Ark of Inquiry: Inquiry Activities for Youth over Europe

Deliverable D6.3

General Report of Large-Scale Implementation

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2	ELLINOGERMANIKI AGOGI SCHOLI PANAGEA SAVVA AE	EA	Greece
3	TURUN YLIOPISTO	UTU	Finland
4	UNIVERSITY OF CYPRUS	UCY	Cyprus
5	UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION (UNESCO) REGIONAL BUREAU FOR SCIENCE AND CULTURE IN EUROPE, VENICE	UNESCO	Italy
6	STICHTING HOGESCHOOL VAN ARNHEM ENNIJMEGEN HAN	HAN	The Netherlands
7	BUNDESMINISTERIUM FÜR BILDUNG	BMB	Austria
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Summary

The Ark of Inquiry project focuses on two closely related concepts: Responsible Research and Innovation (RRI) and Inquiry-Based Science Education (IBSE). Ark of Inquiry aims at raising youth awareness of RRI and, at the same time, building a scientifically literate and responsible society through IBSE practices. In other words, the project's ambition is to translate and demonstrate the abstract term "RRI" into everyday real-life inquiry activities and put it into practice in formal and informal learning environments.

The implementation of the Ark of Inquiry project in school practice took place in 2 phases with the aim to overlap with 3 consecutive school years. The piloting phase lasted six months, starting in September 2015 and lasting until February 2016. During this period, 85 in-service science teachers – 23 in primary education and 62 in secondary education – along with 80 pre-service teachers or science students participated from 7 countries. The large-scale implementation phase began in March 2016 and lasted for 24 months (until February 2018). During this phase a great number of teachers and schools from the 12 countries of the consortium and from 29 additional countries participated in Ark of Inquiry activities. In the first 12 months of the large-scale implementation, 685 in-service science teachers, 6412 pupils and 279 stakeholders (teacher trainers, scientists, headmasters, school counsellors, ministry advisors, pre-service teachers, science museum professionals, etc.) participated in the events implemented by the consortium as has been reported in D6.2. The last large-scale implementation phase of the project extends from March 2017 to February 2018.

This report is an update of Deliverable D6.2 and documents the implementation activities of Ark of Inquiry undertaken at the local, national and international level throughout the second implementation phase of the project, which took place from 1 March 2017 to 28 February 2018. This deliverable is best read in conjunction with its Appendix 1, which lists all implementation activities per country. In this report we describe the general framework of implementation and afterwards focus on the last year of the large-scale implementation phase. The main implementation activities are reported per country. This document additionally contains information about the use of the award system in the 12 partner countries. The Ark of Inquiry project has produced a system as described in D1.6 (*Instruments for Evaluating Inquiry Experiences, Skills and Societal Responsibility*) and D1.7 (*Specification of Support Systems in Ark of Inquiry*) that gives the opportunity to teachers that want to use them for motivating pupils to improve their inquiry skills and receive awards for their involvement. These awards have been used in some of the partner countries, while other countries have chosen not to implement them. More details are given later on in this document. At the end of this deliverable a short overview of the whole implementation of the Ark of inquiry activities (piloting, first large-scale implementation phase, second large-scale implementation phase) is given.

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1. General introduction

The Ark of Inquiry project centres around two closely related concepts: Responsible Research and Innovation (RRI) and Inquiry-Based Science Education (IBSE). Ark of Inquiry aims at raising youth awareness of RRI and, at the same time, building a scientifically literate and responsible society through IBSE practices.

According to the Science with and for Society action of the European Union's Seventh Framework Programme, Responsible Research and Innovation (RRI) is an approach to research and innovation which helps societal actors and innovators to work together during the research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of European society. In practice, this approach involves a) ensuring gender equality, b) taking the ethical implications of research into account, c) promoting science education, d) engaging society more broadly in the research process and e) increasing access to scientific results. (The EU's official articles and policy documents on Science with and for Society and Responsible Research and Innovation can be found at http://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society).

To achieve this aim, the Ark of Inquiry project sets the following clear objectives:

- Developing a pedagogical framework for identifying inquiry activities that promote pupils' awareness of RRI.
- Collecting RRI-related inquiry activities and environments.
- Building a large supportive community including research institutions, science centres and museums.
- Training primary and secondary school teachers.
- Developing the Ark of Inquiry platform integrated with the evaluation and award system.
- Making the inquiry activities available across Europe through the Ark of Inquiry platform.
- Disseminating the approach in schools, universities, science centres and museums and society in general.

In this context the Ark of Inquiry project aims to not only build a scientifically literate and responsible society through Inquiry-Based Science Education but also raise young people's awareness of Responsible Research and Innovation by providing them with a collection of engaging inquiry activities in the STEM domain (science, technology, engineering and mathematics). In other words, the project's ambition is to translate and demonstrate the abstract term "RRI" into everyday real-life inquiry activities and put it into practice in formal and informal learning environments.

Within this scope the main goal of the project is to implement the aforementioned initiative and approach on a large scale in Europe, namely, at about 1000 schools involving at least 20 000 pupils and 1000 teachers from 12 countries (Estonia, Greece, Finland, Cyprus, Italy, the

Netherlands, Austria, Germany, France, Belgium, Turkey, Hungary), in two phases – the piloting and the large-scale implementation phase.

This report documents the implementation activities of Ark of Inquiry undertaken at the local, national and international level throughout the implementation period of the project (second phase) that took place from 1 March 2017 to 30 November 2018 and the use of the award system in the partner countries. It is best read in conjunction with the accompanying Appendix 1 that lists all implementation activities per country as reported by each partner.

2. Objectives

The aim of Work Package 6 of the Ark of Inquiry is to implement the pedagogical approach and the related inquiry activities developed in Work Package 1 on a large scale in schools in Europe. The project was implemented in two phases, the piloting phase, with a duration of 6 months, and the large-scale implementation phase, which lasted 24 months. The goal was to recruit at least 20 000 pupils and 1000 teachers from 12 countries, or equivalently, a total of 1000 schools from the participating countries. This was a very challenging task, which was indeed realized, as all partners followed their national plans as they were defined already at the beginning of the project and further on adapted according to each country's needs. These implementation plans were developed for each participating country and were included in D6.1 in the form of reports that a) described the methodology of organizing implementation activities and involving schools, b) defined the key partners responsible for the management of the implementation in each country, and c) described the reporting procedure per implementation phase.

In the first and second year of the large-scale implementation these objectives or procedures were followed according to the initial plan. Adjustments were made by the partners (e.g., exploring new channels for approaching schools) when relevant that reflected on the experience gained as the project advanced and helped the project implementation excel.

3. Implementation activities

In general, an implementation activity intends to bring into the classroom practice the pedagogical and methodological approach of the Ark of Inquiry project and related resources in an innovative, user friendly and engaging way so that both teachers and pupils have a stimulating experience in STEM education. A series of support activities (such as introductory presentation seminars and training workshops) were organized for teachers in order for them to become familiarized with the relevant platform and support materials, gain confidence and adopt it in their everyday school practice.

All in-school activities with pupils and preparation or support actions, such as training for teachers, both hereinafter referred to as implementation activities, events or actions, have been centrally coordinated by the Work Package 6 Leader and the Work Package 4 Leader with respect to training, but also managed locally by one partner in each country who acted as the National Coordinator and was responsible for the local management and localization of the project resources and activities. These roles and duties of the National Coordinators were reported in D6.1 in a section dedicated to describing their responsibilities and tasks.

Below we present the list of National Coordinators. It contains the acronym of the institutions that will resume the role and the name of the person in charge.

Table 1. The National Coordinators of the Ark of Inquiry project

Country	National Coordinator	Name
Estonia	UT	Meelis Brikker
Greece	EA	Aliki Giannakopoulou
Finland	UTU	Tomi Jaakkola
Cyprus	UCY	Marios Papaevripidou
Italy	UNESCO	Lauren Bohatka
Netherlands	HAN	Annelies Dickhout
Austria	BMB	Monika Moises
Germany	UBER	Amany Annaggar
Turkey	BEKAS	Bulent Cavas
France	EADN	Christian Siatka
Belgium	KHLim	Erica Andreotti
Hungary	HRTA	Szilvia Toth

4. Distribution of teachers and schools per country

The implementation of the Ark of Inquiry project took place in 2 phases with the aim to overlap with 3 consecutive school years. In the first phase with a duration of six months, the piloting, 35 schools or about 100 teachers were recruited from 7 participating countries. In the large-scale implementation phase with a duration of 24 months, a large number of teachers and schools from all 12 countries and beyond were included in the network. The original distribution of the total number of 1000 teachers and corresponding schools can be seen in the following tables. The distribution shown in the tables below was presented, discussed and agreed during the project kick-off meeting and the first consortium meeting.

Table 2. Distribution of the indicative number of teachers to be reached across the participating countries during the lifetime of the project

Countries	**Number of teachers**
Greece, Italy, Germany, Turkey, France	100 * 5
Estonia, Finland, The Netherlands, Hungary	80 * 4
Cyprus, Austria, Belgium	60 * 3
Total	**1000**

Additionally to the above, about 100 science and teacher education students were agreed to be engaged to participate in the Ark of Inquiry.

Table 3. Distribution of the indicative number of schools to be reached out across the participating countries during the two main implementation phases

Country	**Pilot implementation phase (6 months)**	**Large-scale implementation phase (24 months)**
Estonia	5	32
Greece	5	40
Finland	5	32
Cyprus	5	24
Italy	5	40
Netherlands	5	32
Austria	5	24
Germany	-	40
Turkey	-	40
France	-	40
Belgium	-	24
Hungary	-	32
Total	**35**	**400**

5. Reporting of implementation activities

An integral part of the implementation plan is the reporting actions and procedures that should accompany the piloting and the large-scale implementation phases across the 12 countries. Proper and up-to-date reporting is vital to monitor the project's implementation development, to have a smooth bookkeeping of activities per country, to determine overall progress and identify countries or regions where this may not be at a satisfactory level, and to ensure the implementation quality. The reports form the basis of the project's official deliverables, to be submitted at the end of each implementation phase, as is the case with deliverables D6.1 (end of February 2016, submitted in M24), D6.2 (end of February 2017, submitted in M36), and the current D6.3 (end of February 2018, to be submitted in M48).

According to the plan, for each implementation event or series of activities the partner or partners involved were expected to produce a report. Reports were sent to the Work Package Leader (EA) and were uploaded to a repository/common workspace of the project. The reports documented basic information about the activity such as date/period held, location, number of participants, target group and type of activity along with a brief and comprehensive description of the implementation activities and learning outcomes reached or expected. Also, any materials in printed or electronic format that were related to the implementation reporting have been used in this report (e.g., drawings, photos, presentation slides, etc.). As indicated in Appendix 1 (columns L, M, N), many materials are available per activity either online or as files that document the activity and are available upon request.

The implementation activity reports compose a key part of the overall public image of the project. Material included in them has been used in dissemination actions and documents. Furthermore, the information contained in the Month 36 reports was assessed and integrated in the validation and evaluation work.

6. Large-scale implementation phase (M37–M48)

The large-scale implementation phase lasted overall 24 months and involved all partners from 12 countries and 45 countries more. Following the reporting of the first phase of the large-scale implementation (March 2016 to February 2017), this report contains information about the remaining period. The overall goal of the project as stated in the project plan was to engage in Ark of Inquiry 20 000 pupils and 1100 teachers or about 400 schools in total. Each partner, following last year's guidelines, was requested to reach a number of schools in their country and engage as many teachers as possible in order to approach the aforementioned indicators.

During this period a series of implementation activities were performed in all 12 countries and beyond. Each partner kept record of their activities and reported specific details per activity in a Google spreadsheet (Appendix 1) file. In the Appendix all implementation activities are organized per country (different sheet) and include details regarding not only the number of schools, teachers and pupils involved but also the type of activity, the connection to the Ark of Inquiry platform, useful links, the person from the Ark of Inquiry consortium monitoring/reporting the activity, etc. Within the Appendix one can see all areas where the information of each activity is distributed. A part of Appendix columns of this file that provide information about the activity itself in depicted below.

Table 4. Partial representation of the Appendix columns to be filled in by National Coordinators as part of their monitoring/reporting of each implementation activity

Date	Location (city, area)	Participating school name(s)	# of teachers	# of pupils	# of other participants	Inquiry activity	Activity link(s) available on the Ark of Inquiry platform

The activities implemented by partners covered a wide range of experiments available in the Ark of Inquiry platform. These include numerous activities in various thematic areas as described in more detail in the WP2 deliverables.

Overall, the last period of the large-scale implementation phase was successfully completed by the project partners across the participating countries and reached a total of 1060 schools, 2479 teachers, 36 710 pupils and 363 stakeholders.

