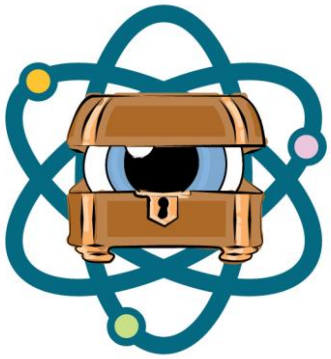

Ark of Inquiry: Inquiry Activities for Youth over Europe

Report on the Pilot Phase in Italy

September 2015 – February 2016

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Background

The Ark of Inquiry (AoI) project aims to raise youth awareness to Responsible Research and Innovation (RRI) by providing young European citizens (7- to 18-year-olds) with a pool of engaging inquiry activities. These activities are intended to improve inquiry skills, increase awareness and understanding of conducting 'real' science, and prepare pupils to participate in different roles in the European research and innovation process through inquiry-based science education (IBSE). Therefore, in order to achieve the 'new science classroom', the AoI project is focused on inquiry-based learning. Inquiry learning is being defined in the current project as "an approach to learning that involves a process of exploring the natural or material world, and that leads to asking questions, making discoveries, and rigorously testing those discoveries in the search for new understanding" (de Jong 2006). More specifically, inquiry learning is a process where the learner formulates hypotheses and then tests them by conducting experiments and making observations (Pedaste et al. 2015). This approach has been derived from an Inquiry Learning Model, which is comprised of 5 phases[1].

This report will detail the pilot implementation phase of the AoI in Italy. Under Work Package 6 (WP6): Implementation of the AoI project, implementation was planned to take place in two phases: the pilot phase and the large-scale implementation phase. Feedback collected during the pilot phase on learning scenarios will be used to improve the AoI project for the future and for developing teacher training activities. Thus, this report of the pilot phase aims to facilitate the scaling-up of the implementation phase in Italy, which will begin in late spring 2016. This report is structured as follows: in the first section, the background of the AoI project will be explored, and in the second section, the data collection methodology will be introduced. The second section will detail the online interviews, the structured interviews and the focus group discussions with participating teachers. In the third section, the key findings from the analysis of the quantitative and qualitative data produced by the instruments in the pilot phase will be presented, followed by some recommendations for the implementation phase of the AoI project. In the last section, conclusions will be drawn to guide the progress and future development of the project overall.

[1] http://www.arkofinquiry.eu/teachers

Introduction

For the pilot phase of WP6, 5 schools from 7 countries were projected to be involved in the AoI project, with the UNESCO Regional Bureau for Science and Culture in Europe being responsible for the activities to be undertaken in Italy. The other countries involved were: Austria, Cyprus, Estonia, Finland, Greece, and the Netherlands; some pilot activities were also carried out in both Belgium and France. This report will focus on the pilot phase carried out by the AoI project partners in Italy.

Overall, the pilot phase in Italy was conducted during a period of 6 months; the initial preparations began in September 2015, and the pilot phase ended in February 2016. Introductory meetings with teachers were conducted in Italy at the end of September and the beginning of October. Another face-to-face meeting took place in November, and questionnaires and interviews were completed in December and January. This is the schedule of the main actions undertaken in Italy for the pilot phase of the AoI project:

1. August-September 2015: Preparatory actions and school/teacher selection process
2. October 2015: Introductory meeting with participating teachers held at the UNESCO Regional Bureau for Science and Culture; "Homework assignment" made available to teachers
3. October-December 2015: Participating teachers implemented 3 inquiry-based science activities from the AoI platform in the classroom
4. November 2015: Optional online interviews concerning the pedagogical scenarios took place, and the Focus Group meeting was conducted in person at the UNESCO Regional Bureau for Science and Culture
5. January 2016: Participating teachers completed the end-of-pilot questionnaire
6. March 2016: Certificates were issued to teachers who participated in the AoI pilot phase

In order to successfully complete the full pilot phase, teachers were asked to participate in the Introductory Meeting, complete the Homework Assignment online, and select and implement up to 3 activities from the AoI platform in their science classroom(s).

