

## SCIENCE OUTSIDE THE CLASSROOM

### RESEARCH REPORT

#### #0: EXECUTIVE SUMMARY

### Summary #1: Introduction and Research Design

#### *Introduction*

Science Outside the Classroom (SOTC) was an international project that took place in 2018-2021. The SOTC project team developed and implemented a development programme (SOTC-DP) for which the aim was to enhance children's scientific enquiry skills and transversal skills (TS) in outdoor learning environments (OLEs) across five educational settings in four European countries. A research study was conducted alongside the SOTC-DP to investigate if and how an outdoor science programme may support the development of children's scientific enquiry skills and TS in five European educational settings. This document is the Executive Summary of the Research Report and comprises these sections:

**#1 SUMMARY: Introduction and Research Design**

**#2: SUMMARY: ATSLO (Assessment of children's Transversal Skills when Learning Outdoors)**

**#3: SUMMARY: OOSE (Observations of Outdoor Setting Environments)**

**#4: SUMMARY: Teachers' Questionnaires 1 + 2**

**#5: SUMMARY: Students' Questionnaires 1 + 2**

**#6: RESEARCH REPORT: Student Post-Box Quick Questionnaire**

**#7: SUMMARY: Student Photovoice**

**#8: SUMMARY: Documentary Evidence: Review Of SOTC-DP Intellectual Outputs**

#### *The Research Design*

The aim of the study was to investigate if and how an outdoor science programme may support the development of children's scientific enquiry skills and transversal skills in five European educational settings.

Four objectives acted as stepping stones to achieving the study aim. They were to identify:

- Scientific enquiry skills children aged 3-11 years may develop outdoors
- Transversal skills children aged 3-11 years may develop through scientific enquiry outdoors

- Features of the physical environment that may enable children aged 3-11 years to develop scientific enquiry skills and transversal skills outdoors
- Pedagogical strategies that may enable teachers to support children aged 3-11 years to develop scientific enquiry skills and transversal skills outdoors.

The SOTC research study was a participatory multisite instrumental case study (Heron and Reason, 1997; Creswell, 2013: 294-5). Academics and teachers worked as research partners across the five educational settings that participated in the SOTC-DP.

Ethical considerations were guided by the British Educational Research Association guidelines (BERA) (2018) and ethical protocols were agreed and monitored by the participating university's Research Ethics Committee. In addition, each partner was responsible for identifying and following additional ethical codes and procedures that were required in their respective partner countries

A purposive sampling strategy was adopted for the study. ES\_Table 2 shows the sampling frame.

*ES\_1 Table 2: Sampling Frame*

Settings in SoTC-DP <i>(pseudonyms)</i>	Teachers in SOTC-DP	All Children in Setting	Information about Socio-Economic Status (SES): all children in setting	Children in SOTC-DP	
				Number in SOTC-DP	Aged
<b>Rowan School</b>	7	467	8% Free School Meals / 20% Special Educational Needs / 28% non-indigenous	256	6-11 yrs
<b>Modrova Kindergarten</b>	6	134	19.2% High SES / 34.8% medium SES / 44.5% Low SES / 0.5 Poverty	75	3-5 yrs
<b>Juno Kindergarten</b>	12	80	Middle and upper class with good economic conditions	37	3-7 yrs
<b>Feliz School</b>	4	421	13% Special Educational Needs / 43% non-indigenous	223	6-11 yrs
<b>Jubilee School</b>	4	420	9.66% of children are eligible for additional funding for children with low SES / 5.8% are eligible for free school meals	120	4-5 yrs 9-10 yrs

A multi-method model was adopted for the research instruments (INT\_Table 3). Data were collected in the partner settings. Data collected at the end of the SOTC-DP followed an extended period of COVID-19 lockdown in all participating countries.

INT\_Table 3: Research Instruments

Before the SOTC Development Programme (n=number of participants)		After the SOTC Development Programme (n=number of participants)	
<b>Documentary Evidence:</b> <i>settings' demographic data, location, mission, values – used to inform understanding of data</i> (5 settings)	<b>ATSLO 1:</b> Teacher-Researchers' <b>Assessments of children's Transversal Skills when Learning Outdoors</b> (n=50)	<b>ATSLO 2:</b> Teacher-Researchers' <b>Assessments of children's Transversal Skills when Learning Outdoors</b> (n=48)	<b>Post-Box:</b> Students' Knowledge of Science Topics (n=399)
	<b>OOSE 1:</b> Teacher-Researchers' Observations of Outdoor Setting Environments (5 settings)	<b>OOSE 2:</b> Teacher-Researchers' Observations of Outdoor Setting Environments (5 settings)	<b>Adapted PhotoVoice:</b> Students' Knowledge of Science Topics (n=48)
	<b>Students' Beliefs and Attitudes Questionnaire 1</b> (n=49)	<b>Students' Beliefs and Attitudes Questionnaire 2</b> (n=49)	<b>Documentary Evidence: Review of SOTC-DP Intellectual Outputs</b>
	<b>Teachers' Beliefs and Attitudes Questionnaire 1</b> (n=32)	<b>Teachers' Beliefs and Attitudes Questionnaire 2</b> (n=31)	

Further detail about each research instrument is set out in each research instrument's relevant section of the Research Report.

## Summary #2: RESEARCH REPORT on ATSLO (Assessment of children's Transversal Skills when Learning Outdoors)

The research for the Science Outside the Classroom (SOTC) project concerning children's transversal skills (TS) featured Teacher-Researchers (TRs) conducting observational *Assessments of children's Transversal Skills when Learning Outdoors (ATSLO)* in their settings. For SOTC, TS are defined as a set of skills (ATSLO\_Table 1)

ATSLO\_Table 1: Transversal Skills for the SOTC Project

Transversal Skills	Subsets of Transversal Skills
Wellbeing	Health and wellbeing
	Behaviour
	Confidence
	Enjoyment of learning
Motivation	Engagement with learning
	Attainment
	Resilience
	Determination
	Involvement
Creativity	Engagement with nature
	Creative
	Inventive
	Enterprising
	Imagination
Social skills	Inventiveness
	Resourcefulness
	Communication
	Team work
Critical thinking	Independence
	Reasoning
	Problem solving (generic)
	Answering questions
	Asking questions
	Understanding nature

Teacher-Researchers conducted observational assessments of students' transversal skills when learning outdoors in the five SOTC settings before and after the SOTC-Development Programme (SOTC-DP), with the exception of two students who were not included in the final assessments (Before: n=50 - 25 boys/25 girls) (After: n=48 - 25 boys/23 girls). For each participating child, TRs used their observations as evidence to complete the ATSLO scale (ATSLO\_Table 1) synthesised from relevant research and literature (Department for Education and Skills (DfES), 2005; Goleman, 1995; 2009; Harms, Clifford and Cryer, 2014; Laevers, 2000; Louv, 2005; Murray, 2017; Murray and Cousens, 2020; Murray and Garner, 2015; Pascal et al., 1996; Standards and Testing Agency, 2017) (see appendix 1):

*ATSLO\_Figure 1: Example from Assessment of Transversal Skills when Learning Outdoors (ATSLO) Scale*

(i) TRANSVERSAL SKILLS GRID: WELL-BEING	Exceeding (3)	Expected (2)	Emerging (1)	3, 2, 1?															
				Child...															
				A	B	C	D	E	F	G	H	I	J						
<b>Health and physical well-being</b>	Always lively, active and full of energy when outdoors.	Usually active and energetic when outdoors.	Often lethargic when outdoors.																
<b>Behaviour</b>	Contributes to making the rules and follows the rules when outdoors  Always open and accessible to what is happening outdoors	Understands and usually follows rules when outdoors  Usually open and accessible to what is happening outdoors	Does not always follow rules when outdoors  Is sometimes withdrawn or aggressive when outdoors																
<b>Confidence</b>	Always likes to engage with new activities outdoors	Usually likes to engage with new activities outdoors	Does not like engaging with new experiences outdoors																
<b>Enjoyment of learning</b>	Always looks happy when learning outdoors	Usually looks happy and cheerful when learning outdoors	Rarely or never looks happy when learning outdoors																
<b>Emotional well-being</b>	Always appears relaxed and comfortable outdoors.	Usually appears relaxed and happy outdoors.  Rarely shows any signs of stress or tension outdoors.	Often shows signs of discomfort outdoors, including signs of stress or tension																
<b>Sub-totals for each child's well-being outdoors:</b>																			

TRs contributed their setting's ATSLO data to the overall project data. The full data sets were then aggregated to elicit scores for children's transversal skills when learning outside before and after the programme; this process allowed for comparison of data before and after the programme.

