, like agency, is an outcome that is situated within the experience itself – and for clarity of interpretation, we would recommend that the post-only items drop the comparison to ‘my normal experiences doing science activities’. This would mean that measurement is focused solely on the audience’s experience of their engagement with the science centre, and responses are not distracted or led by previous engagement with science elsewhere.

Further insights about belonging also came from qualitative data collected, in which the rapport between science centre practitioners and participants was evident, and clearly contributed to a positive welcoming environment. Also salient are the reflections from young people about why they

felt they could be themselves in sessions: ‘This is like learning but they make it into fun games’ (Year 5 pupil participating in National Space Centre’s Space Mile club). This comment, echoed by others, underlines the importance of enjoyment and interest to the sessions. They seem to contribute to an environment that signals to participants that they can relax, have fun and be themselves – that it is for kids like them.

Implications for the Logic Model

The results reported here demonstrate the complexity of measuring inclusivity and informal science learning experiences. In response, the implications of the evaluation work for the logic model and concomitant measurement of outcome areas are as follows:

- The six ‘participant outcome’ areas reflected in the logic model were deemed relevant and appropriate however, quantitative results indicated that the statement ‘I felt proud of what I did during the project’ that was initially intended for the Agency outcome fits better within the Developing Skills outcome.
- With statements arranged as planned but with a small move of one Agency statement to the Developing Skills heading, statements relating to each outcome, when combined demonstrate high reliability, indicating that these statements are measuring the same dimension, or underlying construct.
- Qualitative data highlighted challenges with the Relevance outcome. It is worth considering revising the wording of these statements to be focused on the process of learning or experience of engaging with science, rather than the topic or content. This would also align better with the language used in all other statements. In addition, although agreement was high, it seems that from the perspective of equity and inclusion, it would be better if the relevance statements aligned with the true value and potential of these engagement experiences.
- While all outcome areas were deemed relevant and appropriate for the science centres and community partners, some were of the view that the concept of Enjoyment and Interest should not be overlooked, and all six outcome areas were reliant on this. However, we suggest that Enjoyment and Interest is considered to be a required foundation that surrounds the interventions and facilitates the other ‘outcome areas’ rather than structuring as an outcome area itself.

Evaluation Conclusions

In addition to the implications for the logic model, the evaluation also surfaced further considerations and conclusions overall. While the quantitative data demonstrated validity and the strengths of interventions, it is not sufficient to capture everything. The two main areas in which the qualitative data provided insight were 1) how participants may have been interpreting the questions and the ease or difficulty of responding and 2) the kinds of activity or experiences that may be underpinning their responses. The observations and discussions at the five science centres visited (Aberdeen, Cambridge, Dynamic Earth, National Space Centre and Techniquest), as well as exit interviews with 13 centres, also surfaced areas that might have been missing from the Theory of Change and, potentially, the instrument. Insights from the qualitative data relevant to the six

outcome areas have been incorporated into previous sections of this report and we draw out further conclusions and implications below

For the most part, conversations with participants reflected that they did seem to understand the items the way in which they were intended, providing additional confidence in our quantitative analyses. Discussions with participants, community partners and science centres also indicated that the postcards themselves were not onerous, that participants were able to complete them quickly and did not seem to perceive them as a test or judgement. In other words, they did not detract from the experience. That said, although participants were able to do pre- and post-postcards after one or two sessions, it seems that four or more sessions form a more appropriate span to capture changes and presents a more balanced evaluation-to-implementation ratio. In sum, the postcard approach and using this number of questions to try to capture outcomes ‘works’ from a delivery standpoint – and even to the surprise of multiple practitioners.

The main areas of equitable or inclusive practice do seem to be covered by the categories available for the postcards. The possible exception to this would be enjoyment and interest/curiosity, which practitioners agreed are fundamental but also act more as antecedents than outcomes. They are also interwoven with the activity itself – something experienced during the course of an engagement rather than a change in an individual. This has been reflected in the discussion of the logic model above. That said, science centres could be encouraged to continue to capture data related to enjoyment and interest when needed (i.e. it may not be necessary to capture it for every single activity delivered and that would likely be burdensome for participants). In addition, while it is important to support enjoyment and encourage interest – particularly in this case because they support inclusive outcomes such as Belonging and Agency, they are objectives for almost any science centre activity. That is, they are not in and of themselves inclusive outcomes – rather they contribute to an environment or experience which is inclusive. While questions about enjoyment and interest are not currently included in the outcome measures, they are reflected in the logic model, and could be added to the postcards at a future point. They also appear to be common among centres existing evaluation measures.