Methodology

A. Preparatory Work

This section will explain the preparatory work undertaken for the launch of the AoI pilot phase in Italy, background information about what the UNESCO Regional Bureau for Science and Culture in Europe prepared for the pilot phase, and how teachers and schools were selected to participate in the pilot phase of the project.

i. Developing an Online Training Course

First, to support all teachers interested in the AoI project, an online training course was designed by the UNESCO Regional Bureau for Science and Culture in Europe[2]. The training is hosted on the main Ark of Inquiry website (www.arkofinquiry.eu); the goal of providing the web-based training material was to engage science teachers at primary and secondary schools to learn more about inquiry-based learning. This course, available both in Italian and English, gives an overview of the inquiry process and introduces teachers to what their specific role in the AoI project would be; namely, to support their pupils in the AoI activities and provide them with constructive feedback on completed inquiry activities. The course is divided into four sections (see Figure 1 below):

Figure 1. Screenshot of Table of Contents of Online Training Course ©UNESCO

At the end of the course, teachers can test their knowledge of inquiry-based learning using a quiz called "test your knowledge". All teachers that participated in the pilot phase have completed this course and quiz. Therefore, the "test your knowledge" section at the end of the course has been completed a total of 31 times to-date, both by the teachers participating in the pilot phase and by other individuals who accessed the training course online on their own through the public AoI website.

ii. Teacher Selection Criteria

A selection process took place to select a minimum of 15 science teachers from at least 5 schools in the country of Italy for the pilot phase. It was decided to limit the teacher recruitment process for the pilot phase of the project to the Veneto region of Italy, so that teachers could easily reach the UNESCO Regional Bureau for Science and Culture in Europe (in Venice) for meetings. Thus, a call for participation was sent to the regional newsletter of the Ministry of Education, which they circulated in both English and Italian to their constituents. The same call for teacher participation in the project was also posted on the website of the UNESCO Regional Bureau for Science and Culture in Europe. Both primary and secondary schools and teachers were invited to apply to participate through the completion of an online Google form in Italian. The deadline to apply was on 2 October 2015. The selection criteria used to select the 15 participating teachers was:

1. Teacher(s) with good knowledge of the English language, both in reading and writing;

[2] http://www.unesco.org/new/en/venice/resources-services/host-facilities/special-events/ark-of-inquiry/

2. Teachers and schools with some interest in inquiry-based science education approaches and methodologies;
3. Teachers and schools with positive attitudes towards innovative methods of teaching and learning using new technologies;
4. Teacher(s) with basic experience using computers;
5. Schools equipped with a classroom or lab with computers connected to the internet.

Based on the above criteria, 15 out of 25 teachers who had expressed their interest via Google Forms were selected for participation. However, one of the selected teachers had to withdraw from the project. As a result, 14 teachers from 12 schools were selected for the pilot phase (NB: one teacher who did not have the English language skills to participate worked with a fellow English teacher during the pilot phase of the project). All of the selected teachers were from secondary schools within the Veneto region (See Appendix A).

B. Introductory Meeting with Participating Teachers

An introductory meeting was organized by the UNESCO Regional Bureau for Science and Culture in Europe for the 14 selected science teachers in the Veneto region on 14 October 2015. The purpose of the meeting was for the UNESCO Regional Bureau for Science and Culture in Europe to welcome the teachers and introduce them formally to the Ark of Inquiry project. The UNESCO Regional Bureau for Science and Culture in Europe's expectation for the introductory meeting of the pilot phase was for teachers to understand the basics of inquiry-based science education, and for teachers to understand the role of Responsible Research and Innovation (RRI) in the AoI project. This meeting was also an opportunity to network with other teachers as well as with researchers and scientists from universities, science centers and museums from all over Europe. In this meeting, teachers were given instructions on how to access and use the AoI platform, and their role during the pilot phase was elaborated on by the UNESCO Regional Bureau for Science and Culture in Europe (see Figure 2 below).