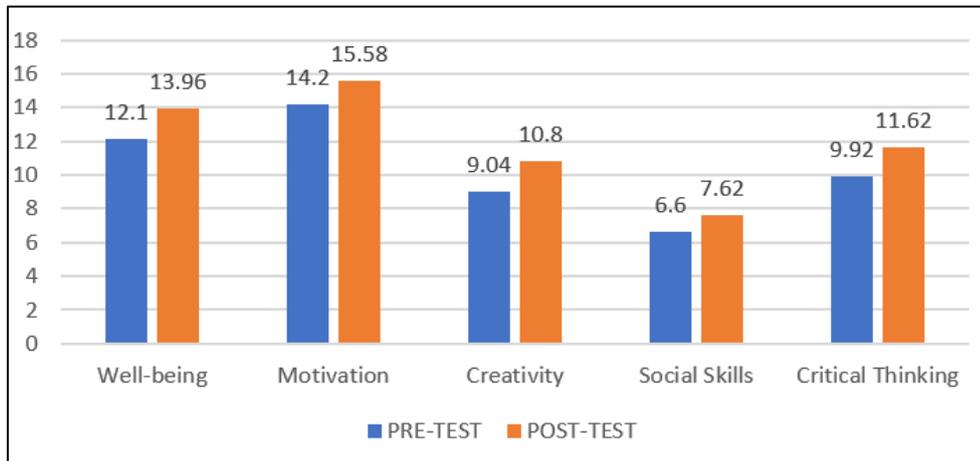
(ATSLO\_Table 2) shows the mean figures for all TS presented by children before and after the SOTC-DP.

*ATSLO\_Table 2: Assessments of students' Transversal Skills when Learning Outdoors (ATSLO)*

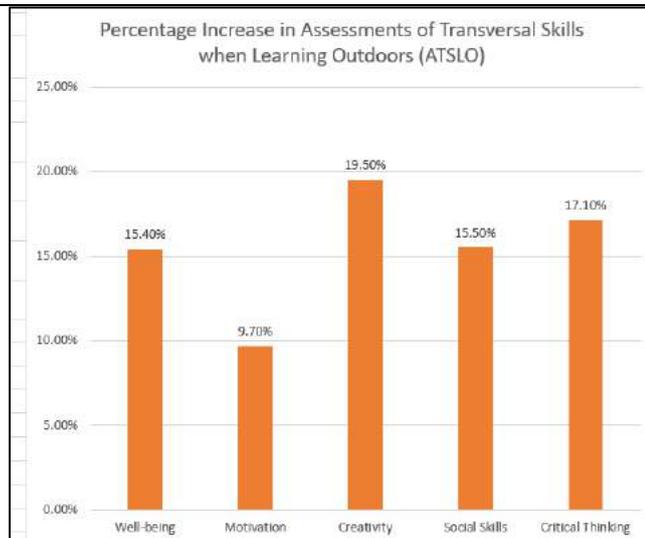
	No. of children assessed	# Gender		Mean Figures: Transversal Skills					Combined Mean Total
		Male	Female	Well-Being	Motivation	Creativity	Social Skills	Critical Thinking	
<b>Pre-SOTC-DP</b>	<b>50</b>	<b>27</b>	<b>23</b>	<b>12.1</b>	<b>14.2</b>	<b>9.04</b>	<b>6.6</b>	<b>9.92</b>	<b>51.86</b>
<b>Post-SOTC-DP</b>	<b>48</b>	<b>25</b>	<b>23</b>	<b>13.96</b>	<b>15.58</b>	<b>10.8</b>	<b>7.62</b>	<b>11.62</b>	<b>59.58</b>

Next, data recorded before and after the SOTC-DP were compared (ATSLO Figures 2, 3).

ATSLO\_Figure 2: Pre-SOtC-DP /Post-SOtC-DP Assessments of students' Transversal Skills when Learning Outdoors (ATSLO)



ATSLO\_Figure 3: Percentage Increase in Assessments of students' Transversal Skills when Learning Outdoors (ATSLO)



Comparison of findings revealed that TRs observed an increase of 15.4% in children's TS when learning outdoors in their settings.

### #3: SUMMARY: OOSE (Observations of Outdoor Setting Environments)

Observations of Outdoor Setting Environments (OOSE) were conducted by Teacher-Researchers as a research method before and after the Science Outside the Classroom Development Programme (SOtC-DP) to provide comparative data about the outdoor environments of settings that participated in the SOtC-DP.

The OOSE scale drew on Cooper’s (2015) *Proposed Minimum Standards to Promote Quality Natural Outdoor Learning Environments* (Figure 1), and ECERS-E3 (Harms, Clifford and Cryer, 2014). OOSE\_Figure 1 shows the first page of the OOSE scale (an adapted version of the full OOSE scale is available in the public domain - see appendix 2).

*OOSE Figure 1: Example from Observations of Outdoor Setting Environment (OOSE) Scale*

ITEM 1. Designated Outside Learning Space			
Excellent	Adequate	Inadequate	3,2,1?
3 	2 	1 	
All children spend time every day in the outdoor space that is formally designated as an outdoor play and learning environment	Outdoor space is formally designated as an outdoor play and learning environment	No outdoor space is formally designated as an outdoor play and learning environment	
ITEM 2. Outdoor Gross Motor Features			
Excellent	Adequate	Inadequate	3,2,1?
3 	2 	1 	
The outdoor environment has three or more outdoor gross motor features (e.g. climbing features or looping pathways)	The outdoor environment has two outdoor gross motor features (e.g. climbing features or looping pathways)	The outdoor environment has only one or no outdoor gross motor features (e.g. climbing features or looping pathways)	
ITEM 3. Outdoor Learning Centres			
Excellent	Adequate	Inadequate	3,2,1?
3 	2 	1 	
The outdoor environment has three or more outdoor learning centres (e.g. gardening area, hide or dramatic play area)	The outdoor environment has two outdoor learning centres (e.g. gardening area, hide or dramatic play area)	The outdoor environment has only one or no outdoor learning centres (e.g. gardening area, hide or dramatic play area)	

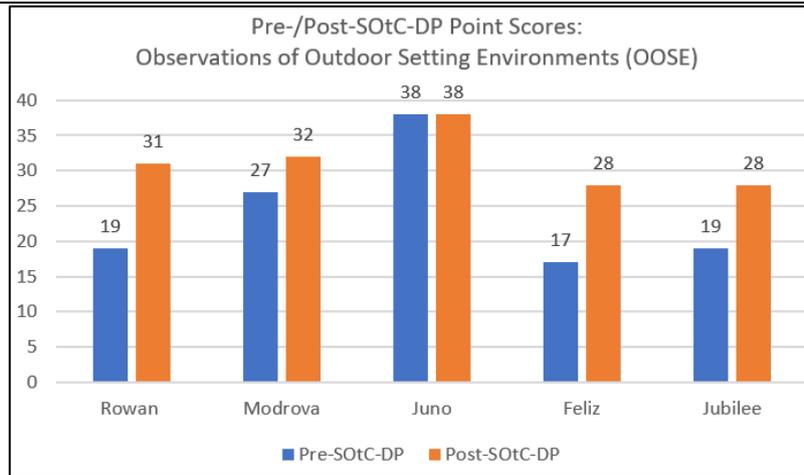
OOSE data revealed increased scores for twelve of the fourteen items observed. Only the scores for Item 5 (Natural Features) and Item 11 (Outdoor Space) remained unchanged (OOSE\_Table 2).