Table 5. Detailed presentation of the number of schools, teachers, pupils and educational authorities/researchers that participated in the final period of the large-scale implementation (M37–M48)

Country	Partner	School	Teachers	Pupils	Other
Austria	BMB	137	151	1143	31
Belgium	UCLL	7	12	210	20

Cyprus	UCY	31	150	908	46
Estonia	UT/ AHHAA	40	100	15	44
Finland	UTU	5	18	305	25
France	EADN	26	63	1072	36
Germany	UBER	32	40	800	3
Greece	EA	235	383	5063	63
Hungary	HRTA	51	106	8655	0
Italy	UNESCO	18	24	1190	33
Netherlands	HAN	55	127	4924	9
Turkey	BEKAS	9	101	2020	36
29 other countries		414	1204	10405	17
	Total	**1060**	**2479**	**36 710**	**363**

The distribution of the number of participants per country (extracted from the detailed Excel file in Appendix 1) is shown in the table above. The column "Other" represents educational authorities such as school counsellors, teacher trainers, ministry advisors, scientists, university staff, science museum representatives, etc. A detailed list of their professional identity is provided in column H of the Appendix that accompanies this report.

Overall, the number of schools, teachers and pupils that were involved in implementation activities during this phase indicates that the project achieved and overpassed the original goals in terms of numbers and geographical spread.

Detailed reports with the implementation activities performed per partner country are given in the following section.

6.1. Estonia

Country summary

As stated in the implementation plan, inquiry learning is a cross-curricular topic of the Estonian national curriculum, and Estonian teachers are aware of IBSE and apply it in their practice to some extent; however they encounter certain difficulties due to curriculum and time constraints. At the end of the implementation phase, it can be identified as the most restraining obstacle – looking back, Estonian teachers were willing and able to implement inquiry activities at most one or only a few times per school year within the context of Ark of Inquiry in a way that would not interfere with their previously planned teaching activities and restraints of the curriculum.

For the above reasons both UT and AHHAA implemented educational activities that required little preparation by the teachers and had the option to be conducted online. Teachers were interested in creating more ILS-s based on existing inquiry activities and modifying previous activities, so lessons on how to use the Graasp environment were also included in the local teacher trainings. These activities proved to be quite popular in the implementation.

Figures from Estonia

The overall number of teachers taking part in these implementation activities from February 2017 to November 2017 was 100 and the number of pupils was 15. Implementation activities also involved 44 other participants, mostly staff members of science centres and museums, pre-service teachers or school headmasters, but in the case of the event held on 22 March in Reykjavik, Iceland, researchers from the University of Iceland, Daugavpils University and Šiauliai University were also involved in implementing activities from the Ark of Inquiry platform under the guidance of project partners from AHHAA.

Total number of schools implementing activities	40 schools
Total number of teachers who participated in the implementation phase	100 teachers
Total number of pupils who participated in the implementation phase	15 pupils
Total number of other stakeholders involved in the implementation	44 researchers, pre-service teachers, science centres and museum professionals, entrepreneurs

Activities in Estonia

In schools teachers mostly implemented two types of inquiry activities: activities available in the Ark of inquiry platform or activities they had modified or created themselves as part of the second phase of the Ark of Inquiry teacher trainings.

Many of these inquiry activities were implemented outside of schools, in science centres and museums as well. An additional set of inquiry activities was developed by AHHAA and used on-site during workshops. Three of the most popular activities throughout the duration of the project are detailed in the table below. For each activity, a link to the activity in the Ark of Inquiry platform is presented along with a brief description of its content.

Name: Sinking and Floating (ENG)
Link: http://arkportal.ut.ee/#/inq_act/102
Example of implementation: workshop with pre-service teachers from the University of Tartu, part of the course “Digitaalsed tehnoloogiad kunstiõpetuses” focusing on the design of learning materials, 07.11.2017
The activity focuses on the phenomena of sinking and floating and the various influencing properties, such as mass, density, volume and material.
The activity is designed according to the theoretically informed principles of the Pedaste et al. (2015) inquiry cycle model. The environment offers materials and inquiry tools tailored to each inquiry phase.

Name: DNA eraldamine võrdlevate katsete abil (EST/ENG)
Link: http://arkportal.ut.ee/#/inq_act/1270
Examples of implementation: workshop at the University of Iceland, 22.03.2017; workshop at Science Centre Eureka!, 30.05.2016
The activity focuses on the extraction of DNA from different sources: from fruits, saliva, soil and sand. Where can we find DNA and why? How can we extract DNA outside of a lab? These are the questions that guide pupils through the inquiry cycle.
The activity was designed by Science Centre AHHAA based on the principles of the Pedaste et al. (2015) inquiry cycle model.

Figure 1. Project partners and different stakeholders engaged in inquiry activities at Science Centre Eureka! in Finland (30.05.2016)

Name: Katsed erinevate lahustega (EST)
Link: http://arkportal.ut.ee/#/inq_act/1283
Example of implementation: AHHAA workshop with participants from various Estonian schools along with entrepreneurs, 15.11.2017
The activity focuses on different nutrients and on how to differentiate one from another. How can we detect different nutrients in solutions? Which nutrients are present in common liquids? These are the questions that guide pupils through the inquiry cycle.
The activity was designed by Science Centre AHHAA based on the principles of the Pedaste et al. (2015) inquiry cycle model.

In addition to inquiry activities presented in the platform, additional activities based on the Graasp platform were used in schools and designed by teachers themselves throughout the implementation period. These activities are potential activities to be added to the Ark of Inquiry platform after further development. Some examples include:

- Virtual Moon Atlas (http://graasp.eu/ils/583dca124df584dad59867c0/?lang=et)
- Photosynthesis (http://graasp.eu/ils/585187e54df584dad598937e/?lang=et)
- Pine Seeds (http://graasp.eu/ils/584d227a4df584dad59888c7/?lang=et)

Figure 2. Pupils engaged in the "Pine Seeds" activity at Neeme School (12.–17.01.2017)

Sustainability actions in Estonia

A new teacher training group is expected to start implementing Ark of Inquiry activities in January 2018, which means that implementation activities will continue in Estonian schools for at least another year. Although not finalized, similar trainings are planned to continue in the following years as well. Also, the inquiry activities developed for workshops by Science Centre AHHAA will continue to be implemented on-site as they will remain the focal point of workshops with different themes for school groups to choose from.

Activities that were developed but not finalized by the teachers during the teacher trainings are planned to be developed further with the help of our teacher trainers as parts of different trainings or collaboration efforts.

As the Ark of Inquiry platform will remain open for at least 5 years after the end of the project, we believe that using different materials from the project during further in-service and pre-service training of Estonian teachers and introducing them to the platform will yield further implementation activities in Estonian schools. Some inquiry activities developed during the Ark of Inquiry project will continue to be demo activities for many teacher trainers from both AHHAA and UT and researchers from UT.

Use of the award system in Estonia

The award system was not used in Estonia. Time restraints became apparent right away – even at the beginning of the training courses the teachers felt that the training period was not long enough to obtain all the needed knowledge for implementing the award system, mostly the aspect of formative evaluation that should be implemented in the initial evaluation of inquiry activities and, as mentioned in the initial implantation plan, would have to be implemented alongside the current evaluation system in Estonia.

It was also considered too much extra work to implement the award system, as many different local and national competitions and awards exist which require their own preparation. The teachers preferred events and competitions that yielded an actual award rather than a symbolic one that Ark of Inquiry offered. In the context of Estonian schools, we are currently seeing a slight shift towards formative assessment and consider it a possible future direction. The teacher trainers feel that the award system developed within the Ark of Inquiry project could work in Estonian schools after the concept of formative assessment is more rooted in the educational system.

6.2. Austria

Country summary

As described in the previous report, the organisation set the focus on the following: a) activities that can be easily implemented in Austrian classrooms, b) very specific activities in combination with new technologies (the Raspberry Pi) and c) BMUKK presented some of their proposed implementation activities during education conferences in Austria to a large number of interested science teachers and education stakeholders.

Figures from Austria

In Austria BMUKK organized 7 implementation activities, reaching more than 150 teachers, more than 1000 pupils, and more than 30 other participants (mainly teacher trainers and education stakeholders).

Total number of schools implementing activities	137 schools
Total number of teachers who participated in the implementation phase	151 teachers
Total number of pupils who participated in the implementation phase	1143 pupils
Total number of other stakeholders involved in the implementation	31 mainly teacher trainers and education stakeholders

Activities in Austria

BMB implemented mainly activities designed by them or by their community, which were uploaded to the Ark of Inquiry platform. See the indicative list of activities below.

RRI-Activity with PlayDecide (Digital lives)
http://arkportal.ut.ee/#/inq_act/773
April – May 2017
PlayDecide is a discussion game which enables a discourse on controversial science topics. Pupils learn about relevant facts and aspects worth knowing, and they practice opinion making, how to form arguments and how to critically reflect on new technologies.

Figure 3. Pupils in Austria playing the PLAYDECIDE game

Below there is a list of activities all performed with the use of Raspberry Pi. These activities were developed in collaboration with teachers and the SCIENTIX ambassador for Austria Hermann Morgenbesser, at “Raspberry Pi Day” at the BG/BRG Klosterneuburg (secondary school in Lower Austria, Klosterneuburg) and implemented on 27 April 2017 and at other opportunities. The Ark of Inquiry event was part of the STEM Discovery week (http://www.stemalliance.eu/stem-week-2017). During this workshop 15 pupils inquired through 15 different inquiry activities that they could do with a Raspberry Pi.

Let Light Shine Happily
http://arkportal.ut.ee/#/inq_act/1782
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. This exercise follows the activities "Let Light Become" and "Push Button". With a Raspberry Pi and a few components pupils can mix every imaginable colour of the light. With a bit more hardware, LED strips can be controlled instead of a single LED to illuminate spaces exactly as you want them. Afterwards the pupils can discuss the application possibilities of the program.

Let There Be Light
http://arkportal.ut.ee/#/inq_act/1772
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. In this tutorial, pupils learn to light a LED with a Raspberry Pi. With a little more equipment and code, any form of lighting can be controlled by a Raspberry Pi program. Afterwards the pupils can discuss the application possibilities of the program.

As Far as the Eye Can See
http://arkportal.ut.ee/#/inq_act/1783
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. Pupils build an ultrasound sensor with the Raspberry Pi and its components in this exercise. Afterwards, the pupils can talk about the possible applications of ultrasound sensors in everyday life.

Voltage Divider
http://arkportal.ut.ee/#/inq_act/1784
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. Pupils build a circuit with resistors with the Raspberry Pi.

Loeten - Ein Herz aus Zinn
http://arkportal.ut.ee/#/inq_act/1785
April – May 2017
In this experiment, pupils learn to unleash resistance on a strip board by constructing a doomsday device or a time machine.

Motors - Shoot
http://arkportal.ut.ee/#/inq_act/1786
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. In this exercise, pupils learn to make a cheap, small DC motor rotate. The engine needs an external power source (here: a 9 volt battery), because the 5 volts of the Raspberry Pi are not enough. To protect the Raspberry Pi, it needs diodes (only one way); for the sake of simplicity, the IC L293 is used here.

Potentiometer - Turn Up to 11
http://arkportal.ut.ee/#/inq_act/1787
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. The pupils experiment independently with a potentiometer and reflect on where to use it in everyday life.

Smartphone Tethering
http://arkportal.ut.ee/#/inq_act/1922
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. If the smartphone has Internet access, Internet access can be forwarded to a Raspberry Pi 3. This is called tethering. For this, a mobile hotspot must be set up on the smartphone; then its access data can be set on the Raspberry Pi.

The Invisible Hand
http://arkportal.ut.ee/#/inq_act/1924
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. This exercise follows the activity "Smartphone Tethering": http://arkportal.ut.ee/#/inq_act/1922. A smartphone as a remote control for Internet of Things devices is convenient, since it is always within reach. All you need is a server on the Raspberry Pi and a Wi-Fi connection to your smartphone. After that, a website can be accessed in the browser of the smartphone, which controls the Raspberry Pi. In this activity, the pupils learn to set up such a system and thus to switch on a LED with the smartphone. This exercise requires a smartphone with internet connection and runs directly on the Raspberry Pi with touchscreen.

Camera Non Obscura
http://arkportal.ut.ee/#/inq_act/1925
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. In this activity, pupils learn how to easily control a camera with the Raspberry Pi. The camera used in this exercise is actually a night vision camera. Photos taken with this camera are pale, as the sensor is very sensitive to infrared light. If a few infrared LEDs are added to the construction you can see it in the dark.

Are You Already Alive?
http://arkportal.ut.ee/#/inq_act/1926
April – May 2017

This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. Pupils learn to control radio-controlled sockets with a Raspberry Pi. You can make your own smart home with just a few wireless sockets. A big advantage of radio-controlled sockets is the safety: the Raspberry Pi does not have to switch to 230 Volt directly.