Although the postcards cover major categories of inclusive practice, one area that is not explicitly asked about in the postcards, nor does it feature prominently in the logic model, is the importance of practitioner-participant relationships and the manner in which activities are delivered. For instance, with the National Space Centre in Leicester, the activities were delivered in a school multi-purpose room, and on the surface, did not differ hugely from activities found in standard classrooms (e.g. the use of PowerPoint slides, some cutting and pasting). Yet, the environment created by the practitioner was hugely relaxed and ‘fun’ – much more aligned with the kinds of interactions that might be expected in a science centre or other informal setting. Moreover, over the weeks of the project, the practitioners had developed a relationship with the pupils, who clearly felt comfortable and at ease in the sessions. In one touching incident, a pupil answered a question and the teacher jumped up in praise, not because the answer was right or wrong, but because this pupil never spoke in class. The pupil felt comfortable enough in the science club to answer a question. Similarly, in Aberdeen, young people – and their parents – were always pleased to see Sam and Vanessa and in the primary school, were clamouring to join in the session. They clearly felt cared for and cared about, which contributed to the experience of engaging with science being impactful for them. They

also felt like they could go to the science centre ‘anytime’ – because they know who works there and the trust they have in the practitioners means they are willing to try things they might not otherwise.

Although the incorporation of practitioner-participant relationships remains an area for further consideration and has implications for the duration of science centres’ engagement with their audiences, it is worth considering how practitioner-participant relationships or relationship-building may be incorporated into the logic model. While we did not explicitly measure relationships as an outcome, observations as well as other research suggest that the items in the Belonging category could be closely aligned. The Social Connections category could also be expanded to include connections with practitioners as well as connections with peers or family members.

Finally, while not an additional component for the logic model, the participant outcome for Relevance is deemed worthy of reframing to ensure the language of such statements align with the relevance of audience’s experiences rather than the relevance of the subject matter. Such reframing also has implications for where Relevance sits within the theory of change. Centres should ensure the activities they provide to audiences are meaningful so that through these experiences, the audiences come away with a sense of personal connection to science. Thus, meaningful activities are a necessary input, so that personal relevance can be measured as an outcome.

Next Steps

While the evaluation has made considerable progress in informing the logic model, it will continue to evolve as more data is collected and further insights gained. In addition to the potential incorporation of relationships into the model (as noted above), attention also should be paid to the line of accountability and ensuring that it is clear what science centres can reasonably be held accountable for. That is, the evaluation underlined the way in which science centre activity is situational and outcomes for participants are inevitably influenced by other contextual factors in their lives and locations. This was particularly clear in the discussions around Relevance and to what extent particular science content can be relevant to issues such as poverty, substance abuse, unemployment and so forth. Likewise, while science centres can play an important role in supporting individuals to be ready to choose STEM, these choices – and especially whether individuals ultimately land in STEM-related jobs – are very much influenced by factors far beyond the control of science centres, such as gatekeeping by schools (who is allowed to study particular qualifications), support provided by universities, environments in university departments, hiring practices by employers, to name a few.

The quantitative instrument itself (the postcards/questionnaires) could also be further tested and refined. In particular, cognitive testing of the statements through focus groups, especially those around Relevance, would be helpful for interpretation as it would increase understanding of what participants are thinking of when they respond to the statements. Knowledge about how respondents understand the statements would also support use of the questionnaire, as it could provide insight as to how much explanation of the items might be appropriate when needed.

Such guidance could also be incorporated into further development of an evaluation framework, which would sit alongside the logic model and provide detailed guidance as to how to use the

questionnaire. Additionally, the evaluation underscored the value that qualitative data can bring to quantitative results. The framework would thus include not only the quantitative measures but also include suggestions for qualitative methods and creative approaches to capture inclusive outcomes that could complement quantitative measures. Such a framework would support science centres in the integration of quantitative and qualitative measures, and provide guidance around how to be selective about which data to collect and when. It could also address the measurement of outcomes related to enjoyment and interest. As more data is collected across centres, further refinement of the logic model would follow.

Another step that would build upon this would involve supporting science centres in translating the logic model into practice. Using the model to inform and develop more inclusive practice could be supported in different ways, from the creation of resources to support reflective practice within and across centres, to the formation of communities of practice, mentoring, and/or training programmes.

Appendix 1 – Example Postcard



You are sending a postcard to the Royal Astronomical Society team!

They would like to hear about your experiences with science!

Circle one of the faces, to show us how you feel about each of the sentences. There are no wrong answers!



(a) Since taking part in the Astronomy Through The Herschels workshop, I feel more interested in knowing about careers involving astronomy

Strongly Disagree Disagree I Don't Know Agree Strongly Agree



(b) Since taking part in the Astronomy Through The Herschels workshop, I think astronomy will be more useful to me in the future



(c) Since taking part in the Astronomy Through The Herschels workshop, I feel more able to work with astronomy in my future



(d) During the Astronomy Through The Herschels workshop, I heard about other astronomy activities I can do at home or in my area



(e) During the Astronomy Through The Herschels workshop, I enjoyed doing astronomy activities with my friends and family



(f) During the Astronomy Through The Herschels workshop, I enjoyed having conversations about astronomy with my friends and family



(g) During the Astronomy Through The Herschels workshop, I felt connected to my friends and family when doing astronomy activities together



(h) Since doing the Astronomy Through The Herschels workshop, I am more interested in developing my skills in astronomy



(i) During the Astronomy Through The Herschels workshop, I tried something I had not done before



(j) During the Astronomy Through The Herschels workshop, I learnt something new



The Royal Astronomical Society is part of a bigger project that is learning about people's experiences with science so they can improve their science activities. Please tick the boxes if you agree with the statements: I am happy for my responses to be used in the project I understand I will not be named or identified in the project