*OOSE\_Table 2: Observations of Outdoor Setting Environments (OOSE)*

ITEMS	Pre- SOTC-DP	Post- SOTC-DP	Pre/Post Score Comparison
ITEM 1. Designated Outside Learning Space	10	14	+4
ITEM 2. Outdoor Gross Motor Features	10	12	+2
ITEM 3. Outdoor Learning Centres	10	14	+4
ITEM 4. Plants and Habitats	7	10	+3
ITEM 5. Natural Features	9	9	=
ITEM 6. Outdoor Water Source	8	11	+3
ITEM 7. Wheeled Toys	8	11	+3
ITEM 8. Time	10	12	+2
ITEM 9. Fruits and Vegetables	7	9	+2
ITEM 10. Professional Development	8	12	+4
ITEM 11. Outdoor Space	10	10	=
ITEM 12. Science Resources	6	9	+3
ITEM 13. Science processes: Non-living	8	11	+3
ITEM 14. Science processes: Living processes	9	13	+4
<b>SCORE FOR ALL ITEMS ACROSS 5 SETTINGS</b>	<b>120</b>	<b>157</b>	<b>+37</b>
<b>MEAN TOTAL</b>	<b>24</b>	<b>31.4</b>	<b>7.4</b>

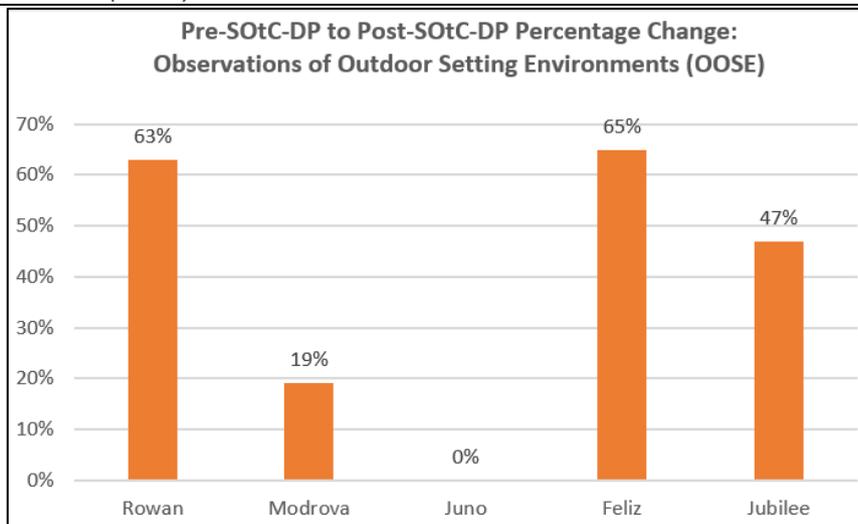
As indicated in OOSE\_Figure 2, four partner settings showed increased OOSE scores. Juno setting scores remained the same, possibly because Juno setting was a kindergarten in a Nordic country, where there is a strong tradition of learning outside (Sandseter and Lysklett, 2016: 115).

OOSE\_Figure 2: Pre-SOtC-DP /Post-SOtC-DP Observations of Setting Outdoor Environments (OOSE)



For each setting, percentages were calculated for the differences between OOSE scores before and after the SOtC-DP (OOSE Figure 3), revealing a **percentage increase of 39%** (rounded) across all settings' OOSE scores over the duration of the SOtC programme.

OOSE\_Figure 13: Percentage increases: Pre-SOtC-DP /Post-SOtC-DP Observations of Setting Outdoor Environments (OOSE) Scores



The enhancements in OOSE data between the beginning and the end of the SOtC-DP programme suggest that four of the five SOtC settings developed their outdoor learning environments during the programme to align more closely with Cooper's model (2015). These enriched, outdoor spaces featuring natural elements and greater diversity were likely to be conducive to students' development of scientific enquiry skills (Jadrich and Bruxvoort, 2011).

Moreover, changes in the settings' outdoor environments in line with Cooper's model (2015) are likely to have provided opportunities for students to develop their well-being, intrinsic motivation, creativity, social skills and

critical thinking - all five transversal skills in the SOTc programme - as well as their physical and mental health, development, learning, behaviour, and self-regulation (Cooper, 2015; Louv, 2005; Marchant et al., 2019; White, 2011; Wilson, 1984).

#### **#4: SUMMARY: Teachers' Questionnaires 1 + 2**

This section summarises the SOTc Teachers' Questionnaire Findings (RI3 and RI5). It is structured as two sections: (i) Teachers' questionnaire data for teaching science and (ii) Teachers' questionnaire data for teaching transversal skills. Overall, teachers' questionnaire responses indicated that they made the greatest gains in developing their skills for teaching outdoors over the period of the SOTc-DP, though they also identified gains in developing their skills as teachers indoors. Teachers said that this was the case in respect of their skills for teaching across the curriculum, and teaching fundamental science skills outdoors developed as well as their enhanced expertise, confidence and enjoyment in respect of supporting children to gain transversal skills by the end of the SOTc-DP

##### ***(i) Summary: Teachers' questionnaire data for teaching science***

This sub-section summarises teachers' questionnaire data for teaching science over the period the SotC-DP took place and compares key data. Of note, these data revealed that teachers believed their skills for teaching across the curriculum, teaching science and teaching fundamental science skills indoors and outdoors progressed between the beginning and the end of the SOTc-DP, the greatest improvements were in their teaching across the curriculum, teaching science and teaching fundamental science skills outdoors. The sub-section opens with selected summaries of data setting out teachers' demographic data.

##### **TQ6: Teachers' EQF science qualifications**

TQ6 asked teachers what European Qualification Levels they held for Biology, Chemistry, Physics and General Science. The data for TQ6 indicate that SOTc teachers were most commonly qualified to EQF Level 2 in Science subjects. Around a quarter of teachers were educated to EQF Level 6 (Bachelor degree level) in Science subjects (TQ\_Tables 2 and 3; TQ\_Figure 8).

##### **TQ7: Teachers' past science teaching**

In their responses to TQ7, teachers told us about their science teaching before the SOTc-DP. Teachers' responses to TQ7 indicate that 81% of teachers had taught science before the SOTc-DP, and this figure was the same for all three science subjects.

#### **TQ14: Teachers' knowledge of science topics**

Teachers responding to TQ14 rated their own content knowledge for each of the science topics taught in SOTC-DP. These data showed Teachers' Excellent/Good Ratings of their content knowledge for each science topic had increased after the SOTC-DP across all Science Topics, with a mean increase of +33%.

#### **TQ15: Teachers' knowledge of fundamental science skills**

For TQ15, teachers were asked to rate their knowledge of 19 fundamental science skills, according to a five-point Likert Scale: Excellent/Good/OK/Poor/Bad. With the exception of #8: 'Carrying out a simple test', these data showed that Teachers' Excellent/Good Ratings of their overall knowledge of all fundamental science skills had increased by the end of the SOTC-DP, resulting in a mean increase of +15% in teachers' Excellent/Good ratings of their self-efficacy in their knowledge of fundamental science skills. Teachers' responses to TQ16, TQ17 and TQ18 focused on teachers' skills for teaching across all curriculum areas, science and fundamental science skills indoors, before and after the SOTC-DP. These data are displayed below, then compared with teachers' responses to TQ19, TQ20 and TQ21 which focused on teachers' skills for teaching all curriculum areas, science and fundamental science skills outdoors, before and after the SOTC-DP.

#### **TQ16: Teachers' skills for teaching all curriculum areas indoors**

TQ16 asked teachers to rate their skills for teaching across all curriculum areas indoors, according to a five-point Likert Scale: Excellent/Good/OK/Poor/Bad. Across 19 skills for teaching, TQ16 data showed that teachers' Excellent/Good ratings of their skills for teaching across all curriculum areas indoors had increased by the end of the SOTC-DP except for one skill - 'Questioning'. Overall, TQ16 data showed a mean increase of +17% in teachers' Excellent/Good ratings of their skills for teaching across all curriculum areas indoors.

#### **TQ17: Teachers' skills for teaching science indoors**

TQ17 asked teachers to rate their skills for teaching science indoors, according to a five-point Likert Scale: Excellent/Good/OK/Poor/Bad. Across the same 19 skills for teaching used for TQ16, TQ17 data showed that teachers' Excellent/Good ratings of their skills for teaching science indoors had all increased by the end of the SOTC-DP. Overall, by the end of the SOTC-DP, TQ17 data showed a mean increase of +31% in teachers' Excellent/Good ratings of their skills for teaching science indoors. Therefore, by the end of the SOTC-DP, teachers' Excellent/Good ratings of their skills for teaching science indoors had increased by 14% more than their Excellent/Good ratings of their skills for teaching across all curriculum areas indoors. These data suggest that while the teachers believed their engagement in the SOTC-DP had enabled them to develop their skills for teaching right across the curriculum indoors, they believed this was especially the case in regard of their skills development for teaching science indoors.

### **TQ18: Teachers' skills for teaching fundamental science skills indoors**

For TQ18, teachers were asked to rate their skills for teaching indoors the same 19 fundamental science skills indicated in TQ15, according to a five-point Likert Scale: Excellent/Good/OK/Poor/Bad. TQ18 data showed that Teachers' Excellent/Good Ratings of their skills for teaching fundamental science skills indoors had all increased between the beginning and the end of the SOTC-DP, with a mean overall increase of +27%.