Sprachsteuerung - Es tut mir leid Dave, aber das kann ich nicht tun
http://arkportal.ut.ee/#/inq_act/1927
April – May 2017
This activity is performed with a Raspberry Pi, which is particularly useful for in-depth learning in the classroom. There has been a lot of progress in speech recognition in the last few years. Most modern mobile phones have such a system; one of them, Jasper, has been optimized for the Raspberry Pi. In this exercise, the pupils create their own voice command that makes a LED blink.

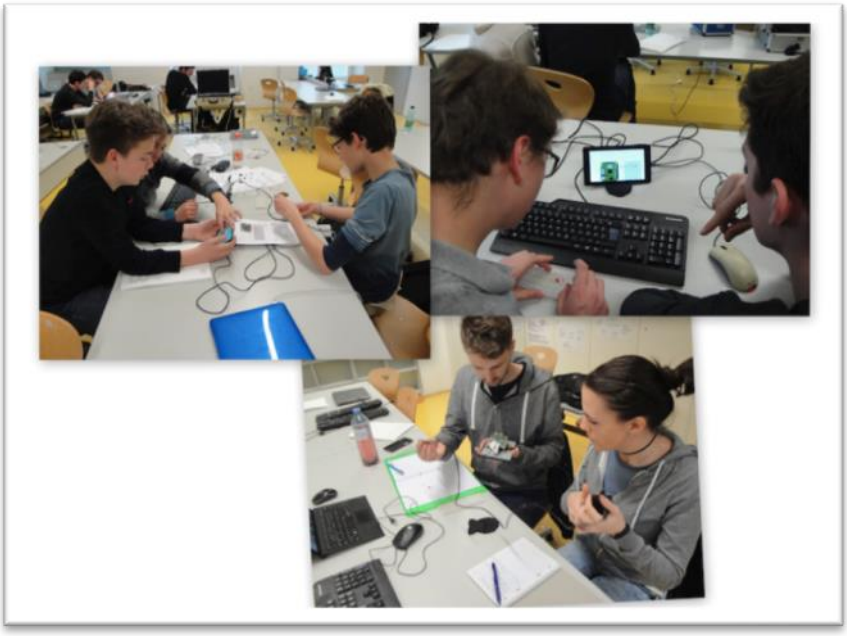

Figure 4. Pupils performing the Raspberry Pi activities

The Science of Egg Peeling
http://arkportal.ut.ee/#/inq_act/765
April – May 2017
The learning cycle "The science of egg peeling" deals with the practical topic "cooking and peeling eggs". The pupils should deal with a daily problem of a chef, namely the fact that not all eggs peel the same after cooking. The materials encourage the pupils to face the problem in "research teams". The materials for this are based on the 5-phase inquiry cycle model.

Sustainability actions in Austria

At the beginning of the project BMUKK set up their own Ark of Inquiry Moodle Platform Austria. The platform serves as a community hub and gives teachers and other interested persons free access to localized teaching materials, project documents and community activities. The platform will be online beyond the end of the project. Teachers can use and implement the activities whenever they want. A link to the Ark of Inquiry platform can be found on the national Moodle.

ARK OF INQUIRY MOODLE AUSTRIA 

All courses are freely accessible via guest access.

Teaching Materials and Activities
http://www2.lernplattform.schule.at/vis/course/view.php?id=57

Community Activities
http://www2.lernplattform.schule.at/vis/course/view.php?id=51

Programming and Experimenting with the Raspberry Pi in schools
http://www2.lernplattform.schule.at/vis/course/view.php?id=55

RRI in schools
http://www2.lernplattform.schule.at/vis/course/view.php?id=54

Use of the award system in Austria

BMB discussed the award system during the first Ark of Inquiry community meeting and during their national implementation activities. Austrian teachers agreed that they did not want to create any further differences (besides the grades) between their pupils by giving some of them an award and others not. They felt that an award system would create more inequalities among their pupils. Following these discussions it was therefore decided not to use the awards in Austria. Apart from that, teachers already need to evaluate their pupils'

performance through grading. It also turned out that it was not necessary to award pupils for doing science. Their motivation depended on the activity and how it was presented to them and not on the award. Introducing the award system would also mean additional work for teachers, who already need to plan how to conduct the time-consuming RRI and inquiry activities besides their every-day teaching obligations.

6.3. Belgium

Country summary

Similarly to the previous periods, during this last project year UCLL organized a few activities in schools, involving in the organization some of the university teacher students. UCLL also organized activities with pupils and their teachers in several research institutions/universities like UCLL, Antwerp University, Vrije Universiteit Brussel, Hasselt University and Belgian companies like Mirion Technologies (former Canberra Olen). These visits were included in the Quantum SpinOff trajectory 2016-2017 and 2017-2018, both run under the Ark of Inquiry project. All activities included in this trajectory are present in the platform and the teachers and (at least part of) the pupils are included in the online community 'Kwantumfysica – België'. This was also the most successful set of activities run in Belgium allowing also assigning inquiry awards.

Activities performed involved a total of 9 schools, with pupils and teachers as follows:
- 5 schools participating in the Quantum SpinOff trajectory 2016-2017 with the final day (presentation of work done) in May 2017 (people involved: 8 teachers, 47 pupils, 4 researchers, 3 entrepreneurs, 3 teacher educators).
- 3 schools participating in the Quantum SpinOff trajectory 2017-2018, still running: 2 out of the 3 schools participated in 2016-2017 as well (people involved 5 teachers, 42 pupils, 4–5 researchers).
- 1 school for other activities performed in the classroom; people involved: 2 teachers, 30 pupils, 4 teacher students.
- More than 100 pupils and parents on the 'Flemish Science day' (26.11.2017): pupils were accompanied by their families. In addition, 5 teacher students from UCLL were involved in the organization of the activities.

Figures from Belgium

N.B. the totals below are not just the sum of the numbers mentioned in the different activities above, as some stakeholders (teachers and researchers) were involved several times in different activities.

Total number of schools implementing activities	7 schools
Total number of teachers who participated in the implementation phase	12 teachers
Total number of pupils who participated in the implementation phase	210 pupils
Total number of other stakeholders involved in the implementation	20: 5 researchers, 3 entrepreneurs, 3 teacher educators, 9 teacher students

Activities in Belgium

In general the activities performed in schools came from the university recommendations and most of them were already present in the platform (added by UCLL in the first project period).

Quantum SpinOff - bedenk een eigen virtuele spin-off!
http://arkportal.ut.ee/#/inq_act/643
02.03.2017
Visit of one class to the company Mirion Technologies (former Canberra Olen) that produces radiation detectors, discussions with entrepreneurs. This activity was included in the Quantum SpinOff trajectory 2016-2017 and is part of the Ark of Inquiry platform activity 'Quantum SpinOff - bedenk een eigen virtuele spin-off!'. The activity involved one class of 10 pupils, 2 teachers and 2 entrepreneurs. Through this activity the pupils came in contact with the real world of companies and had the opportunity to discuss with entrepreneurs.

Figure 5. Pupils visiting Mirion Technologies – Canberra Olen, a Belgian company, in the course of the Quantum SpinOff trajectory

Een tijdslijn 'onderzoek van het onderzoek'
http://arkportal.ut.ee/#/inq_act/944
31.05.2017
Final day of the national Quantum SpinOff trajectory

This activity was included in the Quantum SpinOff trajectory 2016-2017. In total, 47 pupils and 7 teachers from 5 different schools participated: the pupils had to present their work done during the Quantum SpinOff trajectory 2016-2017 to a jury of experts composed of researchers and entrepreneurs. In total, also 4 researchers + 1 entrepreneur + 3 teacher educators were involved.

Muziek en fysica - Kleurmenging onderzoeken met een RGB-LED gestuurd met een Arduino
http://arkportal.ut.ee/#/inq_act/1739 and http://arkportal.ut.ee/#/inq_act/573
16.03.2017 and 19.05.2017
School Agnetendal in the town of Peer: - Muziek en fysica: investigation of the sources of music, explain through physics how music and sound are generated. - Kleurmenging onderzoeken met een RGB-LED gestuurd met een Arduino: investigation of RGB-LED's and learning to program with an Arduino. 4 teacher students from UCLL participated and proposed the activities in the class. A total of 30 pupils and 2 teachers from the school were involved.

Start Day of the Quantum SpinOff Trajectory 2017-2018
http://arkportal.ut.ee/#/inq_act/944, http://arkportal.ut.ee/#/inq_act/596; http://arkportal.ut.ee/#/inq_act/598; http://arkportal.ut.ee/#/inq_act/600; http://arkportal.ut.ee/#/inq_act/412
15.09.2017
During this event groups of pupils from 3 different Flemish secondary schools had the opportunity to do inquiry activities at the University of Antwerp. These activities are included in the Ark of Inquiry platform and are part of the 'Quantum SpinOff' activities. The pupils will participate in the Quantum Spinoff trajectory this school year via the Ark of Inquiry platform. This way they will work with the related activities present in the platform and, in the contest of the 'advanced' activities, they will come in contact with researchers and entrepreneurs. RRI will also be an important element in this process. Activities performed: - Quantum SpinOff - Een tijdslijn 'onderzoek van het onderzoek': an example was given. - Quantum SpinOff hands-on activities: • Discrete emission lines of chemical elements: with this inquiry activity pupils learn how to measure the emission lines of He, or of any other chemical element. • Measuring Planck's Constant with LED's: the aim of this activity is to measure Planck's constant in a very simple way and with simple material. At the same time pupils learn more about LEDs. • Diffraction of light at a hair: the aim of this activity is to measure the thickness of a hair using light diffraction. • Electron diffraction at carbon crystal: this activity allows pupils to compare the predicted wavelength of the electron – following from de Broglie's hypothesis – with the experimental value measured from the electron diffraction pattern.

Figure 6. Pupils in Belgium during the Quantom SpinOff trajectory event

Quantum SpinOff - Een tijdslijn 'onderzoek van het onderzoek' and bedenk een eigen virtuele spin-off!
http://arkportal.ut.ee/#/inq_act/944
October 2017 – February 2018
The activities are being implemented with the same 3 classes during this period of time. The pupils visited or will visit companies and research groups and develop their own 'Timeline' on a specific assigned subject within the high-tech field and quantum physics.

Vlaamse Dag van de Wetenschap (Flemish Science day) – 'Muziek en fysica'
http://arkportal.ut.ee/#/inq_act/1739
26.11.2017
During this event pupils and their families (parents) can visit research institutes and universities were several scientific activities are performed. UCLL participated with the inquiry activity 'Muziek en fysika'. In this activity 5 teacher students were involved. More than 100 pupils and parents participated in this activity.

Sustainability actions in Belgium

UCLL will certainly go on with the Quantum SpinOff trajectory 2017-2018 within the Ark of Inquiry framework after the end of the project (May 2018). The university will also present the Ark of Inquiry platform to teachers in their network looking for interesting inquiry activities, as the Ark of Inquiry platform offers many possibilities for these teachers and many activities we developed in previous projects are also present in the platform.

Use of the award system in Belgium

Award assigned in 2016-2017:
- 27 distinguished young scholar awards on the platform "Hall of Fame" page, all from the same school (Agnetendal Peer): the awards were issued following an activity performed in this school by our teacher students in September 2016.
- 33 silver medal awards in the Quantum SpinOff trajectory 2016-2017, 2 of which are on the platform (pupils representative of their class).

- 14 gold medal awards in the Quantum SpinOff trajectory 2016-2017, not on the platform.

Figure 7. Gold medal award assigned to the pupils of Katholieke Scholengemeenschap Harlindis en Relindis Maaseik participating in the Quantum SpinOff trajectory 2016-2017

UCLL plans to assign awards (silver or gold) to pupils (about 55) participating in the Quantum SpinOff trajectory also in 2017-2018, but this will be done after the end of the project.

In general, it was noted that in Belgium it was difficult for teachers to implement the award system by themselves. The system has worked well, however, when the award system has been proposed and organized by an external organization, like UCLL, and in case all pupils of one class can work on the same activity and have a chance to win a 'collective' award (instead of an individual one).

6.4. Cyprus

Country summary

In the last year of implementation (March 2017 – November 2017), teachers in Cyprus implemented a total of 10 activities that are uploaded to the Ark of Inquiry platform and were recommended by the University of Cyprus. Some of the activities derived from the Go-Lab portal and are related to the following subjects: titration, phases of the Moon, osmosis, pH scale, the mystery of th extinction of dinosaurs. Also, teachers implemented offline activities such as "Earthquakes", "Drawing a scientist", "Black Box activity" and the "Eratosthenes Experiment". At this point it should be noted that the last activity was very popular with the teachers.