Figure 2. Introductory Meeting ©UNESCO

Participating teachers' interests and their education varied; they completed education degrees in areas ranging from agricultural education to mathematics and environmental studies. The teachers all taught subjects in the fields of Science, Technology, Engineering and Math (STEM fields). Teachers

were inclined to participate in the pilot phase for different reasons. For example, some teachers were asked to participate by their schools, in order to increase science scores at their schools. Other teachers believed that the AoI project would be an interesting opportunity for them to diversify their instruction in the classroom. Some teachers were already familiar with inquiry-based science education (IBSE) and wanted to put their knowledge into action. After the UNESCO Regional Bureau for Science and Culture gave an introductory presentation about the AoI project, teachers learned about the AoI platform through a video prepared by the University of Tartu, an AoI project partner.[3] The teachers asked very practical questions about the implementation of the pilot phase, including questions about lesson preparation, future use of the activities, and timing of the lessons. This discussion demonstrated the participating teachers' dedication to the implementation of the pilot phase for the AoI project in Italy.

At the meeting, teachers were also given the agenda, a welcome letter from the local coordinator and team leader, leaflets on the project (in English and Italian), and the first two issues of the Ark of Inquiry newsletter (in English only). Furthermore, teachers were given a "Piloting: Ark of Inquiry platform" reference document, detailed instructions for their "Homework Assignment", a list of IBSE activities on the platform, three copies of the activity reporting form and a sample template for submitting new activities.

C. "Homework Assignment" for Teachers

As an immediate follow-up to the introductory meeting, a "Homework assignment" was given to the teachers, which was due by 31 October 2015. For this assignment, teachers needed to access the AoI platform and the inquiry activities, and add their own if they felt inclined to do so. This assignment also allowed the teachers to take the online training course developed by the UNESCO Regional Bureau for Science and Culture in Europe. After teachers completed the online course and gained full access to the AoI platform, they were then asked to answer some questions about the AoI platform online. These questions were designed by the AoI project team to gain teachers' insights on the current state of the online platform; teachers were able to provide insight about the state of the platform, and critically assess its potential for use in the classroom. In Italy, teachers were requested to perform this task at home, and to submit their answers via an online Google form[4].

All of the 14 selected teachers completed the Homework Assignment and provided preliminary responses about the state of the platform. It was found that over 80% of teachers were well or very well aware of inquiry-based science education practices, and had been familiarized with IBSE concepts before the introductory meeting. However, 15% of participating teachers reported feeling unclear about the use and assessment of the inquiry cycle and RRI in the classroom.

[3] https://www.youtube.com/watch?v=tQfwbsO1k2s)
[4] https://docs.google.com/forms/d/1czHwoDH4VaUfFuC1hW9pZ8hWCZL8vk1-IY785VtgNpM/viewform

In terms of the usefulness of the platform, around 85% of teachers thought that managing and navigating the platform was simple, and that it could be useful in their classrooms. However, one teacher made a suggestion that the search settings on the AoI platform should make it easier to look up a specific activity. For example, teachers mentioned that activity descriptions should include "an abstract of the contents", "a list of keywords" or "a schema of the topic's connections"; incorporating these suggestions into IBSE activity descriptions would make it easier to look up a specific activity using the search function on the AoI platform. Furthermore, most teachers (approximately 60%) reported that they believed all STEM domains (ex. Chemistry, Physics, Mathematics, Biology, etc.) were covered in the activities available on the platform. It was reported that 40% of teachers did not agree with the targeted age groups listed for some activities on the AoI platform. One of the teachers, for example, considered that one activity would be better targeted to pupils aged 7-16, rather than 16-18.

Furthermore, 30% of teachers felt that the time duration for some of the activities listed on the platform were too short; they reported that many complex tasks needed to be completed in a short time span. For example, one teacher stated: "There's too much to do in a short time because some aims [of the activities] are not very simple". A large majority of the teachers also noted that they were facing difficulties connecting RRI concepts to the activities in their classroom. Specifically, half of the teachers surveyed after the homework assignment confirmed that they were not sure how to facilitate RRI concepts within the context of their classroom activities. Overall, all teachers mastered how to access and use the AoI platform effectively. When teachers assessed the usefulness of the AoI platform, they felt that the layout of the "Homework assignment" was easy to understand and was well-structured (see Figure 3 below).