### **TQ19: Teachers' skills for teaching all curriculum areas outdoors**

TQ19 asked teachers to rate their skills for teaching across all curriculum areas outdoors, according to a five-point Likert Scale: Excellent/Good/OK/Poor/Bad. Across 19 skills for teaching, TQ16 data showed that teachers' Excellent/Good ratings of their skills for teaching across all curriculum areas outdoors had increased by the end of the SOTC-DP. Overall, TQ19 data showed a mean increase of +20% in teachers' Excellent/Good ratings of their skills for teaching across all curriculum areas outdoors. This overall figure of +20% for teachers' Excellent/Good ratings of their skills for teaching across all curriculum areas outdoors is +3% above the overall figure of teachers' Excellent/Good ratings of their skills for teaching across all curriculum areas indoors (TQ16): +17%. The data indicate that the teachers believed the SOTC-DP had enabled them to develop their skills for teaching across all curriculum areas indoors and outdoors, but more so for teaching across all curriculum areas outdoors: teaching children outdoors was a major element in the SOTC-DP project.

### **TQ20: Teachers' skills for teaching science outdoors**

TQ20 asked teachers to rate their skills for teaching science outdoors, according to a five-point Likert Scale: Excellent/Good/OK/Poor/Bad. Across 19 skills for teaching (the same skills for teaching that featured in TQ16 and TQ17), TQ20 data showed increases in teachers' Excellent/Good ratings of all their skills for teaching science outdoors by the end of the SOTC-DP. Overall, TQ20 data showed a mean increase of +60% over the course of the SOTC-DP in teachers' Excellent/Good ratings of their skills for teaching science outdoors. This meant that the overall increase in teachers' Excellent/Good ratings of their skills for teaching science outdoors over the course of the SOTC-DP (TQ20: +60%) was +29% higher than the overall increase in teachers' Excellent/Good ratings of their skills for teaching science indoors (TQ17: +31%) over the same period.

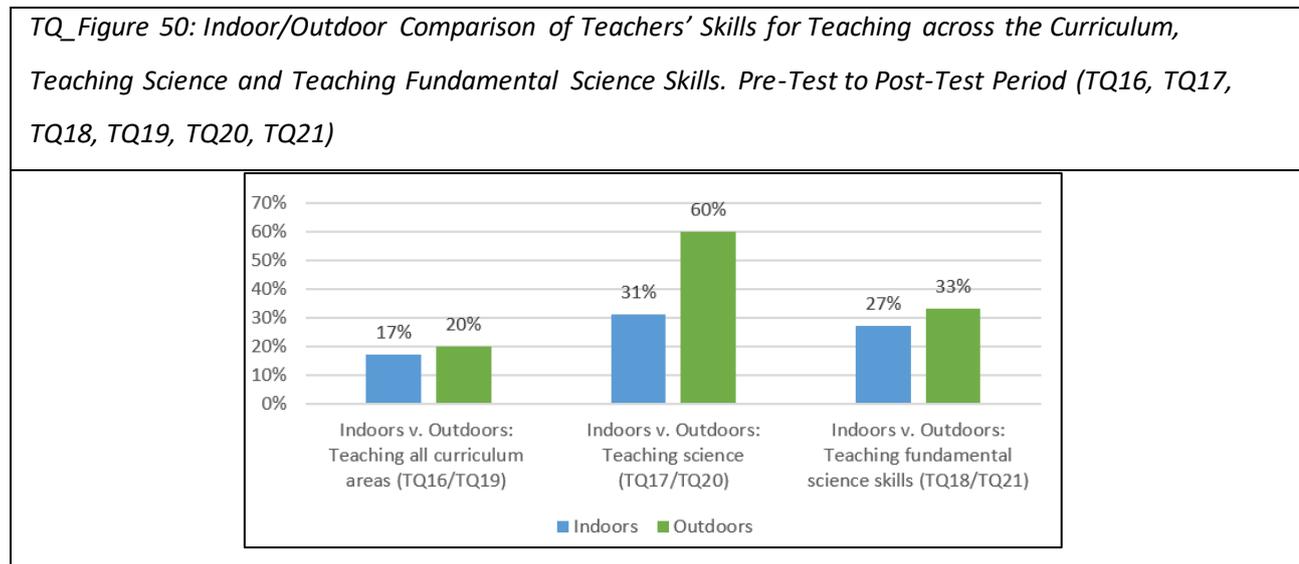
### **TQ21: Teachers' skills for teaching fundamental science skills outdoors**

For TQ21, teachers were asked to rate their skills for teaching indoors the same 19 fundamental science skills indicated in TQ15 and TQ18, according to a five-point Likert Scale: Excellent/Good/OK/Poor/Bad. TQ21 data showed that Teachers' Excellent/Good Ratings of their skills for teaching fundamental science skills outdoors had all increased between the beginning and the end of the SOTC-DP, with a mean overall increase of +33%. This meant that the overall increase in teachers' Excellent/Good ratings of their teaching of fundamental science skills

outdoors over the course of the SOTC-DP (TQ21: +33%) was +6% higher than the overall increase in teachers' Excellent/Good ratings of their skills for teaching science indoors (TQ18: +27%) over the same period.

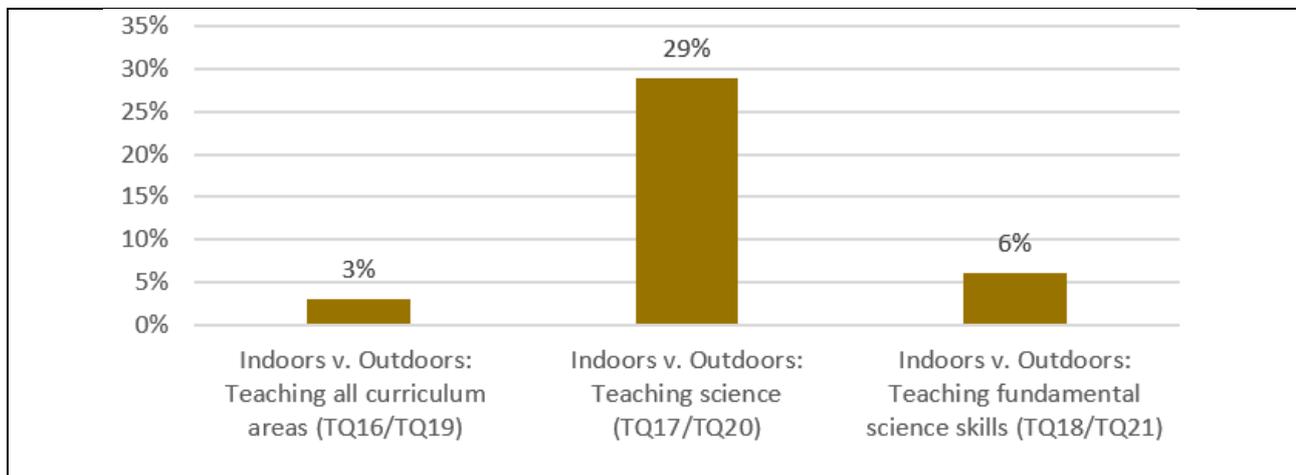
**Comparison of Data: Teachers' Skills for Teaching Indoors and Outdoors across the Curriculum, Teaching Science and Teaching Fundamental Science Skills. Pre-Test to Post-Test Period (TQ16, TQ17, TQ18, TQ19, TQ20, TQ21)**

TQ\_Figure 50 displays the comparison of indoor and outdoor data relating to teachers' skills for teaching across the curriculum, teaching science and teaching fundamental science skills, from the beginning to the end of the SOTC-DP (TQ16, TQ17, TQ18, TQ19, TQ20, TQ21).



TQ\_Figure 51 shows the extent to which outdoor data showed increases when compared with indoor data in relation to teachers' beliefs about their skills for teaching across the curriculum, teaching science and teaching fundamental science skills during the SOTC-DP (TQ16, TQ17, TQ18, TQ19, TQ20, TQ21).