However, what is very interesting in the case of Cyprus is that the majority of the teachers designed their own activities and implemented them in their class (a total of 38 activities were created by teachers). The descriptions of most of these activities were uploaded to the Ark of Inquiry platform.

An obstacle that was mentioned by a number of teachers was the feeling that they are not motivated to adopt, adapt and implement non-traditional teaching methods and practices in their classrooms because of the Cypriot education system, as it neither encourages them nor acknowledges their extra effort. Also, the time constraints and the tight curriculum set by the Ministry poses a strong barrier to implementing the activities.

Figures from Cyprus

The overall figures of implementation in Cyprus are the ones below for the relevant period:

Total number of schools implementing activities	31 schools
Total number of teachers who participated in the implementation phase	150 teachers
Total number of pupils who participated in the implementation phase	908 pupils
Total number of other stakeholders involved in the implementation	46 researchers

Activities in Cyprus

The activities from the Ark of Inquiry platform that were performed in schools are presented below:

The Mystery of the Dinosaurs Extinction
http://arkportal.ut.ee/#/inq_act/1428
Implementation period: March-April
Pupils are prompted to reflect on why the dinosaurs went extinct in the past and then examine the implications of the assumption that dinosaurs' extinction was caused by an asteroid that fell on Earth.
The activity was proposed by the teacher and was added in the last year (March 2017).

Figure 8. Pupils performing the Dinosaurs Extinction activity

Titration
http://arkportal.ut.ee/#/inq_act/1368
Implementation period: March-April
Pupils titrate a strong base solution with a weak acid and find an unknown concentration from the results of the titration.
The activity was proposed by the teacher and was added in the last year (December 2016).

Phases of the Moon
http://arkportal.ut.ee/#/inq_act/789
Implementation period: February–April
In the lesson, pupils explain the Moon phases, evaluate and revise their explanations through the practice of argumentation.
The activity was proposed by the teacher and was added in the last year (May 2016).

Osmosis
http://arkportal.ut.ee/#/inq_act/1371
Implementation period: February–April
This lesson deals with the phenomenon of osmosis in living cells. Pupils define the phenomenon of osmosis and explain what happens if we place a cell in different environments. The lesson also aims to develop pupils' inquiry skills such as formulation of questions and hypotheses.
The activity was proposed by the teacher and was added in the last year (December 2016).

pH Scale
http://arkportal.ut.ee/#/inq_act/1349
Implementation period: February–April
In this activity pupils explore the basics about the pH scale. At the same time, they discover how to calculate the pH of an acid or base.
The activity was proposed by the teacher and was added in the last year (December 2016).

Drawing a Scientist
http://arkportal.ut.ee/#/inq_act/1622
Implementation period: September
The activity was designed to explore children's perceptions of scientists through drawings.
The activity was proposed by the teacher and was added in the last year (May 2017).

Black Box
http://arkportal.ut.ee/#/inq_act/580
Implementation period: October
This is a designed curriculum that entails a sequence of learning activities in the context “Black Box”. The activity sequence can be completed within a three-hour session and participants become familiar with all phases of the inquiry cycle model through a challenging task.
The activity was proposed by the teacher and was added in the last year (April 2016).

Eratosthenes Experiment in Primary Schools
http://arkportal.ut.ee/#/inq_act/1547
Implementation period: March & September
Teachers collaborate with other schools all over the world and measure with their pupils the circumference of the Earth, using simple means, reviving this way in their school yard the historical measurement taken by Eratosthenes about 2250 years ago at Alexandria of Egypt.
The activity was proposed by the teacher and was added in the last year (March 2017).

Eratosthenes Experiment in Secondary Schools
http://arkportal.ut.ee/#/inq_act/1545
Implementation period: March & September
Teachers collaborate with other schools all over the world and measure with their pupils the circumference of the Earth, using simple means, reviving this way in their school yard the historical measurement taken by Eratosthenes about 2250 years ago at Alexandria of Egypt.
The activity was proposed by the teacher and was added in the last year (March 2017).

Earthquakes
http://arkportal.ut.ee/#/inq_act/1357
Implementation period: July
Pupils learn how scientists identify the epicentre of an earthquake.
The activity was proposed by the teacher and was added in the last year (December 2016).

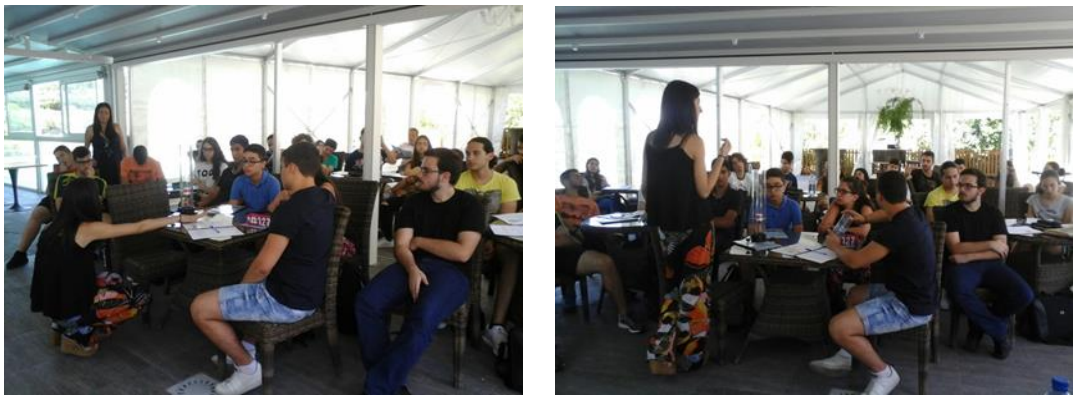

Figure 9. Pupils during the Earthquakes activity

An overview of one exemplary activity that a teacher designed and implemented is presented below:

« «Το ευεργετικό αγκάθι» - Opountia ficus-indica»
http://arkportal.ut.ee/#/inq_act/1704
Implementation period: March
The purpose of the activity is to investigate the antimicrobial properties of three parts of a prickly pear.

The activity was proposed by the teacher and was added in the last year (September 2017).

Sustainability actions in Cyprus

As the project comes to an end, it is not foreseen to continue with face-to-face training workshops for teachers. Nevertheless, in the coming months, a number of already trained teachers have expressed their will to implement existing inquiry activities from the Ark of Inquiry platform with their pupils such as “Earthquakes”, “Extinction of Dinosaurs” and the “Black Box”.

Use of the award system in Cyprus

The award system has been implemented in a simplified format in Cyprus. The university used the award system on school level. The UCY collaborated with a teacher from a private school to implement the awards. The teacher implemented inquiry and RRI activities with her pupils in grades 8 – 11. A few pupils obtained a diploma (7 pupils) and 16 pupils obtained a star. At the end of the school year, a ceremony was organised in collaboration with the school and a formal certificate was given to the pupils. Also, pupils’ names were published on the Ark of Inquiry platform Hall of Fame page. The teacher and the pupils were very enthusiastic. The awards appeared to motivate them to participate actively.

Even though in Cyprus most of the teachers got familiar with the RRI concept, got informed about the award instruments and expressed their satisfaction with the award system during the training courses, other teachers who participated in the training courses did not use them. The time needed for using the award system within their everyday teaching practice seemed to be the most important obstacle they were facing, since they felt obliged to follow closely the recommendations of the national curriculum. The curriculum acted as a time constraint for teachers because it is often not flexible enough to enable teachers to use these innovative tools.

6.5. Finland

Country summary

During the current period, a total of 18 teachers from 4 different cities have implemented inquiry activities in their classroom. The implementation has involved 305 pupils. This number is significantly lower compared to the previous period, where a total of 90 teachers and 1904 pupils were involved in the implementation. The lower number is due to the fact that the Finnish implementation was closely related to teacher training courses that took place in the previous period. However, the numbers of the current period are likely heavy

underestimates of the reality. For instance, in the later part of autumn 2017 UTU trained (one day mini-training) 40 in-service teachers (in Tampere district) and 80 pre-service teachers (at the University of Turku), but we have not been able to collect data on how many of these teachers actually implemented inquiry activities. It is also uncertain how many of those 130 teachers that participated in the initial/formal training have re-implemented inquiry activities in autumn 2017 (in the first period, 90 teachers out of 130 implemented the activities).

From the 18 teachers that have certainly implemented the inquiry activities in the current period, eight (44%) selected an inquiry activity from the Ark of Inquiry platform. The remaining 10 self-designed an activity, though many of them mentioned that they used existing activities from the platform as an inspiration for their own activities. In this sense, it can be argued that there are two even categories of teachers: those that want to use existing materials and those that want to design their own activities. All of the inquiry activities that have been implemented are in Finnish, suggesting that teachers appreciate inquiry activities in their local language.

Figures from Finland

Total number of schools implementing activities	5 schools
Total number of teachers who participated in the implementation phase	18 teachers
Total number of pupils who participated in the implementation phase	305 pupils
Total number of other stakeholders involved in the implementation	18 parents, 2 researchers and 5 teacher trainers

Activities in Finland

Below are translated example descriptions of three inquiry activities that Finnish teachers selected from the platform.

Optimal Plant Growth Conditions
http://arkportal.ut.ee/#/inq_act/919
In this biology experiment the factors that influence seed germination are studied by the exclusion method. These include light, moisture, air, heat, and mould. The experiment is an application of the famous biology experiment in which a similar method studies the effects

of a plant hormone on plant growth. Pupils learn how to make controlled experiments and about the factors that affect seed germination and which condition(s) offer the most optimal conditions for plant growth. The material helps pupils to understand why agriculture is challenging in Nordic regions. At the baseline, sunflower and oat seeds are used in this experiment, but the experiment can be extended to include other kinds of seeds to understand the boundary growth conditions for different plant species.

Carbon Tree
http://arkportal.ut.ee/#/inq_act/759
This activity consists of two parts. In the first part the carbon tree simulation (hiilipuu.fi) is used to study how the pine binds carbon dioxide from air at different times of the year and in different weather conditions. Schools can also borrow a "carbon suitcase" from the science centre; the suitcase includes carbon dioxide and temperature and light sensors. The sensors can be manipulated (by spraying, heating, and illuminating), whereby the suitcase reacts to changes. In the second part of the activity pupils calculate the energy required for charging a cell phone battery and the carbon dioxide emissions it causes, the carbon footprint, and the time needed to re-carbonize the carbon from a single pine.

Basic Principles of Electric Circuits
http://arkportal.ut.ee/#/inq_act/692
In this activity pupils are guided to explore the basic principles of electric circuits by using a computer-based simulation that models the functioning of electric circuits. The objective of the activity is to discover the basic principles behind the functioning of electric circuits on a qualitative (relationship between the number of bulbs, the circuit configuration, and the bulb brightness) and quantitative (relationship between the number of circuit components, the circuit configuration, and the voltage across circuit components) level. The activity consists of a series of 9 worksheets that are designed to activate pupils' prior conceptions of electricity, confront common misconceptions identified by previous research and to correct these misconceptions by gradually introducing the scientific model.

Sustainability actions in Finland

Ark of inquiry activities will be referenced in all future trainings that relate to STEM education organized by the University of Turku. The university will inform schools about the

Ark of Inquiry platform via various means and networks (e.g., they will propose that the National Board of Education lists the platform on their website). They are also planning a small newsletter article for the Finnish Teacher magazine that has a nationwide coverage to inform the target group about the platform and the activities. All the schools and teachers that have participated in the training courses will be contacted in order to ask them about their future plans regarding inquiry learning and Ark of Inquiry activities. As part of these contacts, the university will try to encourage teachers to keep using the activities and also ask them to encourage their colleagues to use the activities. In addition to the above, Ark of Inquiry activities have been used by the pre-service teachers at the University of Turku. UTU has identified a plan to include some of the activities in the regular teacher training curriculum at the University of Turku. A forthcoming accepted presentation at the largest national ICT and science teachers' seminar in April is already scheduled as well. At this event they will present and summarize the project outcomes from a national perspective and this way try to encourage more teachers to use the existing activities and contribute new activities.

Use of the award system in Finland

For two main reasons, the awards were not used in Finnish schools. First and foremost, the awards, and differentiating pupils is very much against the principles of the Finnish school culture, which aims for equality in all areas. The second reason is that the teachers spent most of their efforts on implementing the inquiry activities and getting familiar with the inquiry approach. In other words, though some of the teachers recognized the potential of the awards, the awarding was not on the top of their priority list as far as the implementation was concerned.

6.6. France

Country summary

The implementation part was driven mainly by EADN in collaboration with the strong support of the network of DNA schools. This implementation action is based on activities that have already been validated and which correspond to the teachers' expectations regarding the teaching programme. From EADN's side, the main activities are based on criminal sciences, diagnosing genetic diseases and molecular phylogeny.