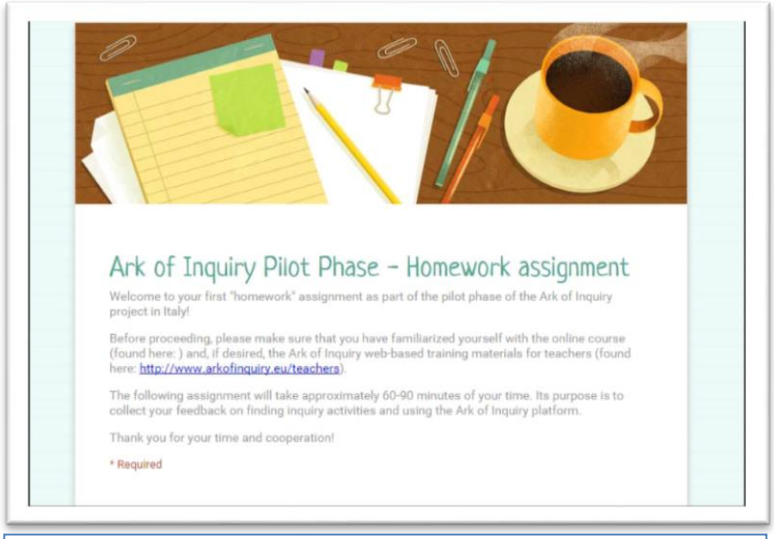

Figure 3. Screen shot of Homework Assignment ©UNESCO

The key areas for improvement to the AoI platform found from teachers' homework assignment answers concern the following: updating the activity descriptions on the platform to include "key words" and other information that will make searching for specific activities more straightforward

for teachers, updating the targeted ages and time duration for certain activities, and finding ways to help teachers better implement RRI concepts into the IBSE classroom activities that they selected.

D. Teacher Feedback on Activity Implementation in the Classroom

The next part of the pilot phase required teachers to implement 3 activities from the AoI platform in their classroom from October – December 2015. As a result of this implementation, 629 pupils from the Veneto region were involved in 19 different AoI activities implemented in 38 classes, with the average class size being 17 pupils per teacher (rounded from 16.55 pupils per teacher).

After the activities were put into practice in the classroom, each teacher was required to report on the activities' implementation. The teachers were required to use the feedback form provided by the AoI project (available through Google Forms), and were also asked to provide photos of the class completing the AoI activity as proof of participation (see Appendix B). The feedback form required teachers to report on the activities they used in their classrooms, their desired learning outcomes for the activities, and a critical analysis of the activity. The feedback form also required teachers to state if they would use the same AoI activity again. This section of the pilot phase report will therefore summarize the type of activities teachers implemented in their classrooms, and explore teachers' feedback concerning these activities in-depth.

To begin, all participating science teachers implemented at least two activities from the AoI platform; 9 teachers fulfilled the requirement of implementing three activities in the classroom. As some teachers did activities together or happened to choose the same activity, a total of 19 activities were implemented 38 times in Italy during October -December 2015. The activities that teachers selected the most often from the platform can be seen in Table 1 below, in order or popularity.

Table 1: Top 5 activities used by teachers, (1 is most popular, 5 is least popular).

Name of Activity	STEM domain(s) covered	No. of Teachers that implemented Activity	Location of Activity
1. Build an Atom	Physics	5	Inside of school
2. Which Soap is the Best?	Chemistry	4	Inside of school
3. Carbon detective in Transport	Chemistry & Mathematics	2	Outside of school
4. Sinking and Floating	Physics	2	Inside of school
5. Where does food come from?	Biology	2	Inside of school

The following STEM domains were covered during the implementation of activities in the pilot phase; 16 activities involved Chemistry content, 11 activities involved Physics topics, and 6 activities covered Biology content. A total of 33 activities were carried out on school grounds (87% of the activities that took place during the pilot phase) and 5 of the selected activities were completed off of school grounds (13% of the activities that took place during the pilot period). All of the pupils that completed the activities were 11 years of age or older, and 81% of the AoI activities implemented during the pilot phase were catered towards pupils aged 13 to 16 (31 out of the 38 total implemented activities). Furthermore, 12 out of the 38 activities (31.6%) implemented during the pilot phase were at the "Basic" (A) inquiry level (the lowest inquiry level), 25 out of the 38 activities (65.8%) implemented

were at the intermediate Advanced (B) Inquiry level, and only 1 out of the 38 activities implemented (0.03%) were Expert (C) level activities. Lastly, there was no obvious trend between the age of the pupils and the level of inquiry activity that they completed; pupils as old as 16 completed Basic (A) level activities, and the only Expert activity selected was for a class of 14 year-old pupils. A complete list of all activities selected by the participating teachers is available in Appendix C.