*TQ\_Figure 51: Indoor/Outdoor Comparison. Increases in Teachers' Skills for Teaching across the Curriculum, Teaching Science and Teaching Fundamental Science Skill. Pre-Test to Post-Test Period (TQ16, TQ17, TQ18, TQ19, TQ20, TQ21)*



**TQ31: Will /Did SOTC-DP help teachers to develop as science teachers? If so, how?**

All teachers who responded to the teachers' questionnaires responded to TQ31 before (n=32) and after (n=31) the SOTC-DP. Before the SOTC-DP, all the teachers said they believed the SOTC-DP would help them to develop as science teachers. Afterwards, they all said they believed the SOTC-DP had helped them to develop as science teachers. These responses indicate that the programme fulfilled the teachers' expectations.

Also as part of TQ31, before the programme, we asked them to say why they thought it would help them to develop as science teachers, and afterwards, we asked them to say how the programme had helped them to develop as science teachers. These data were qualitative and provide testimonials from the teachers about how their expectations of the SOTC-DP were met. They are located within the main report (TQ\_Figure 27).

**TQ32: Will /Did SOTC-DP help children to learn better? If so, how?**

63% (n=20/32) of teachers who responded to the teachers' questionnaires responded to TQ32 before the SOTC-DP and all responded to Q32 afterwards (n=31). Before the SOTC-DP, all the responding teachers said they believed the SOTC-DP would help children to learn better. Afterwards, all the teachers said they believed the SOTC-DP had helped their children to learn better. As for Q31, TQ32 responses indicate that the programme fulfilled the teachers' expectations.

Also as part of TQ32, before the programme we asked the teachers to say why they thought it would help children to learn better, and afterwards, we asked them to say how the programme had helped their children to learn better. Once again, these data were qualitative and provide testimonials from the teachers about how their expectations of the SOTC-DP were met. They are located within the main report (TQ\_Figure 28).

### **TQ33: Do /Did teachers want to add anything else about the SOTC-DP and their teaching?**

For their questionnaire before the SOTC-DP, TQ33 asked teachers if they wanted to add anything else about the SOTC-DP and their teaching and just 16% of those who responded to the teachers' questionnaires (n=5/32) took the opportunity to do so. Afterwards, that figure more than doubled to 35% (n= 11/31) of teachers.

Teachers' responses to TQ33 were qualitative and provide testimonials from the teachers about the SOTC-DP. They are located within the main report (TQ\_Figure 29).

### ***(ii) Summary: Teachers' questionnaire data for teaching transversal skills***

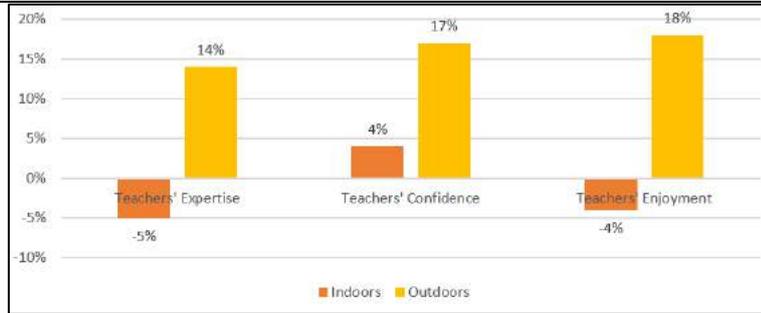
Teachers' responses before and after the SOTC-DP to questions about their own expertise, confidence and enjoyment for supporting children to gain TS **indoors** and **outdoors** were compared. By the end of the SOTC-DP programme, 14% more teachers rated their expertise in helping children gain TS **outdoors** as 'Excellent' or 'Good', 17% more teachers did so in respect of both their confidence and 18% did so for their enjoyment in helping children gain TS **outdoors**. (TQ26, TQ27, TQ28: Fig. 42). Conversely, 5% fewer (-5%) teachers rated their expertise in helping children gain TS **indoors** as 'Excellent' or 'Good', while only 4% more teachers did so in respect of their confidence and 4% fewer (-4%) did so for their enjoyment in helping children gain TS **indoors**. (TQ26, TQ27, TQ28: TQ\_Figure 51).

Direct comparisons of teachers' responses concerning indoors and outdoors reveals:

- Teachers' 'Excellent' or 'Good' ratings of their own **expertise** were **19% higher for outdoors** (14%), than indoors (-5%) (TQ22/TQ26)
- Teachers' 'Excellent' or 'Good' ratings of their own **confidence** were **13% higher for outdoors** (17%) than indoors (4%) (TQ23/TQ27)
- Teachers' 'Excellent' or 'Good' ratings of their own **enjoyment** were **22% higher for outdoors** (18%) than indoors (-4%). (TQ24/TQ28).

Overall, in their responses to TQ22, TQ23, TQ24, TQ26, TQ27, TQ28, teachers rated their expertise, confidence and enjoyment as 18% higher by the end of the SOTC-DP in respect of supporting children to gain TS outdoors, compared with indoors.

*TQ\_Figure 52: Comparing Teachers' Expertise, Confidence and Enjoyment for supporting Children's TS Acquisition Indoors and Outdoors (TQ22, TQ23, TQ24, TQ26, TQ27, TQ28)*



## #5: SUMMARY: Students' Questionnaires 1 + 2

This section summarises the SOTc Students' Questionnaire Findings (RI4 and RI6i). It is structured as two sections: (i) Students' questionnaire data concerning science and (ii) Students' questionnaire data concerning transversal skills. Overall, student questionnaire responses indicated that children were generally positive about their experiences of the SOTc-DP.

- Pre-SOTc to Post-SOTc, mean increases of...
  - +7% in children's top ratings of their self-efficacy for learning different science topics.
  - +16% in children's top ratings in their beliefs that they learned science topics better outdoors (than indoors).
  - +0.6% in children's top ratings of how much they enjoyed learning science skills.
  - +14% more children saying they prefer to learn outdoors than those who said they prefer to learn indoors.
- Pre-SOTc to Post-SOTc, mean decreases of...
  - -4% in children's top ratings concerning their beliefs in their self-efficacy for science skills.
  - -2% students agreeing with positive statements about their transversal skills after the SOTc-DP
- Key comparisons of children's responses concerning outdoors/indoors:
  - -14% fewer children who thought they were good at learning outdoors than those who said they were good at learning indoors. This lower figure is out of step with other data and may be due to children enjoying being outdoors so they did not equate being outdoors with learning.
  - +12.4% more children agreed that learning outdoors (7.4%) enhanced their TS acquisition than those who agreed that learning indoors (-5%) enhanced their TS acquisition.

### *(i) Summary: Students' questionnaire data concerning science*

This sub-section summarises students' questionnaire data concerning science over the period the SotC-DP took place and compares key data.

**SQ12: Students' enjoyment: science topics**

For SQ12, Teacher-Researchers (TRs) showed children pictures of different science topics and asked them to select a response to indicate the level of their enjoyment when learning different science topics that were taught as part of the SOTC-DP (SQ\_Figure 3). (SQ12) compares Pre-Test to Post-Test data to reveal increases and decreases in student ratings of their enjoyment of different science topics. Overall, SQ12 data reveal that between the beginning and the end of the SOTC-DP, there was a mean increase of +6% in children's ratings of their enjoyment of different science topics.

**SQ13: Students' self-efficacy: learning different science topics**

Using a similar format to SQ12, SQ13 asked students to say how good they thought they were at learning each of the ten science topics: '3-Good' / '2-Not sure' / 'Not good'. Overall, SQ13 data reveal that between the beginning and the end of the SOTC-DP, there was a mean increase of +7% in children's top ratings of their self-efficacy for learning different science topics.

**SQ14: Students' beliefs: learning science outdoors**

Again, using a similar format to SQ12 and SQ13, SQ14 asked students to say if they believed they learned each of the ten science topics better outdoors (than indoors): '3-Yes' / '2-Not sure' / 'No'. Overall, SQ14 data reveal that over the duration of the SOTC-DP, there was a mean increase of +16% in children's top ratings in their beliefs that they learned science topics better outdoors (than indoors).

**SQ15: Students' enjoyment: science skills**

SQ15 asked students to say if they enjoyed learning science skills according to a 3-point Likert scale: '3-Like' / '2-Not sure' / 'Don't like'. Overall, SQ15 data reveal that between the beginning and the end of the SOTC-DP, there was a small mean increase of +0.6% in children's top ratings of how much they enjoyed learning science skills.

**SQ16: Students self-efficacy: science skills**

SQ16 asked students to say how good they thought they were at science skills. Data for SQ16 were less positive overall than for most other questions. Overall, they reveal that over the course of the SOTC-DP, there was a mean decrease of -4% in children's top ratings concerning their beliefs in their self-efficacy for science skills.