The use of network partners made it possible to implement the activities nationwide. The realization of the implementation has been a smooth part for EADN, as schools have been very motivated to participate. EADN's mission during the implementation was to propose activities where the teachers would then freely pick the most appropriate to their needs. The activities described below were the ones most often used; however, some teachers

chose to implement their own activities that were from outside the project in order to sensitize young people to a greater openness to science.

Figures from France

For this phase a total of 29 implementation actions took place in 26 schools that cover mainly high schools but also colleges (in France colleges cover the age range of 12–15 years of age).

In total, 1171 people benefited from the implementation of the Ark of Inquiry project in France.

Total number of schools implementing activities	26 schools
Total number of teachers who participated in the implementation phase	63 teachers
Total number of pupils who participated in the implementation phase	1072 pupils
Total number of other stakeholders involved in the implementation	36 people, especially scientific activity animators and parents

Figure 10. Map of Ark of Inquiry implementation in France

Activities in France

The main activities that have been implemented are activities that EADN offers to teachers. The teachers remain masters of their choices. There are no specific periods for activities, the random choice depends on the requesting teachers.

DNA fingerprint
http://arkportal.ut.ee/#/inq_act/241
"The Restriction Fragment Length Polymorphisms (RFLP) technique has been used for 20 years in inquiry activities in order to analyse molecular variations in DNA. Applications are various, RFLP can be used for genetic mapping in disease, for polymorphic markers analysis or phylogenesis. The RFLP technique explores all DNA sequences (codant or not) as opposed to genetic linkage mapping which identifies mutations with phenotypic effects. Widely used genetic marker of this type depends on the way small differences in DNA sequence can alter restriction enzyme cutting patterns. The RFLP technique is used for genetic linkage analysis and identifying parental DNA inherited copies. The inquiry activity gives the possibility to apply the RFLP technique in DNA fingerprint with the aim of solving crimes."

Figure 11. Teacher in a French school implementing an Ark of Inquiry activity

Molecular Phylogeny
http://arkportal.ut.ee/#/inq_act/244
"At the molecular level, it is possible to construct a phylogeny on principles similar to those used at the morpho-anatomical scale. The molecular approach is based on the comparative analysis of genetic sequences where the position and organization of nucleotides reflect phylogenetic phenomena. The complementarity of molecular and morphogenetic approaches makes it possible to refine the study of the relationships between living organisms on the one hand, and to better understand the function of genes and their evolution on the other. The practical part uses the RFLP technique on extracts representing DNAs of different species of primates. The differences in restriction profiles are analysed and

the results tend to prove the common inheritance of these species on the one hand and on the other to identify their identity at the molecular level. The relevance of molecular arguments is then addressed in the context of the creation and use of phylogenetic trees to clarify the degree of kinship between the groups studied. Nowadays, it is common to make comparisons on nucleotide sequences. With the tools of molecular biology, it is possible to search for specific sequences on DNA samples from various species. The results obtained allow to justify the search for kinship links between species. The relevance of these molecular arguments is addressed in the creation and use of phylogenetic trees to clarify the degree of kinship between the groups studied."

Figure 12. Pupils performing Ark of Inquiry activities in France

Common Genome
http://arkportal.ut.ee/#/inq_act/860
"In this experiment, the polymerase chain reaction (PCR) is used to amplify a region of chromosome 8, in order to highlight the presence or absence of a DNA sequence called Alu or TPA-25 in the gene of plasminogen activator. Although the DNA is very similar from one individual to another, several chromosomal regions in humans are highly diverse. These polymorphic DNA sequences have made it possible, among other things, to develop diagnostic techniques for genetic diseases, identification methods in criminal police and paternity tests. The source of DNA used consists of several thousand cells obtained by trainees from their own saliva, by mouth rinsing with saline solution. Once the pupils have extracted their own DNA, it is incorporated into the PCR mix and the samples are taken to the thermocycler. In order to be able to compare the genotype of the different participants, a fraction of the PCR reaction is deposited on an agarose gel. After electrophoresis and staining, the amplification products appear as distinct bands. The migration distance of the fragments makes it possible to determine their size by comparison with a scale of known molecular weight DNA fragments. For each individual, one or two bands can be

distinguished, which makes it possible to determine for each participant whether he is homozygous or heterozygous for the Alu insertion. Depending on the results obtained, pupils will be able to calculate the allelic frequency for the presence and absence of the Alu insertion in their group."

Sustainability actions in France

The activities of the DNA school are validated by the national education authorities in France. Therefore, all the activities that have been carried out in school correspond to the requirements of the teaching programmes. The exploitation of the activities in France is a common thing, so the presented activities will be used in a recurring way. The collaboration that has been established with teachers will remain and the activities will be used again.

It is obvious that the activities that have been chosen by EADN in France were chosen in collaboration with the teachers and will be reused in the future. One of the strong and major reasons for this observation is that the activities are commonly used during educational programmes. EADN has made an effort to set up the French version of the Ark of Inquiry website in advance, but the fact that the platform is not translated for French teachers is an obstacle for some teachers. The teachers' positive remarks so far in Ark of Inquiry are still about the richness of the proposed activities.

Figure 13. Meeting with policy makers and teachers in France

Use of the award system in France

The activities of the school of DNA are validated by the national education system. Therefore, all the activities carried out in school correspond to the requirements of the teaching programmes. It turns out that all the lessons are subject to ratings and evaluations, so it is clear that setting up an external evaluation is not recommended. Therefore, it is much easier to set up activities that do not require any constraints of rating and evaluation. The principle of reward through award is not welcomed very favourably in the French

national education system. However, we have found that private institutions that have more flexibility are definitely not closed to using awards.

6.7. Germany

Country summary

The main activities for implementation of the Ark of Inquiry project in this last year in Germany focused on a series of activities that UBER recommended to teachers. In this semester UBER trained more than 30 teachers who widely used in their classroom the activities from the Ark of Inquiry platform that the university recommended to them.

In total, more than 30 schools with 40 teachers and more than 800 pupils implemented the recommended activities, mostly related to the topic of chemistry.

Figures from Germany

Total number of schools implementing activities	32 schools
Total number of teachers who participated in the implementation phase	40 teachers
Total number of pupils who participated in the implementation phase	800 pupils
Total number of other stakeholders involved in the implementation	3 researchers

Activities in Germany

Strom aus der Teetasse
http://arkportal.ut.ee/#/inq_act/1741
Solar cells have become increasingly important in recent years. Solar energy is regarded as an environmentally friendly alternative to power generation in nuclear or coal power plants.

However, critics also point to the high production costs, the harmful ingredients of the cells and the interference with nature through huge solar parks (photo left). As in many things, nature is far ahead of man in this matter. Plants have been using photosynthesis for millions of years to extract energy from sunlight in the form of glucose. A single leaf is, so to speak, a "solar cell of nature".

Gefahr aus dem Wasserhahn
http://arkportal.ut.ee/#/inq_act/1692
In the present learning environment, the SuS should investigate the nitrate content of water of different origin.

Science Fair Event for Pre-School Pupils
May 2017
At the Chemistry Institute of the Humboldt University of Berlin in Germany, a science fair event was held in collaboration between 2 researchers, 3 educators and 1 laboratory assistant to 15 pre-school pupils with permission from the parents. This event was planned for pre-school pupils to create experiences that encourage discovery through play, asking questions, exploration and using lab materials at this age to convince children that science is fun. In this investigation, pupils worked on four different experiments in four groups which depended on the educators' ideas and their backgrounds. The experiments were paper chromatography, colour changing cabbage experiment, dissolving experiment and inflating balloon with baking soda & vinegar. Each pupil got to try each experiment themselves, discover, invent and investigate, using the skills necessary to engage in the scientific process and learn that chemistry is fun.

Figure 14. Science Fair in Germany

Einführung in das Periodensystem der Elemente
http://arkportal.ut.ee/#/inq_act/1306
In this learning scenario, the pupils learn the following content: Construction of the PSE by property and atomic structure. Names and symbols of the elements. Tendencies of electronegativity, atomic radius, metal/non-metallic character, reactivity. The octet rule and the establishment of molecular formulas. The prediction of chemical reactions between elements using the periodic table. In addition, they acquire competencies in the field of communication, organization and systematization, planning and execution of scientific investigations, as well as structuring and presentation of technical content. For this learning scenario, pupils should create a folder called PSE, either on their computer's user account or in the shared class wiki.

Tenside im Waschmittel
http://arkportal.ut.ee/#/inq_act/1305
In this lesson we want to focus on soaps and surfactants. At the end of this scenario, we want to answer the following questions:

1. Which ingredients are present in the detergent and what role do the surfactants play in this? 2. Why do you even need soap and detergent? 3. And what happens at the molecular level during washing with surfactants? Now that the pupils have looked at the individual ingredients in the detergent, the focus of this scenario will be on the washing performance of surfactants. In order to make this clear to the pupils, the three main goals of this learning unit are pinned here and should be considered in retrospect.

Flammenfärbung
http://arkportal.ut.ee/#/inq_act/654
In case of difficulties the teacher has possible chemical questions: - What is burning in a fireworks rocket? - Where does the light with the different colours come from? - How is the light of different colours created?

Alkansäuren
http://arkportal.ut.ee/#/inq_act/652
In a teacher lecture, the (and further) examples of alkanoic acids represented by pictures are to be given: - methanoic acid as secretions of the ants and as an ingredient of the nacreous capsules in the stinging hair of the leaves of the stinging nettle; - the ethanoic acid as a seasoning and preservative; - the propanoic acid as a product of the propionic acid bacteria in cheese production; - butanoic acid as a degradation product of sebum and skin residues (typical Käsefußgeruch) and in traces by oxidation in butter; - hexadecanoic acid as a fatty acid component in palm oil.

Sustainability actions in Germany

Following the implementation actions performed in Germany by UBER and especially through the organisation of the science fair, the university received very good feedback from the parents and the educators who asked to repeat it again with the same group and other groups. For that reason and in order to motivate schools in the region even more, the university is planning to prepare a safe laboratory and inquiry learning plan for the institute intended for primary school pupils. The plan is to create a permanent space and, in the future, to invite pupils and schools to visit a real chemistry laboratory in a research institute, to carry out a real science activity with the cooperation of researchers, teachers and the lab assistants. The university will work in the coming months towards this step.

Use of the award system in Germany

The award system has not been implemented by German teachers. As the university explored the possibility to implement the award system in the German classrooms it was evident it had to acquire a special permission from the Ministry of Education. Following discussions it was confirmed that it was not allowed to use the current structure of the Ark of Inquiry awards as it would not fit the current school policy.

In Berlin/Brandenburg (and in all other parts of Germany) it is strictly forbidden by law for schools of all types to give or use names, birthdays, etc. of their pupils to or by a third party. This is clearly described (in German) in “Schuldatenverordnung" (School Data Protection Regulation) and in the General Data Protection Regulation (see, for example, Art. 6 (1) and Art. 7). So, UBER was not allowed to ask for such data and encountered reluctance to use the system as it was designed in the project.

6.8. Greece

Country summary

EA’s strategy for the large-scale implementation phase of the Ark of Inquiry project has been twofold. On the one hand, the organisation has focused on promoting both via the teacher trainings but also via its existing national and international channels a list of specific activities created by EA and EA’s partners. In order to encourage the use of these activities, competitions in some cases as well as special events were created to further motivate teachers to use them. On the other hand, EA has made an effort to promote the Ark of Inquiry platform to the Greek teachers, empowering them to upload their own activities and implement them in an autonomous way. This report will focus mainly on the activities promoted by EA but will give a short overview of some of the teachers’ activities too.

In total, more than 30 activities were added and used by Greek teachers and EA and are now available in the Ark of Inquiry platform.

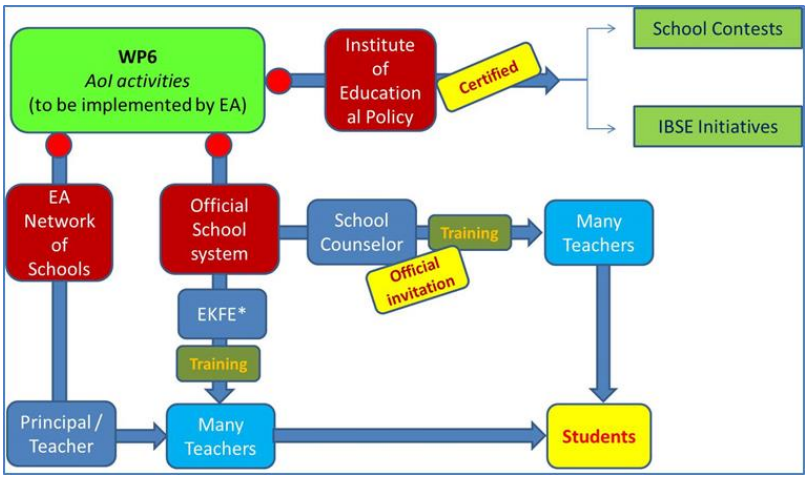

Figure 15. EA's communication channels promoting Ark of Inquiry initiatives through contests and collaboration with formal educational authorities

Figures from Greece

Total number of schools implementing activities	235 schools
Total number of teachers who participated in the implementation phase	383 teachers
Total number of pupils who participated in the implementation phase	5063 pupils
Total number of other stakeholders involved in the implementation	63 researchers, museum professionals, teacher trainers

Activities in Greece

This is an indicative list of the activities promoted by EA and then a few of the activities provided by the teachers.