In terms of teachers' feedback collected about the activities, teachers generally made positive remarks about the activities being effective learning tools. Teachers commented that their pupils showed interest and enthusiasm throughout the learning process, stating that the activities gave pupils "greater independence" in the classroom. Teachers also noticed that inquiry-based education methods allowed pupils to work on their discovery skills, communication skills, teamwork skills and presentation skills. Images of the pupils completing some of these activities can be seen in Figures 4 and 5 below.

Figure 4. Pupils involved in experimenting with light fixtures in a small group classroom setting- "How are the light fixtures in a house connected?"©Cividin, Alessia.

Figure 5. Pupils investigate where daily bread comes from while on a class trip at the local supermarket using the activity "Our Daily Bread?" ©Costantina, Righetto.

The inquiry stages were well-received by the teachers and pupils, with one teacher stating that the stages helped with "reinforcing pupils' knowledge naturally". Some teachers noted that the inquiry cycle made their pupils more curious about the science content at hand. One teacher claimed that "the worksheets and laboratory experiments have encouraged the discussion on … the importance of carbohydrates, proteins and fats in the diet". Many pupils also enjoyed the more interactive learning materials provided, such as an introductory video used in the orientation phase of one AoI activity. Thus, from the feedback outlined above, it is clear that pupils generally garnered positive attitudes towards the AoI activities, and developed new skills due to the implementation of the inquiry phases in class.

Lastly, when the participating teachers were asked whether they would use the same topics again via the feedback form, the majority of teachers responded that they would do so because the

activities were “well-designed”, “simple”, “interesting”, and generated high pupil engagement. For example, one teacher commented that the AoI activity topics “involve all pupils easily”.

On the other hand, some barriers and concerns about the activities emerged from the feedback provided by teachers. One of the main barriers to success with the activities was the lack of technical resources for pupils inside and outside of the classroom. For instance, one teacher stated that “for most of the activities, only half of the pupils were able to complete the assignment at home”, due to a lack of technical resources available to these pupils. This comment can illustrate the gap between pupils with access to technology, and pupils without access to technology; if pupils are not able to access the information on the platform on their own, they lose the ability to work on science activities on their own time. This gap needs to be addressed, as pupils’ success in the AoI project is heavily dependent on the possession of technical resources in the classroom and at home to continue their learning.

Teachers also mentioned that facilitating the activities in English was difficult, with one teacher noting that “many of them [the pupils] were unable to understand the questions in English”. Therefore, teachers were struggling with starting the activities, especially in the orientation phase.
The most frequent comment from teachers was that it took more time than expected to translate the activities/materials and to prepare for the activity ahead of time. Teachers also noted that the lessons took longer than expected in class. For example, in the activity where pupils need to estimate the density of an endangered plant species in a certain ecosystem, typical learning time suggested for the activity in the AoI platform is listed as 2 academic hours, however one teacher commented that it took 19 academic hours to complete in class. With regard to the timing of the phases in the inquiry cycle, one teacher said, “The introduction phase was too long so I would like to start with investigation and conclusion phase”. Therefore, alterations to some of the activities may need to be made by teachers to better suit their classes, and lesson times should be adjusted on the AoI platform to better reflect realistic lesson timeframes.

In conclusion, the teacher responses reflected positively on the AoI project, with teachers commenting that the activities provided pupils with the opportunity to learn new skills, and raised pupils’ curiosity surrounding scientific topics. However, some constructive criticism was received and, as a result, the AoI project team should assess these comments and consider making revisions and appropriate changes to the activities on the platform. Overall, further informing schools about the technical requirements for the project, providing Italian translations of popular activities, and providing accurately timed lesson plans/activities are actions that the AoI team will help to facilitate for the future of the project. To do this, remaining in constant communication with participating teachers and schools is important, which is something that will continue into further phases of the AoI project.