**SQ17: Students' additional comments about learning science outdoors**

For SQ17 students were asked if they would like to say anything else about learning science outdoors. Before the SOTC-DP, 39% of the children who responded to the students' questionnaires (n=19/49) took responded to SQ17, whereas afterwards, 60% of children who responded to the questionnaire commented for SQ17 (n= 28/47) of teachers. Students' comments in response to SQ17 are displayed in SQ\_Figure 14. They were qualitative and provide testimonials from the children about the SOTC-DP.

## ***(ii) Summary: Students' questionnaire data concerning transversal skills***

This sub-section summarises students' questionnaire data concerning their transversal skills over the period the SotC-DP took place and compares key data.

### **SQ7: Students' responses: comments about their transversal skills**

For SQ7, students responded to statements regarding their own TS, according to a 3-point Likert scale (SQ\_Figure 16). SQ7 data gathered before and after the SotC-DP were then compared (SQ\_Figure 17). Overall, after the SotC-DP, 2% fewer students (-2%) agreed with positive statements about their own TS.

### **SQ8: Students' preferred locations for learning: indoors, outdoors or both**

In their responses to SQ8, students stated where they preferred to learn: indoors, outdoors or indoors *and* outdoors (Figure 19). Before the SotC-DP, 38% more students said they preferred to learn outdoors than those who said they preferred to learn indoors, whereas after the SotC-DP, 52% more students said they preferred to learn outdoors than those who said they preferred to learn indoors. Overall, therefore, following the project, although there was no change in children's stated preference for learning indoors, 14% more children said they prefer to learn outdoors than those who said they prefer to learn indoors.

### **SQ9: Students' identified locations for learning well: indoors, outdoors or both**

SQ9 asked students to say where they believed they were good at learning: indoors, outdoors or indoors *and* outdoors (SQ\_Figure 20). Before the SotC-DP, 27% more children said they were good at learning outdoors than those who said they were good at learning indoors. Afterwards, 13% more children said they were good at learning outdoors than those who said they were good at learning indoors. Therefore, after the project, 14% fewer children thought they were good at learning outdoors than those who said they were good at learning indoors. This finding is out of line with most of the other study findings which indicate that children learned better outdoors than indoors by the end of the SotC-DP. One reason may be that children enjoyed being outdoors more than indoors (SQ8), so did not equate being outdoors with learning.

### **SQ10: Students' beliefs about their TS acquisition when learning indoors**

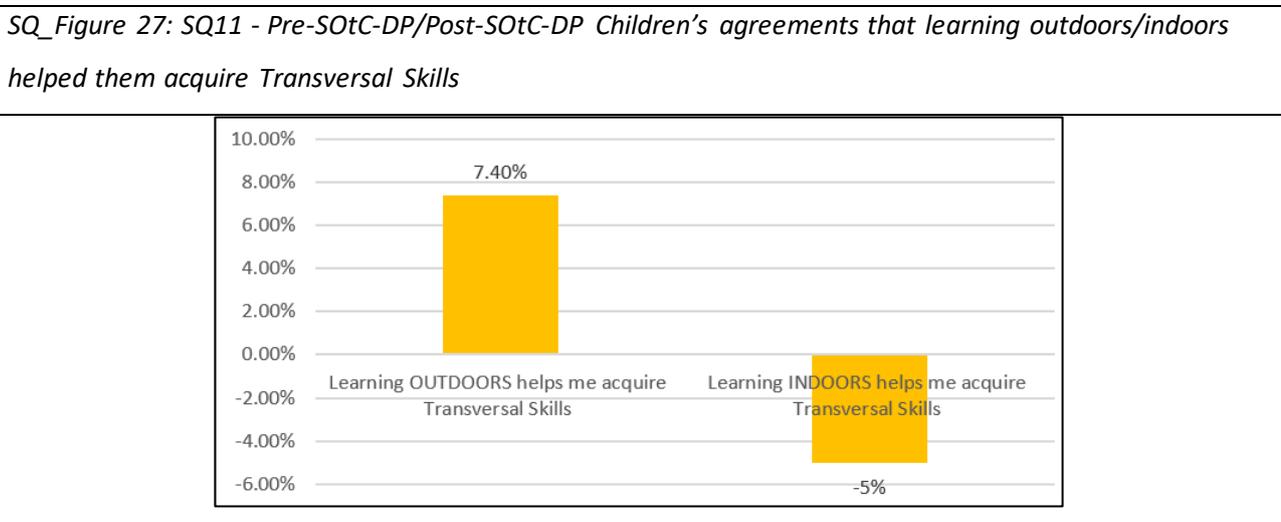
For SQ10, teachers asked children to share their beliefs about their own transversal skills acquisition when learning indoors by selecting a Likert scale option for each statement provided (SQ\_Figure 21). When responding to SQ10 before the SotC-DP, 79% more children agreed than disagreed that learning *indoors* helped them to acquire TS (SQ\_Figures 22, 23), whereas after the SotC-DP, 75% more children agreed than disagreed that learning *indoors* helped them to acquire TS. Having experienced the SotC-DP, overall 4% fewer children (-

4%) thought learning indoors helped them to acquire TS (SQ\_Figures 22, 23). Overall, by the end of the SOTC-DP, 5% fewer children (-5%) agreed that learning indoors helped them to acquire TS (SQ\_Figure 27).

**SQ11: Students’ beliefs about their TS acquisition when learning outdoors**

SQ11 invited children to share their beliefs about their own TS acquisition when learning outdoors by selecting a Likert scale option for each statement provided (SQ\_Figure 24). When responding to SQ11 before the SOTC-DP, 92% more children agreed than disagreed that learning outdoors helped them to acquire TS, whereas after the SOTC-DP, 97% more children agreed than disagreed that learning outdoors helped them to acquire TS (Figs 25, 26). Overall, by the end of the SOTC-DP, 7.4% more children agreed that learning outdoors helped them to acquire TS (SQ\_Figure 26).

Comparing children’s responses for indoors with their responses for outdoors, 12.4% more children agreed that learning outdoors (7.4%) enhanced their TS acquisition than those who agreed that learning indoors (-5%) enhanced their TS acquisition (SQ\_Figures 27).



**#6: RESEARCH REPORT: Student Post-Box Quick Questionnaire**

**Summary: RI 6ii. Students’ Post-Test Quick Questionnaire**

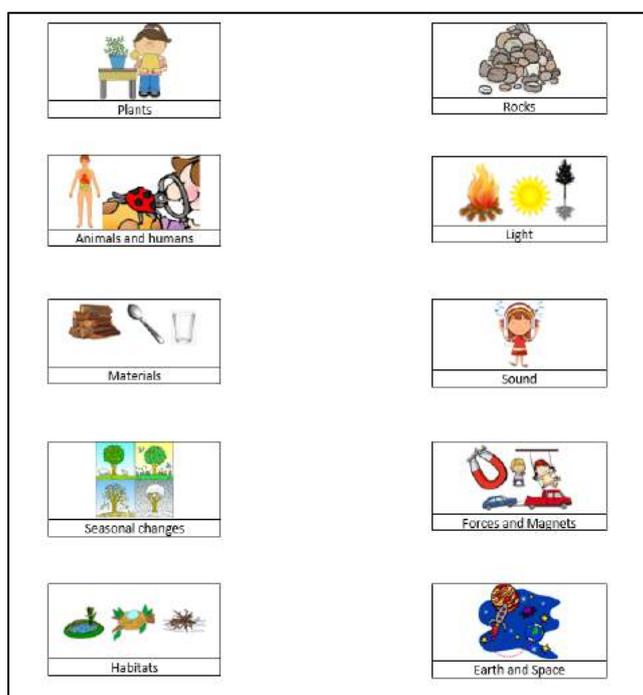
The purpose of the Students’ Post-Test Quick Questionnaire (RI 6ii) was to offer all students who had experienced the Science Outside the Classroom Development Programme (SOTC-DP) an opportunity to state their self-efficacy regarding their knowledge of each of the ten science topics taught outdoors during SOTC-DP:

- 1/ Plants
- 2/ Animals
- 3/ Materials

- 4/ Seasonal changes
- 5/ Habitats
- 6/ Rocks
- 7/ Light
- 8/ Sound
- 9/ Forces
- 10/ Earth and Space

After they had experienced the science topics outdoors during SOTC-DP, students aged 3-11 years were invited to indicate their level of knowledge about each science topic: they responded 'Yes', 'Not sure', or 'No' to their teacher's question 'Now do you know about (science topic)?' by placing science topic cards picturing each topic (QQ\_Fig 2) into one of three boxes (QQ\_Fig 1).