Build Your Own Seismograph
http://arkportal.ut.ee/#/inq_act/1574

Period: March – May 2017
In Greece, EA in collaboration with the National Observatory of Athens (NOA) organized a thematic educational contest which runs at national level. Teams of pupils in secondary, both general and vocational, education participated in the contest. The main goal or challenge of each team was to build a seismograph, to elaborate on the principles of operation, to document the whole procedure, and finally to make a comprehensive presentation of their study, work and construction. The winner teams and their teachers/supervisors were then invited to receive a commemorative symbolic certificate and more importantly to present their work and demonstrate their seismograph at a ceremony that was hosted by NOA in a historic building on 5 May 2017.

Figure 16. Pupils and teachers in the National Observatory of Athens during the "Build your own seismograph" final event

pH of the Planet (Acidity)
http://arkportal.ut.ee/#/inq_act/1751
Period: April – May 2017
This activity is part of a set of 4 activities for high school pupils concerning the chemistry of water. These activities were first developed by IUPAC and UNESCO in 2011 in the framework of the international year of chemistry. The following activity focuses on the use of the chemistry kit that has been distributed to the participant schools, in order to measure the pH of a natural water supply. Pupils will learn about acids, alkali, acid strength and pH measurement in a hands-on approach using both hands-on and virtual experimentation**.**

Coding in Pencil Environment
http://arkportal.ut.ee/#/inq_act/1627

Period: March 2017 – May 2017
This course is an introductory programming lesson. At the same time, it is an attempt to transition pupils from a scheduling environment to a tile programming environment using code. The online Pencil Code programming environment is used to implement the activities. The main objectives of the series are for pupils to be able to implement programming activities and acquire programming skills using commands**.**

The Foucault Pendulum for Elementary School
http://arkportal.ut.ee/#/inq_act/1939
Period: September 2017
Pupils observe/analyse the movement of Foucault's pendulum in order to understand the rotational motion of the Earth.

Salty Waters (Salinity)
http://arkportal.ut.ee/#/inq_act/1753
Period: April – May 2017
This activity is part of a set of 4 activities for high school pupils concerning the chemistry of water. These activities were first developed by IUPAC and UNESCO in 2011 in the framework of the international year of chemistry. The following activity focuses on the use of the chemistry kit that has been distributed to the participant schools, in order to measure the salinity of fresh seawater. Pupils will work on basic chemical procedures and measurements in a hands-on approach using both hands-on and virtual experimentation.

Draw a Scientist
http://arkportal.ut.ee/#/inq_act/1622
Period: April – June 2017
The Draw-A-Scientist (DAST) activity was designed to explore children's perceptions of people involved in scientific research. Originally developed by David W. Chambers in 1983, with the main purpose of identifying at what age the known stereotyped image of the shy, distant, scientist appears for the first time. After the simple prompt pupils can share their

plans with the rest of the classroom and discuss comments, including common features and differences between projects. This approach makes pupils' thinking visible to both educators and pupils and sets the foundation for a shift of beliefs through exposure and participation in science.

The Eratosthenes Experiment

As this Ark of Inquiry activity has achieved very high numbers both in Greece and in other countries of the consortium, a more detailed explanation is given on how it was led by Ellinogermaniki Agogi and implemented internationally.

Eratosthenes Experiment in Secondary Schools / in Primary Schools
http://arkportal.ut.ee/#/inq_act/1545 / http://arkportal.ut.ee/#/inq_act/1547
21 March 2017 and 22 September 2017
Pupils will measure the Earth's circumference based on Eratosthenes' experiment, which he carried out in 3rd century B.C. (Basic trigonometry will be applied.) The activity follows the IBSE model. As teachers run this activity with their classes, they are encouraged to touch upon several issues related to the topic of Responsible Research and Innovation. Before running the activity and as teachers introduce Eratosthenes, a short discussion about the role of women in the history of science can be added. Via this discussion teachers can bring up the gendered image that science has had for centuries and the stereotypes often associated with it. Following the measurements and conclusion phase of the activity another element may be introduced. A discussion about the role of human impact on the planet that Eratosthenes first tried to measure, the sense of fragility that should become more evident to the pupils and a discussion about issues such as climate change may add to the activity additional RRI elements.

The Eratosthenes Experiment was organized first on 21 March 2017 and then on 22 September 2017 and received an overwhelming response, as schools all over the world participated in this celebration of science and education, calculating the circumference of the Earth by using eLearning educational tools and simple instruments. Starting from the end of January, the activity was disseminated to a great number of teachers from all over the world by preparing a short text providing all the necessary information about what they had to do in order to take part in the Eratosthenes activity and in the relevant international photo contest, available online educational scenarios for primary and secondary education (these resources and full inquiry activities were uploaded to the Ark of Inquiry platform),

ways of assessment of pupils' problem solving skills and performance on the topic and useful links on how to perform the experiment on a cloudy day, etc.

Overall, 675 schools participated in March 2017, representing 44 countries all over the world. The distribution of schools per continent is shown in Figure 17 below and the exact allocation per country in Table 6 below.

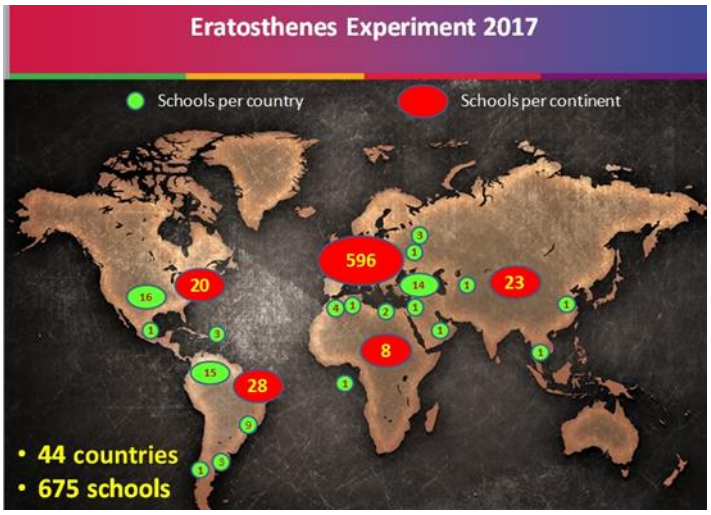

Figure 17. Eratosthenes schools around the globe

Table 6. Schools implementing the Eratosthenes experiment across the globe

Schools from Ark of Inquiry European countries		Schools from non-Ark of Inquiry European countries		Schools from Africa		Schools from North America		Schools from South America		Schools from Asia	
Belgium	4	Bosnia-Herzegovina	4	Algeria	1	USA	16	Argentina	3	China	1
France	2	Bulgaria	13	Egypt	2	Mexico	1	Brazil	9	Israel	1
Italy	**62**	**Croatia**	**103**	Morocco	4	Puerto Rico	3	Chile	1	Kyrgyzstan	1
Finland	5	FYROM	4	Sao Tome & Principe	1			Colombia	15	Saudi Arabia	1
Germany	4	Ireland	4							Thailand	1
Estonia	1	Lithuania	2								
Hungary	12	Montenegro	1								
Greece	**118**	Poland	12								
Netherlands	0	Portugal	28								

Cyprus	16	**Romania**	**120**								
Austria	5	Russia	3								
Turkey	14	Serbia	20								
		Slovakia	1								
		Slovenia	2								
		Spain	18								
		Ukraine	1								
		UK	17								
Total	**243**		**353**		**8**		**20**		**28**		**5**

Moreover, in the framework of the educational activity, EA launched a photo contest for teachers, namely The Eratosthenes Photo Contest March 2017. In order to participate in the photo contest, each teacher had to become member of the aforementioned online community (Eratosthenes 2015) and submit his/her photo to the relevant contest group of the community. The platform was used because it provides transparency, as all members of the community can see the submitted photos. By the end of the contest, there were 314 members in the online community. In total, 40 teachers took part in the contest, submitting pictures capturing their schools' involvement in the experiment. The winning teacher was Mr. Krsto Maslesa from the Jovan Serbanovic Primary School, located in the city of Ranovac, Serbia. He received a scholarship to attend the Ark of Inquiry Summer School 2017 in Marathon, Greece (http://ark.ea.gr). The winning picture is depicted below.

Figure 18. The winning Eratosthenes photo

The Eratosthenes experiment was organized for the second time in the same year, 22 September 2017 during the autumnal equinox day, by EA's Research and Development team.

Schools from 47 countries participated in this event. 401 new (compared to March 2017) teachers created an account on our website providing information about their school (geographical coordinates and level of education). The total number of schools that implemented the activity was 403, involving a total of 455 teachers, 26 educational stakeholders (headmasters, university students and teacher trainers) and 4955 pupils.

After the successful photo competition in March 2017, EA launched a similar competition for September, following the same rules, which attracted 40 teachers all over the world.

Figure 19. The winning picture of the September 2017 Eratosthenes photo competition by Mrs. Vasiliki Kantza from the Primary School of Kato Kamila (Greece)

Table 7. Eratosthenes schools in 2017 March and September events

	March 2017	**September 2017**
Countries	44	47
Participating schools	675	403
Registered teachers / accounts (new)	704	401 (in addition to those of March)
Pupils (all)	7039	4955
Schools submitted data	273	273
All participating teachers (more than one per school)	1007	455

		(+26 educators/stakeholders)
Participating teachers in the photo contest	55	40

Sustainability actions in Greece

EA will continue to implement activities that were added to the Ark of Inquiry platform following the end of this project. The Eratosthenes Experiment will be implemented again internationally in March 2018 and the process will be led by EA. The Build Your Own Seismograph competition will also continue in the coming school year. EA will keep in touch with the network of Ark of Inquiry teachers who have been trained by the project and will promote future activities both in the field of RRI and IBSE. The project has given an opportunity to the organisation to create a common framework for a series of activities to be implemented in Greece.

Use of the award system in Greece

The award system has not been widely implemented in Greece by teachers. It has been piloted with one class in the Ellinogermaniki School but has not been extended to more classes and schools. The main reasons behind this have been the following: a) introducing any form of awarding within the classroom initiated by the teacher without the approval of the Ministry of Education is very difficult; as Greece is a country where the formal education system is very much centrally based, any deviation from the exact lesson plan has to be approved by the ministry; using tools provided by the Ark of Inquiry platform has also gone through an accreditation procedure, but adding the element of awards to it is something much more complex; b) teacher trainings in Greece had to be done in short periods of time (3–4 hours, usually), as teachers do not get the opportunity for longer trainings; this resulted in the trainers focusing on the use of the platform and the recommended activities, rather than the more thorough introduction to the award system; as the introduction of the system has been brief, the teachers did not feel confident enough to pursue the use of them in their classroom.

6.9. Hungary

Country summary

During the last year of implementation, HRTA continued working with the strong network of schools and teachers the organisation had built during the first year of implementation. In 2017, following the original plans, more than 80 teachers who participated in the teacher training sessions kept implementing the activities from the Ark of Inquiry platform.

In total, 106 teachers were involved in the implementation actions in Hungary together with more than 8500 pupils. In the implementation process, HRTA involved local science centres and museums, and a number of activities were implemented in collaboration with them (for example, the Mobilis Science Centre).

Figures from Hungary

The overall figures of implementation in Hungary are the ones below for the relevant period:

Total number of schools implementing activities	51 schools
Total number of teachers who participated in the implementation phase	106 teachers
Total number of pupils who participated in the implementation phase	8655 pupils
Total number of other stakeholders involved in the implementation	0 trainers/science centre professionals

Activities in Hungary

From the Hungarian-language materials uploaded to the Ark of Inquiry platform, the teachers who participated in the training and were involved in the implementation chose activities based on their interest, connected to their subject and suitable for their group's profile. When uploading the Hungarian-language activities to the platform, HRTA tried to choose diverse activities connected with almost all the science subjects so that every school and age group could find relevant materials. Below are some of the most popular activities that were used in Hungarian schools from the platform.