E. Pedagogical Scenarios

In order to achieve the 'new science classroom' as envisioned by the Ark of Inquiry (AoI) project, an enhanced learning environment is required in the classroom. To facilitate this, the AoI project developed six general teaching focuses, which were referred to as 'pedagogical scenarios'. The situations are designed to help teachers adapt existing activities to better suit the needs and goals of their specific school environments, while keeping the core focuses of the AoI project in mind. Teachers were given explanations of the pedagogical scenarios during the introductory meeting in a presentation given by the UNESCO Regional Bureau for Science and Culture in Europe. In order to capture the learning situation that was emphasized in these pedagogical scenarios, structured interviews were conducted online via Google Forms in November 2015 with nine teachers who volunteered to review each of the scenarios.

The aim of these interviews was to collect feedback around the understandability and usability of the pedagogical scenarios. Prior to the interviews, teachers were asked to familiarize themselves with one of the six scenarios proposed by the AoI project team and were required to design a learning situation for one of the activities on the platform. The six pedagogical scenarios as identified by the AoI project are as follows:[5]

- **Scenario 1: The concept of inquiry learning and Ark of Inquiry model:** This scenario describes how teachers can become more comfortable with the IBSE method and the 5 phases of the inquiry cycle.
- **Scenario 2: Proficiency Level:** This scenario encourages teachers to acknowledge that different learners in the same classroom may differ in how competent they are with the inquiry learning cycle.
- **Scenario 3: Adding/ or improving inquiry phases**: This scenario encourages teachers to add or take away phases of the inquiry cycle, depending on how well-developed the phases of the AoI activities are on the platform.
- **Scenario 4: Empowering girls in science:** A major goal of the Ark of Inquiry project is to attract more girls to science and STEM careers. As a result, teachers are encouraged to develop learning environments with characteristics that motivate and engage girls.
- **Scenario 5: Overcoming language barriers:** Teachers are encouraged to use activities that are not in their first language, or their pupils' first language.
- **Scenario 6: RRI (Responsible Research and Innovation) emphasis:** RRI is a central theme in the European Union vision. RRI initiatives in science education aim to boost the interest of children and youth in math, science and technology, and to prepare them to take responsibility in the research and innovation processes as researchers or societal actors in the future.

Teachers were provided with the above 6 scenarios, as well as a short check-list to help them to:

1) Identify areas of adjustment for some inquiry activities and

[5] https://drive.google.com/file/d/0B1cCT4KQ-CA8UXZRREtWZFZTaFU/view?pref=2&pli=1

2) Obtain ideas about how and when to make these adjustments in order to accommodate all learners.

i. Understandability of the Pedagogical Scenarios

In general, teachers reported that the six pedagogical scenarios were simple and easy to understand. However, teachers found that the scenario descriptions were confusing, and also found it difficult to implement the scenarios in practice. For example, the scenario which suggests altering the activity to suit a specific class's proficiency level (Scenario 2) requires the teacher to have the skills to recognize what is encompassed in each proficiency level, which were not skills that had yet been solidified in the pilot phase. Furthermore, the RRI scenario (Scenario 6) did not show specific examples of how to implement RRI in the classroom; the implementation of RRI in the classroom requires individual teachers to elaborate on RRI concepts to ensure their class can link it to their inquiry process. Some of the suggestions put forth by the teachers were to make the descriptions of the scenarios clearer, to include lists or summaries of the main action points of the scenarios, as well as to include the time duration for each step of the inquiry cycle for activities on the platform.

ii. Usability of the Pedagogical Scenarios

Teachers also confirmed that the descriptions of the 6 scenarios raised their awareness of the core focuses of the AoI project. For example, girls' inclusion in the science classroom (Scenario 4) is facilitated when teachers include girls' interests in science into lesson plans. Girls are more engaged in science lessons when they involve the fields of medicine, environmental studies, or climate; these STEM topics allow girls to connect their scientific knowledge to the real world. Teachers reported that this was true in practice, as their female pupils were more engaged when lessons involved the above STEM content. The pedagogical scenarios also created room for teachers to reflect on their classes' progression to higher levels of inquiry and scientific learning (Scenario 3), and encouraged making connections between the classroom content and the real world (Scenario 6). Teachers were also able to facilitate effective learning by introducing the orientation phase, in which pupils showed engagement and interest in the scientific topics at hand (Scenario 1).