QQ\_Fig 2: Children's Science Topic Cards



QQ\_Fig 1. Three Boxes

3 Yes	2 Not sure	1 No

Teachers tallied the cards, recorded the findings and uploaded the findings to the research project secure data storage site. For children in countries where English is not the home language, all

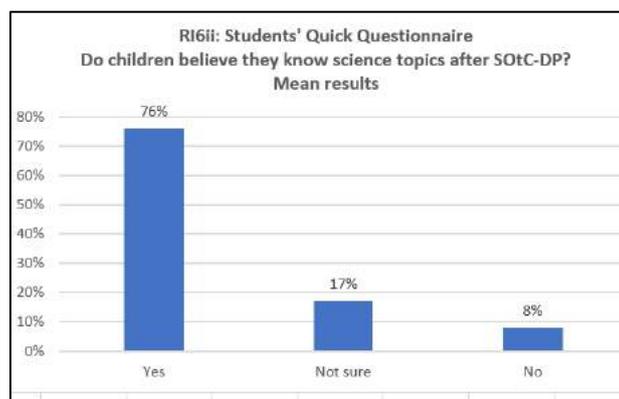
materials were translated into the children’s home languages for data collection and data were translated into English for analysis. The findings were then collated and analysed.

Overall, the data collected for R16ii indicated that after experiencing each science topic during SOTC-DP, children’s self-efficacy was high regarding their knowledge of science topics. Just over three-quarters of children believed they knew about them (76%), just over one sixth said they were not sure (17%) and fewer than one tenth said they did not know (8%) (QQ\_Table 2; QQ Fig. 4).

QQ\_Table 2: Children’s self-efficacy: their knowledge about science topics after SOTC-DP (mean)

Do children believe they know about Science Topics after SOTC-DP?	Yes	Not sure	No
	76%	17%	8%

QQ\_Figure 4: Children’s self-efficacy: their knowledge about science topics after SOTC-DP (mean)



## #7: SUMMARY: Student Photovoice

By eliciting children’s selected images and words, SOTC R17i – Adapted PhotoVoice – teachers captured data around children’s beliefs regarding the scientific enquiry skills and transversal skills they practised during the Science Outside the Classroom Development Programme (SOTC-DP).

Teachers asked children specified questions (PV\_Fig.1) concerning transversal skills and science enquiry skills set out on checklists (PV\_Figures 2 and 3). They uploaded the children’s responses to a secure site.

PV\_Fig 1. Adapted PhotoVoice Schedule

Child's pseudonym:  
 Child's setting:  
 Child's age:  
 Science topic:  
 Child's selected photograph:

1. Which photo reminds you most of learning about ....(insert Science Topic)...
2. Why did you choose this photo?
3. Tell me about what you did
4. What did you learn?
5. What science skills did you learn?
6. What helped you to learn?
7. What else would you like to tell me about what you learned?

PV\_Fig 2. SOTC Transversal Skills Checklist

Science Outside the Classroom - Transversal Skills -	
Wellbeing	Health and wellbeing
	Behaviour
	Confidence
	Enjoyment of learning
Motivation	Engagement with learning
	Attainment
	Resilience
	Determination
	Involvement
	Engagement with nature
Creativity	Creative
	Inventive
	Enterprising
	Imagination
	Inventiveness
	Resourcefulness
Social skills	Communication
	Team work
	Independence
Critical thinking	Reasoning
	Problem solving (generic)
	Answering questions
	Asking questions
	Understanding nature

PV\_Fig 3. SOTC Science Enquiry Skills Checklist

Science Outside the Classroom - Science Enquiry Skills	
Planning an enquiry	Recording
Enquiry	Comparing
Problem solving	Grouping or classifying
Speculating	Asking appropriate questions
Justifying	Answering questions using data
Predicting	Presenting data
Setting up a fair test	Concluding findings
Carrying out a simple test	Communicating findings
Observing	Evaluating
Measuring	

## Introduction to Photovoice Findings (RI 7)

Data were gathered for all ten science topics. There was 90% engagement across all settings and 65% of responses were received from the cohort of 50 case study children (PV\_Figure 4). For each of the ten science topics covered in SOTc, data from the five settings were collated separately in tables and 45 out of a possible 50 tables were completed (Figure 4).

PV\_Fig 4. SOTc Adapted PhotoVoice: Numbers of children's responses across science topics

SCIENCE TOPIC		Settings engaging n= /5	Children's responses: n= /50 (case study children)	Age range of children responding
1	PLANTS	5	37	4-11 yrs
2	ANIMALS	5	36	4-11 yrs
3	MATERIALS	4	35	5-11 yrs
4	SEASONAL CHANGES	3	11	4-8 yrs
5	HABITATS	5	34	4-11 yrs
6	ROCKS	4	36	5-11 yrs
7	LIGHT	5	37	4-11 yrs
8	SOUND	5	37	4-11 yrs
9	FORCES & MAGNETS	5	36	4-11 yrs
10	EARTH & SPACE	4	28	4-11 yrs
		45/50	327/500	
		90% engagement across all topics	65% responded	

Data that had been collated in the 45 tables were analysed to extract both explicit and implicit references to the science enquiry skills and transversal skills that children indicated they practised while engaging in the SOTc-DP.

Purely by responding to PhotoVoice questions, children 'communicated findings' (a science enquiry skill) and demonstrated they were 'answering questions', an element within critical thinking: a transversal skill. As such, incidences of these skills are high in comparison with others in the data so they are excluded from discussion regarding each data set.

## Summary of SOTc PhotoVoice Results: All Science Enquiry Skills

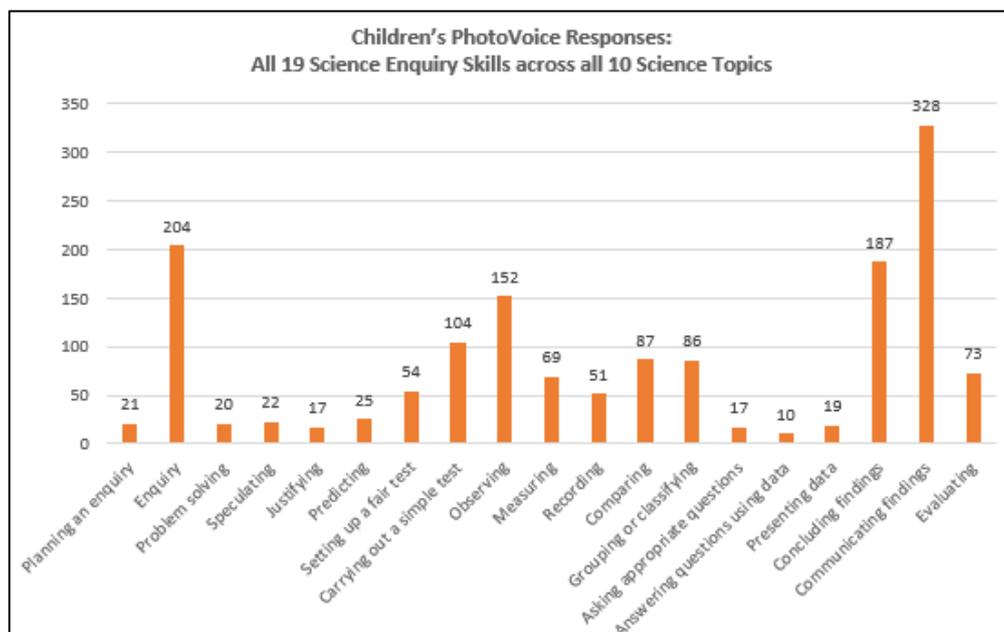
PV\_Table 1 and PV\_Figure 6 show the results from all the children's responses in respect of 19 science enquiry skills across all ten science enquiry topics that were the focus on SOTc-DP.