Bioinformatics with Pen and Paper: Building a Phylogenetic Tree
http://arkportal.ut.ee/#/inq_act/814
Think about how to classify different animals! Traditionally, physical differences (morphological signs) between organizations have been used to derive their evolutionary relationships, for example, that an organization has a backbone or has wings. This can cause problems. For example, birds, bats and insects all have wings, but are they really close relatives? How would you measure how the current organizations have changed from the previous common one? In the course of the activity, we will prepare a phylogenetic tree using the five primordial homologous DNA sequences. Since these sequences have been fabricated, we actually can't estimate genetic distances; to create a meaningful phylogenetic tree we would need to have real data and to build it from much longer sequences. However, these fictive sequences were chosen to provide a

reasonably accurate picture of the relationship between primates.

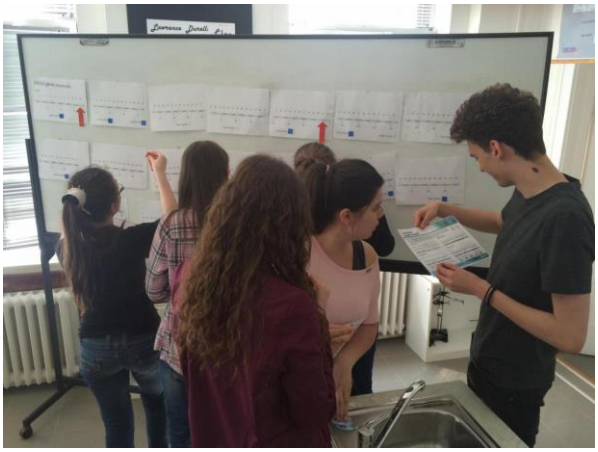

Figure 20. Hungarian pupils implementing Ark of Inquiry activities

Can You Spot a Cancer Mutation
http://arkportal.ut.ee/#/inq_act/686
The aim of the educational activity is to help high-school pupils interested in biology to find mutations potentially causing cancer, using genomic data. The procedure is in fact not experimental, so there is no need for laboratory equipment. Instead, search is conducted on a theoretical basis using credible data. All the materials you need during the activity, along with detailed instructions, can be downloaded free of charge from the program's website. Apart from describing the various steps involved in the activity, the article and the support website contain important information on cancer, what causes them, how they develop and how genomic information can be used to improve their management. There are a number of controversies around cancerous diseases that our pupils are able to discuss about.

Figure 21. Pupils in Hungary performing an Ark of Inquiry activity

How Can the Bear's Nose Be Switched On?
http://arkportal.ut.ee/#/inq_act/874
We use a lot of lighting devices in everyday life, but perhaps the light bulb is one of the most personal. Why and how does it light up? You can get answers from the next activity. The following is a summary of the proposed course of processing a topic. It's a good idea to start with something familiar to your kids, such as the everyday use of batteries and light bulbs. A good example of this is the flashlight. You can then examine the battery and light bulb more in detail.

A Fresh Look at Light: Build Your Own Spectrometer
http://arkportal.ut.ee/#/inq_act/811
White light is, in fact, not white, but in a variety of colours. The components of light - the spectrum - can be studied by means of the spectroscope device. This activity describes how to create a functional spectroscope using a CD, a cereal box and some other small things. With this self-made tool, you can admire the colours that are hidden by everyday objects such as a light bulb, a fluorescent lamp, a computer monitor, or a candle flame. Discover it!

Microscale Chemistry: Experiments for Schools
With the help of materials and tools found even in the households, pupils look for the acidity, alkalinity or neutrality of different substances.

Figure 22. Pupils in Hungary during an Ark of Inquiry activity

Sustainability actions in Hungary

HRTA will keep the materials on the organisation website and will implement Ark of Inquiry activities during their regular science fair (in collaboration with Mobilis Science Center). In the future they will (as we have in 2015 and 2017) organize workshops for teachers to foster the use of Ark of Inquiry activities and pedagogical scenarios.

Use of the award system in Hungary

Teachers in Hungary were not enthusiastic about the award system. One negative factor is that there are too many science contests in Hungary, making educators less interested in getting involved in such a process, even though the awards are not meant to be competitive. In Hungary, the talent care scene is organized around contests, each having some sort of an evaluation/assessment system already, so teachers expressed their disappointment with another system to acquire. Secondly, because, as teachers have put it, the Ark of inquiry award system uses different perspectives than the majority of other systems widely used and also differs from that of school-leaving systems, and to learn and to operate it is one more demotivating factor. Moreover, although the National Core Curriculum encourages the use of formative assessment, there is a gap between present school culture and policy will. Participants clearly refused to use the award system when presented with it, and it did not seem appropriate to insist upon using it, especially when the teachers were working as "magnet teachers" in the implementation of the project.

6.10. Italy

Country summary

Following the completion of the pilot phase of the Ark of Inquiry project in March 2016 and the first year of implementation of the project in Italy (June 2016 – February 2017), the 2nd year of implementation lasted from March 2017 until the end of the project in February 2018. Implementation activities followed the previous year's accomplishments, which had seen 104 teachers trained in three regions of Italy: Naples (southern Italy), Rosa (northern Italy) and Foligno (central Italy). The trainings were conducted in close cooperation with the National Association of Natural Sciences Teachers (ANISN) in Italy, helping administer the trainings through the use of their network and their members' facilities to host the trainings.

After the trainings concluded in February 2017, a follow-up continued with all of the teachers trained, asking them to complete an online activity report form every time they completed an inquiry activity (whether in the Ark of Inquiry platform or not) in their classrooms. Regular reminders were sent to the teachers to encourage them to report and ensure they had the links to the forms handy. In the 1st year of implementation, of the 104

teachers who participated in the trainings, 72 returned activity reports on the implementation of 76 activities in their classrooms. In the second year of implementation, covering spring 2017 and autumn 2017 terms, 14 teachers reported back completing 38 activities. This totals 114 activities reported over the two-year implementation period.

Figures from Italy

Total number of schools implementing activities	18
Total number of teachers who participated in the implementation phase	24
Total number of pupils who participated in the implementation phase	1190
Total number of other stakeholders involved in the implementation	33 other stakeholders assisted, mainly teaching assistants and pre-service teachers

Activities in Italy

After the trainings concluded in February 2017, a follow-up continued with all of the teachers trained, asking them to complete an online activity report form every time they completed an inquiry activity (whether in the Ark of Inquiry platform or not) in their classrooms. Regular reminders were sent to the teachers to encourage them to report and ensure they had the links to the forms handy. In the 1st year of implementation, of the 104 teachers who participated in the trainings, 72 returned activity reports on the implementation of 76 activities in their classrooms. In the second year of implementation, covering spring 2017 and autumn 2017 terms, 16 teachers reported back completing 62 activities.

The most popular activities reported in this second year of implementation were again the "Clementine Test" and "Paper Napkins", along with a third activity, "Life in a Fistful of Earth: the Snail". All three activities were contributed by ANISN to the Ark of Inquiry platform.

Clementine Test
http://arkportal.ut.ee/#/inq_act/1199
Knowing how to identify similarities and differences and notice the details, in a word, observe, is the basis of any investigation, and it is a competence that can be taught: this is the aim of the activity we present. Each pupil is given a mandarin with the task of drawing it. The child does not know that his or her work will after several steps act as a map for another pupil to help him or her to find just

"that" fruit. The short path is punctuated by moments of reflection\discussion that guide the understanding of what favours a "focused observation".

Paper Napkins
http://arkportal.ut.ee/#/inq_act/1204
Anna is organizing her birthday party. She will use plates, glasses and plastic cutlery, so as not to have to deal with the washing of dishes and to fully enjoy the company of friends and relatives. Even the napkins will be made of paper, coordinated in colour to the tablecloths that will cover the tables of the guests. However, she wants the napkins to be of good quality, especially to absorb liquids quickly.

Life in a Fistful of Earth: the Snail
http://arkportal.ut.ee/#/inq_act/1169
How can you awaken a snail and get it out of the shell? Pupils engage in the enterprise using the most varied strategies. Thus, they discover that the variables involved are different and that a single investigation is not sufficient to answer the question. The snails are practical animals to bring in the classroom because they can be observed at any time of the year: they are generally closed in their shell in a slowed state of life, but a leaf of fresh lettuce and a few splashes of water are sufficient to simulate the rain, so that the snails will resume an active life. The activity is divided into 4 steps.

Teachers also contributed with their own activities, such as teacher Maria Grazie Ercolese from the Circolo Didattico "G. Marconi ", who shared what her pupils did with the inquiry activity “What’s in a grape?”. Pupils explored sub-topics such as how wine is made, how vinegar is made, and how we get the juice out of the grape. Using inquiry learning as demonstrated in the Ark of Inquiry trainings, the teacher enabled her pupils to reach conclusions as to the various roles that bacteria play in the fermentation process, as demonstrated by the inflating balloons in the photos below.

Figure 23. Italian pupils doing Ark of Inquiry activities

Sustainability actions in Italy

After the administrative and programmatic closure of the Ark of Inquiry project in Italy, new teachers will still be encouraged to sign up for the Ark of Inquiry platform by the UNESCO team and its partners at ANISN. Administrator rights have been granted to the President of ANISN for any new teachers that would subscribe to the platform, which is invaluable, as one of the main lessons learned in Italy has been that teachers cannot just simply be offered these resources and be expected to make sense of them right away: they need support to help them "interpret" how best to utilize and apply these resources in the classroom, and ANISN is best situated to do just that.

Efforts have also been made to link with other UNESCO projects and activities in the field of science education. This includes adding inquiry activities from the Ocean Literacy project to the platform, as well as creating a virtual "introductory kit" on Ark of Inquiry to be sent to other UNESCO field offices around the world.

Use of the award system in Italy

In Italy, so far only two teachers have reported trying to use the award system in their classroom. Another 10 or so have indicated a willingness to try in the future but have not yet done so. When asked why it was not being used, some of the primary school teachers thought that the award system was not doable with younger pupils (ages 6-7), the procedure seemed too complicated, plus, at this early age, pupils are not familiarized with the observation yet (from the scientific method). Other teachers thought that they would need more time to understand how to apply it in their particular classroom, as on the surface they do not think it is applicable to their environment.

6.11. The Netherlands

Country summary

In the last year of implementation (March 2017 – November 2017), following the trainings provided by HAN to teachers of both primary and secondary schools across the NL, teachers implemented a variety of activities from the Ark of Inquiry platform.

HAN offered to teachers different types of trainings from inviting teachers from different regions and schools to focusing on specific schools and training a large number of their teachers or providing masterclasses to teacher students. The organisation also provided trainings to teachers in a science museum (the Watermuseum in Arnhem) and used activities of the museum to engage the participants (the activities that are now added to the ECAS portal).

Figures from the Netherlands

The overall figures of implementation in the Netherlands are the ones below for the relevant period:

Total number of schools implementing activities	55 schools
Total number of teachers who participated in the implementation phase	127 teachers
Total number of pupils who participated in the implementation phase	4924 pupils
Total number of other stakeholders involved in the implementation	9 trainers / science centre professionals

Activities in the Netherlands

HAN promoted the activities from the Ark of Inquiry platform that were recommended by the organisation to the teachers and also encouraged teachers to bring their own activities and propose them for the platform too. In the Netherlands, teachers used a great mix of activities, which made the reporting of all the activities and providing a thorough overview difficult.

Below are described two of the most popular activities as reported by teachers: two of the activities mostly used in the HAN trainings in NL. Both activities have been developed by the Watermuseum in Arnhem/NL.

Water Journey (Waterreis door de tijd)
http://arkportal.ut.ee/#/inq_act/1469
Do you know which are the 'high' and the 'low' regions in the Netherlands? Where in the country is the danger for flood? What happens when the sea level rises further? How can we keep the Netherlands safe and dry? Pupils learn to get answers to these questions with the relief map of the Netherlands. They do some tests with this map and get insight into what climate change means for the Netherlands and more specifically for the place where they live.
The activity has been designed by the Watermuseum.

Figure 24. Dutch pupils in the Watermuseum

Making the Dutch Flag by Mixing Liquids (Vloeibare driekleur)

http://arkportal.ut.ee/#/inq_act/1472
Pupils are asked to mix three liquids (red-white-blue) in a test tube. They discover that these liquids do not mix but all seek their own place. If you mix carefully, you can make the Dutch flag. On the basis of their observations they are asked to think about how this happens: what makes the liquids not mix into one colour?
The activity has been designed by the Watermuseum.