On the other hand, some challenges were found while putting the scenarios into practice. One of the main challenges noted by teachers was the language barrier; pupils were sometimes unable to express their ideas in English during the AoI activities. However, it was noted by teachers that using English allowed their pupils to increase their language abilities and to gain new communication skills (Scenario 5). The teachers also expressed that adjusting the age range and learning levels for the activities was especially difficult for higher level pupils (Scenario 2 and 3). Lastly, some teachers explained that the equipment required for experiments during the activities was not easy to find for the class and was also, in some cases, expensive.

iii. Designing the Learning Situation with Pedagogical Scenarios

Throughout the interview process, teachers provided advice on designing appropriate learning environments for their science classrooms. Teachers noted that it was important to be flexible during class, because it took time to explore, observe, and respond to the questions that pupils had about the activity. The feedback from teachers also highlighted that their pupils gained practical skills in the classroom through the AoI activities. Teachers commented that communication skills are imperative to pupils' academic success, as these skills allow pupils to share their ideas and interact effectively with their peers.

In order to teach the AoI science lessons effectively, teachers noted that "the grocery terms in English" [read: list of terms] should be given to pupils at the basic level of inquiry, so as to overcome language barriers. Some teachers also recognized the importance of applying the inquiry cycle, in particular the "orientation phase", as this phase can trigger pupils' interest in the real-world application of the inquiry activities.

Furthermore, the teachers noted that one should start teaching from a lower level of inquiry (i.e. Basic as compared to Advanced or Expert), so as to easily remove some steps in the activities. This removal of steps from the activities allows pupils with higher levels of inquiry skills to gain more independence during the lesson, and encourages them to use their critical thinking skills to solve the scientific problem in new and different ways[6]. Similarly, teachers recognized the importance of adding steps to the AoI lessons if a pupil was struggling with the content at hand, thus catering to all levels of IBSE learners. Presenting more steps and thereby introducing more structure to the lesson plan allows pupils struggling with solving the scientific problem at hand a chance to learn about inquiry itself, and use the strategies they learn as an example for later inquiry activities in class.

In conclusion, by using the 6 pedagogical scenarios in a classroom setting, teachers were able to involve all of their pupils in the inquiry process by connecting their pupils to real world applications of scientific problems. The description of the 6 scenarios were easy to follow for teachers, however some specific examples should be described in more detail to help teachers put RRI into practice. Some criticisms included that an English "list of terms" should be added to the activities to overcome language barriers. It was also found that assigning accurate levels to activities is important for success in the classroom; the ability for teachers to adjust the activity level for their classrooms is a great asset to the success of the project, and should be encouraged for future revisions to the AoI activities on the platform. Therefore, the efficiency of inquiry-based learning is established through teachers' creativity, which should be supported in the AoI training. In all, teachers' comments showed that these 6 pedagogical scenarios helped them to understand the core ideas of the AoI project, and how to implement these key ideas into their science classrooms and activities.

F. Report on the Focus Group Meetings

[6] http://www.arkofinquiry.eu/deliverables-0

The main aim of the focus group discussion was to collect feedback on the AoI evaluation instruments and award system; the responses and views of the selected teachers were analyzed by the AoI project team. Assessing every pupil's progression through the inquiry cycle is an essential feature of the AoI project[7]. Therefore, the AoI project formulated an evaluation system aimed at assessing the progress pupils make in the classroom and selecting next steps for further achievement. For example, at each of the three inquiry proficiency levels (Basic, Advanced, Expert), pupils can take a summative test to confirm and prove their proficiency. An awards system was also set up for pupils to celebrate their achievement if they passed a certain level. The evaluation is conducted by the following people: the pupil, the teacher, peers from the classroom, or the AoI community.

Evaluation of pupils' progress through the AoI activities is as follows: pupils complete self-reports about their performance, pupils give feedback about their peers' performance (peer-feedback), teachers conduct formative dialogues with their pupils, teachers monitor their pupil's portfolios of work and finally, teachers assess their pupils with a summative assignment which proves the pupils' inquiry level and content proficiency. Images from these meetings can be seen in Figure 6 below.

Figure 6. Focus Group Discussion ©UNESCO

The questions posed to teachers during the focus group session revolved around the extent to which the general, formative, self-report, and peer feedback evaluation systems were relevant to teachers and pupils. This session was held on 24 November 2015 at the UNESCO Regional Bureau for Science and Culture in Europe in Venice with 6 out of the 14 selected teachers in the Veneto region who had

[7] https://sisu.ut.ee/sites/default/files/ark/files/award_system_instruments.pdf
https://sisu.ut.ee/sites/default/files/ark/files/evaluation_system_instruments.pdf

volunteered to participate. Prior to the teachers' arrival at the focus group discussion, the teachers were asked to perform at least one of the activities on the platform and to read through the proposed evaluation and award instruments developed for the project.