PV\_Table 1: Children's PhotoVoice Responses: All 19 Science Skills across all 10 Science Topics

SCIENCE TOPICS >	PLANTS	ANIMALS	MATERIALS	SEASONS	HABITATS	ROCKS	LIGHT	SOUND	FORCES	EARTH + SPACE	ALL TOPICS
<b>SCIENCE ENQUIRY SKILLS:</b>											
<b>Planning an enquiry</b>	1	0	0	1	11	0	1	0	3	4	21

Enquiry	29	20	20	6	26	23	24	18	18	20	204
Problem solving	2	1	6	0	1	5	2	0	1	2	20
Speculating	1	3	3	2	0	3	5	2	2	1	22
Justifying	1	3	0	0	1	1	4	3	2	2	17
Predicting	2	2	3	0	2	4	4	4	2	2	25
Setting up a fair test	2	3	6	1	3	15	8	7	8	1	54
Carrying out a simple test	9	11	13	4	3	13	9	7	23	12	104
Observing	18	14	17	5	22	19	22	12	10	13	152
Measuring	5	8	3	1	11	3	6	9	11	12	69
Recording	4	0	8	7	7	4	9	3	5	4	51
Comparing	4	10	17	1	6	12	9	10	5	13	87
Grouping or classifying	5	4	20	0	18	27	12	0	0	0	86
Asking appropriate questions	3	4	3	0	0	2	1	0	2	2	17
Answering questions using data	0	1	1	0	0	3	1	2	2	0	10
Presenting data	1	2	1	1	3	4	2	1	3	1	19
Concluding findings	38	19	26	12	4	6	17	13	34	18	187
Communicating findings	37	36	35	11	34	36	37	37	37	28	328
Evaluating	2	2	1	0	0	23	22	18	5	0	73

PV\_Figure 6: Children's PhotoVoice Responses: All 19 Science Skills across all 10 Science Topics



Aside from 'communicating findings' (see above), enquiry (204 incidences), 'concluding findings' (187 incidences) and 'observing' (152 incidences) were the science enquiry skills children indicated they practised most often during the SOTC-DP. Conversely, they said they practised 'answering questions using data' (10 incidences), 'justifying' and 'asking appropriate questions' (both 17 incidences) least often during the project.

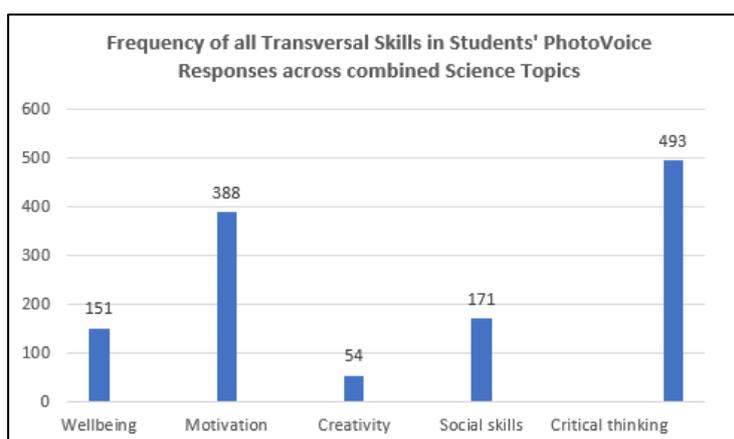
## Summary of SOTC PhotoVoice Findings: Transversal Skills

PV\_Fig 2 shows the transversal skills and their sub-skills identified for SOTC. PV\_Table 3 and PV\_Figures 17 and 18 show the results from all the children's responses in respect of 5 Transversal skills across all ten science enquiry topics that were the focus on SOTC-DP.

*PV\_Table 3: PhotoVoice: Frequency of children's Transversal Skills presentations across SOTC science enquiry topics*

	1. PLANTS	2. ANIMALS	3. MATERIALS	4. SEASONS	5. HABITATS	6. ROCKS	7. LIGHT	8. SOUND	9. FORCES	10. EARTH + SPACE	TOTAL
<b>Wellbeing</b>	13	31	13	4	13	18	14	20	16	9	<b>151</b>
<b>Motivation</b>	79	49	28	29	23	38	54	23	24	41	<b>388</b>
<b>Creativity</b>	3	5	6	1	1	8	6	12	2	10	<b>54</b>
<b>Social skills</b>	11	24	17	6	15	12	35	22	19	10	<b>171</b>
<b>Critical thinking</b>	68	63	41	21	43	59	65	40	39	54	<b>493</b>

*PV\_Figure 18: Frequency of all Transversal skills in Students' PhotoVoice responses across combined Science Topics*



Data displayed in PV\_Table 3 and PV\_Figures 17 and 18 indicate that children engaged most in critical thinking skills and least in creativity while working on science topics outdoors.

## Summary: #8 Documentary Evidence - Review of SOTC-DP Intellectual Outputs

The development of the *Science Outside the Classroom Teaching Manual*, *Science Pictionary* game, *SOTC Photo Book* and additional SOTC teaching activities were a major feature of the SOTC-DP (SOTC, 2021c). These intellectual outputs (IOs) feature curriculum content and pedagogical strategies that are intended to support teachers to help children aged 3-11 years to develop science enquiry skills and transversal skills outdoors.

The SOTC Intellectual Outputs were reviewed using MacNaughton and Williams' (2009:xii) framework of 'teaching techniques to support children's learning' (p.xii) – or pedagogical strategies, transversal skills and fundamental science skills DE\_Table 1; DE\_Table 2).

DE\_Table 1: Teaching techniques to support children's learning' (MacNaughton and Williams, 2009)

Demonstrating	Questioning	Deconstructing
Describing	Reading	Democratising
Encouraging, praising, helping	Recalling	Documenting
Facilitating	Singing	Empowering
Feedback	Suggesting	Philosophising
Grouping	Telling and instructing	Problem-solving
Listening	Co-constructing	Reinforcing
Modeling	Community building	Scaffolding
Positioning people	Decolonising	Task analysis

DE\_Table 2: Key for science enquiry skills and transversal skills

KEY		
Transversal Skills		Fundamental Science Skills
Well-Being	WB	Planning an enquiry
Motivation	M	Enquiry
Creativity	Cr	Problem solving
Social Skills	SS	Speculating
Critical Thinking	CT	Justifying
		Predicting
		Setting up a fair test
		Carrying out a simple test
		Observing
		Measuring
		Recording
		Comparing
		Grouping or classifying
		Asking appropriate questions
		Answering questions using data
		Presenting data
		Concluding findings
		Communicating findings
		Evaluating

The first review identified evidence of pedagogical strategies in the IOs. The second review identified pedagogical strategies in the IOs that afforded children opportunities to practise and so develop science

enquiry skills and transversal skills (DE\_Table 2; DE\_Table 3). The review process revealed that the SOTC-DP featured pedagogical strategies (MacNaughton and Williams, 2009; Pascal and Bertram, 1997; SOTC, 2021b) which enabled SOTC teachers to support children aged 3-11 years to develop science enquiry skills and transversal skills outdoors. The content of the SOTC-DP, including the pedagogic strategies listed in DE\_Table 3, has been transferred to the IOs. The IOs are available in the public domain, so SOTC-DP pedagogical strategies have potential to enable teachers with access to the internet to support children aged 3-11 years to develop science enquiry skills and transversal skills outdoors.

## #9: Summary Conclusion

This 'Summary Conclusion' is a brief version of the full Conclusion.

The aim of the SOTC research study was to investigate if and how an outdoor science programme may support the development of children's scientific enquiry skills and transversal skills in five European educational settings.

Four objectives acted as stepping stones to achieving the study aim. They were to identify:

- OBJ.1: Scientific enquiry skills children aged 3-11 years may develop outdoors
- OBJ.2: Transversal skills children aged 3-11 years may develop through scientific enquiry outdoors
- OBJ.3: Features of the physical environment that may enable children aged 3-11 years to develop scientific enquiry skills and transversal skills outdoors
- OBJ.4: Pedagogical strategies that may enable teachers to support children aged 3-11 years to develop scientific enquiry skills and transversal skills outdoors.

To produce the study findings, germane data were co-constructed by academics and Teacher-Researchers working with children aged 3-11 years, using eight research methods some administered before the SOTC-DP programme began and some afterwards, affording comparative data. The rich data gathered throughout the study affords evidence that the four study objectives were achieved. The four objectives were designed as stepping stones to achieving the study aim so the aim of the SOTC research study - to investigate if and how an outdoor science programme may support the development of children's scientific enquiry skills and transversal skills in five European educational settings – has been achieved. Findings provide robust evidence from a range of sources that children aged 3-11 years in four European countries developed scientific enquiry skills and transversal skills through their engagements in the Science Outside the Classroom Development Programme. Moreover, any teacher with access to the internet can now use the SOTC intellectual Outputs as the basis for supporting the development of their own students' scientific enquiry skills and transversal skills through an outdoor science programme in their setting.