Figure 25. Researchers and pupils in the NL performing Ark of Inquiry activities

Sustainability actions in the Netherlands

HAN is looking over possibilities to offer the designed Ark of Inquiry training again to teachers in the future. This can be done via open registration but also in company trainings. The Ark of Inquiry platform with the activities, scenarios and evaluation tools will be used then. The Ark of Inquiry materials can also be used in the masterclasses 'Science and technology' that HAN is offering to teacher students in their teacher training institute.

HAN has developed a good collaboration with the Science Education Hub Radboud University in Nijmegen that also offers trainings in inquiry learning http://www.ru.nl/wetenschapsknooppunt/english/. In September 2017 they presented the Ark of Inquiry to them (platform, training, tools). Their first impression was that the Ark of Inquiry materials are complementary to the content they offer now and they try to integrate them in their trainings. Before the end of the Ark of Inquiry project HAN will be in contact with them again to discuss further cooperation.

In the last two months of the project they intend to be in touch with the Ark of Inquiry teachers and continue offering concrete tips to work with the activities and the evaluation tools and stimulate them to sign up for the platform.

Use of the award system in the Netherlands

In the Netherlands teachers have not used the award system so far. This has been the case partly because of the complexity of implementing all the different elements of the Ark of Inquiry project, and one more factor seems to be the existing school culture in the Netherlands.

In the Netherlands teachers in general are not really fond of competition. Although the award system has been developed away from simple competition and seeks to award (1) many pupils, and (2) not only on skills but also on originality, communicative performance, creativity and so on (21st century skills related behaviour), the award system is still interpreted as competitive. As a result, the Dutch teachers were not ready to adopt the idea of awarding and hence did not develop efforts to implement it.

6.12. Turkey

Country summary

The implementation plan was done as it was indicated previously, via both face-to-face and online meetings. The implementation plan was followed without deviation. “Elektrik Faturanızdan Memnun musunuz?” and “Basit bir elektrik süpürgesi” were two Turkish activities which were extremely popular among the teachers and pupils and where most widely implemented.

There were 101 teachers from 9 schools (and 36 pre-service teachers) in the implementation. A total of 2020 pupils participated in the implementation. In addition to the teachers and pupils, parents and researchers from universities actively participated in the implementation phase. The implementation included university and science centre visits (for example, to the botanical garden).

Figures from Turkey

The overall figures of implementation in Turkey are the ones below for the relevant period:

Total number of schools implementing activities	9 schools
Total number of teachers who participated in the implementation phase	101 teachers
Total number of pupils who participated in the implementation phase	2020 pupils

Total number of other stakeholders involved in the implementation	36 pre-service teachers

Activities in Turkey

DNA Analysis
http://arkportal.ut.ee/#/inq_act/1871
Implementation period: 05.10.2017
Studying the DNA of a living organism
The activity was proposed by the teacher and was added on 07.11.2017

Hovercraft
http://arkportal.ut.ee/#/inq_act/1878
Implementation period: 01.12.2017
How to reduce friction between surfaces
The activity was proposed by the teacher and was added on 07.11.2017

Measurement of Velocity with Anemometer
http://arkportal.ut.ee/#/inq_act/1845
Implementation period: 01.12.2017
Understanding that the distance travelled and time is required to measure the velocity
The activity was proposed by the teacher and was added on 06.11.2017

Hammer
http://arkportal.ut.ee/#/inq_act/1867
Implementation period: 05.12.2017

Observing the effects of friction
The activity was proposed by the teacher and was added on 07.11.2017

Electric Circuit Components
http://www.arkportal.ut.ee/#/inq_act/1771
Implementation period: 13.11.2017
Introducing the electrical components
The activity was proposed by the teacher and was added on 31.10.2017

Non-Exploding Balloon
http://www.arkportal.ut.ee/#/inq_act/1888
Implementation period: 20.11.2017
Learning how pressure of solids makes our lives easier or harder
The activity was proposed by the teacher and was added on 07/11/2017

Don’t Let our Little Friends Get Cold!
http://arkportal.ut.ee/api/inq-activity/minik-dostlarimiz-usumesin/
Implementation period: 01.09.2017
The aim of the project is to teach how heat transfer and thermal insulation can improve the overall economy of families and countries. Pupils are asked to discover how to use thermal insulation for other purposes apart from buildings and design huts for street animals.
The activity was proposed by the teacher and was added on 9.11.2017

What Kind of Light?
http://arkportal.ut.ee/api/inq-activity/nasil-bir-isik/
Implementation period: 05.11.2017

Pupils are asked to discover the light sources that they see every day and design a light source by building an electrical circuit based on their discoveries.
The activity was proposed by the teacher and was added on 8.11.2017

Surveyor's Wheel
http://arkportal.ut.ee/#/inq_act/1854
Implementation period: 01.11.2017
How does a device which measures the long jump work? Let's discover!
The activity was proposed by the teacher and was added on 06.11.2017

Let's Build a Crane!
http://arkportal.ut.ee/#/inq_act/1852
Implementation period: 02.11.2017
Building a model crane to lift heavy objects to high places.
The activity was proposed by the teacher and was added on 06.11.2017

Atmospheric Pressure
http://arkportal.ut.ee/#/inq_act/1876
Implementation period: 12.10.2017
Studying atmospheric pressure and its effects
The activity was proposed by the teacher and was added on 7.11.2017

Sound Propagation
http://arkportal.ut.ee/#/inq_act/1880
Implementation period: 12.10.2017
Observing how sound is transmitted differently through different materials, devising ways of

insulation using different materials and measuring these with the decibel meter and comparing the results.
The activity was proposed by the teacher and was added on 7.11.2017

Figure 26. Pupils in Turkey implementing an Ark of Inquiry activity

Sustainability actions in Turkey

The Bahcesehir colleges (more than 100 schools in Turkey) will actively use the Ark of Inquiry platform in their teacher trainings / seminars at the beginning of each education semester. This will provide sustainability of the platform. In addition, we will encourage teachers to add their original inquiry activities to the platform.

The Ark of Inquiry platform is now a part of the “Instructional Technologies and Material Design” course, which is taught to pre-service science teachers at Dokuz Eylul University Faculty of Education Department of Science teacher training. In the course, each pre-service teacher should find an inquiry activity from the Ark of Inquiry platform and present it as a task of “inquiry learning activity”. This contributes to the sustainability of the platform.

Use of the award system in Turkey

BEKAS informed and trained teachers to use the award system. However, they could not use the award system because of the intensive workload, official evaluation by schools, etc. The main reason behind this was the lack of time to implement the award system. During the teacher seminars/meetings, teachers’ opinions were really optimistic; however, they could not find enough time to focus on the award system. However, if they find enough time, they plan to use the award system.

6.13. Albania

On 9-10 November 2017, the UNESCO Venice Office, with the support of Ellinogermaniki Agogi, organised a two-day training for Albanian teachers in Tirana, Albania. 40 teachers coming from different regions of the country came to the two-day meeting, which focused on the topic of gender inclusion and Responsible Research and Innovation. A number of activities from the Ark of Inquiry platform were translated into Albanian and implemented by teachers during the two-day workshop. Teachers were given a more extended list of activities they were encouraged to implement in their classrooms. Below is a list of some of the activities that have been translated into Albanian. The exact number of teachers who have implemented the activities is not yet available, but a connection has been established with the Ministry of Education in Albania ensuring the continuation of this initiative.

Figure 27. Participants of the training event in Albania with trainers from EA and UNESCO and the Albanian association of women in science representatives

7. Inquiry award system

Looking at the overall picture in the partner countries in regard to the implementation of the awards, it is obvious that the award system has not been widely used in the majority of the countries. The reasons behind the lack of their use seem to have similarities:

Lack of time from the teachers' side

Teachers have endorsed the Ark of Inquiry activities in all the partner countries. They have followed the trainings, they have been introduced to the Responsible Research and Innovation principles and have been busy implementing the activities. As education systems in most of the countries are very demanding, there has been no space left for them to get more familiar with the awards and implement them in the classroom.

Teachers not confident enough with RRI

The award system is one of the most far-reaching goals that the project has set, so it seems quite natural that it has not been implemented within the timeframe of the project in many countries. Already from the WP5 study card 1 that explored the use of the awards, it could be seen that many teachers have been implementing level A inquiry activities: small and structured experiments. Therefore, teachers find it difficult to combine RRI actions with the experiments.

Nature of the Ark of Inquiry support system

During the trainings the award system has been addressed only after addressing the inquiry cycle model, inquiry activities, formative evaluation and RRI with the teachers. This explains that the award system was not at the front of teachers' heads when implementing the Ark of Inquiry.

School culture

In many countries, either teachers are not in favour of competition or the school system does not allow any additional form of awarding and competition but the one recommended by the relevant educational authorities. Although the award system has been developed away from being a typical competitive system and seeks to award many pupils, and not on their learning but also on originality, ability to communicate, creativity, and so on (21st century skills related behaviour), the award system is still interpreted as competitive. As a result, the teachers have not been keen to adopt the idea of awarding and hence have not widely developed efforts to implement it.

8. Summary

Last implementation phase

During the last 12 months of the project, all eleven partners were extremely active. Once teachers were trained extensively and the Ark of Inquiry platform was enriched with a great range of activities in all the partner countries, schools across Europe implemented the Ark of Inquiry activities at large. Overall, 1060 schools, 2479 teachers, 36 710 pupils and 363 education professionals used the Ark of Inquiry activities in their classrooms. Using different implementation strategies, from choosing a more limited number of activities and widely promoting them across the country, as it happened in Greece or Belgium, to uploading a much greater number of activities and having teachers using them more independently, as it happened in Cyprus, implementation strategies were successful. Methods such as competitions (see the Eratosthenes experiment or schools study earthquakes), which were used as an incentive for teachers to implement the activities of the Ark of Inquiry platform have also been very successful. A very positive aspect of the implementation phase has also been the wide involvement of other professionals besides teachers such as researchers (see Belgium) or museum/science centre professionals (see Estonia).

Overall implementation

The Ark of Inquiry project aimed to implement inquiry activities and raise awareness of Responsible Research and Innovation across Europe, reaching schools and engaging pupils, teachers, researchers and science communicators. The project, during the period of 36 months, not only achieved its original goal, with figures exceeding the original goal of 23 000 pupils and 1100 teachers, but managed to implement activities and involve 1426 schools, 322 teachers, 42 627 pupils in more than 42 countries in Europe and beyond.

The first piloting phase of the project with a duration of six months, as reported in D6.1, started in September 2015 and lasted until February 2016. During this period, 85 in-service science teachers – 23 in primary education and 62 in secondary education – along with 80 pre-service teachers or science students participated from 9 countries. The distribution of the number of participants per country is shown in the table below.

Table 8. Implementation numbers during piloting for teachers

Partner	Country	Number of primary school teachers	Number of secondary school teachers	Number of student teachers
UNESCO	Italy		14	
EA	Greece	2	7	
UCLL	Belgium			8
UT	Estonia	4	11	

UTU	Finland	9		
UCY	Cyprus			72
HAN	Netherlands	6	3	
BMB	Austria	2	9	
EADN	France		18	
Total	**Total**	**23**	**62**	**80**

Through introductory workshops, presentations and hands-on sessions, focus group discussions, interviews and structured questionnaires, a wealth of valuable qualitative and quantitative feedback on various aspects of the Ark of Inquiry platform, proposed activities, award system, etc. was received. This feedback, useful to the partners and national coordinators, was used in order to define the national implementation plan per country. The plans were implemented during the last 24 last months of the project.

During months M24–M48, partners established connections with various stakeholders in their countries, collaborated in many cases at European and even international level and, using the Ark of Inquiry platform, got to perform hundreds of different activities in classrooms and beyond discussing issues from biotechnology to space and from bioinformatics to earthquakes. Even though the award system was not widely used due to various issues given above, it provides the basis for a system that may be useful in the future once the RRI concept is more widely used by teachers and once more time is given to address local differences and restrictions.

Table 9. Detailed presentation of the number of teachers, pupils and educational authorities that participated in the whole implementation period (M13–M48)

Country	**Partner**	**School**	**Teachers**	**Pupils**	**Other**
Austria	BMB	137	281	2100	34
Belgium	UCLL	57	132	482	86
Cyprus	UCY	44	172	1229	143
Estonia	UT/ AHHAA	81	311	389	157
Finland	UTU	13	80	1215	30
France	EADN	57	81	1072	36
Germany	UBER	51	59	1275	3
Greece	EA	257	414	5264	70
Hungary	HRTA	120	112	8782	0
Italy	UNESCO	78	122	2998	90
Netherlands	HAN	105	144	5096	9
Turkey	BEKAS	12	110	2320	39
29 other countries		414	1204	10 405	17
	Total	**1426**	**3222**	**42 627**	**714**

Appendix 1: Implementation activities per country

Detailed overview of implementation activities can be found in Google Drive at http://bit.ly/implementationARK