The instruments of the evaluation system are comprised of: a self-report form and a peer feedback form for pupils, a protocol for teacher-pupil dialogues, a summative skills test and a summative assessment form for teachers. The evaluation system provides guidelines for building and keeping digital or physical versions of portfolios with pupils' work, and a general assessment procedure that guides the start of the portfolio-making process.

The evaluation system is based on the 5-stage inquiry approach: (1) orientation, (2) conceptualization, (3) investigation, (4) conclusion, and (5) discussion. Furthermore, the evaluation system defines three levels of proficiency from Basic (A) to Advanced (B) to Expert (C) inquiry levels. For each level, criteria per phase of inquiry are defined for pupils and teachers. The framework forms the central point of reference for pupils and teachers alike.

i. Report on the Formative Assessment, Self-Report, And Peer Feedback

All of the teachers involved in the focus group agreed that formative assessment is of key importance when evaluating their pupils' educational progress. Teachers noted that during formative assessment, pupils begin to understand the process of evaluation on their own and are then able to judge their learning progress more accurately. Teachers replied that they use formative assessment in conjunction with peer feedback and self-evaluation, because pupils are more motivated to perform well on a task when they know that are being evaluated by their peers and their teacher. In addition, when pupils are evaluated in a group setting, they are more motivated to set goals and that involve the development of social skills, communication skills and relationship building. Teachers commented that formative assessment evaluates the progression and process of pupils' learning, and not just their final work product. Issues pupils may be having with the content can therefore be addressed before the summative assignment takes place.

Moreover, anonymous evaluations for pupils should take place during the peer feedback evaluation. Teachers mentioned that the anonymous nature of peer feedback would avoid biased or subjective comments, and may help to reduce tensions between pupils in the classroom. Thus, the various approaches for evaluation should enhance pupils' learning, and assessment should be continuously developed to reflect classroom learning processes.

ii. Usability of the Evaluation and Award System

This section of the report will summarize discussions centered on each evaluation instrument during the focus group meeting. In general, most of the teachers involved in the discussion noted that they used formative assessment throughout their lessons and followed the evaluation procedure that was provided with the activity on the platform. However, due to language barriers in one teacher's classroom, they found it difficult to implement the evaluation methods. Most of the teachers agreed

that pupils' work in the investigation and conclusion phases of the AoI activities were more difficult to evaluate, as opposed to the orientation phase. Furthermore, when teachers were asked whether the assessment instruments supported formative evaluation, most teachers found these instruments challenging to use because they took a lot of time to implement in the classroom. Also, teachers found the formative assessment tools were difficult to use in their web-based format.

The teachers had yet to implement the self-report in practice. The components of the self-report are broken into 3 main questions/parts: 1) which phase of the activity did the pupils find easy, 2) which phase did the pupils find difficult, and 3) questions pupils had for their teachers about the activity. Teachers' initial impressions of the self-report form was that the questions had to use more appropriate terms; teachers found the wording did not sufficiently capture their pupils' performance by rating the task as 'easy' or 'difficult'. The teachers agreed that the questions should be more direct. Therefore, questions in the self-report should ask pupils questions like the following: "What are the outcomes of your work?", "What was more interesting for you to learn?" "How do you think you are improving?" etc. These kinds of questions may lead pupils to thoroughly and thoughtfully review their own learning during the AoI activity. Teachers also explained that there should be a section on the AoI platform where pupils' work and a profile picture are visible to their classmates and teacher. This would give pupils ownership over their own work on the platform, and teachers noted that pupils seeing their own work published online would be a great motivational tool.

Firstly, teachers agreed that the three-star categorization was not enough to accurately reflect pupils' learning. Teachers then concluded that there is a need for at least a five-star rating system to evaluate pupils' learning on the peer feedback form. In addition, teachers believed that there could be sections on the peer feedback form for evaluating both peers' learning product (final step/product from the activity) as well as their learning process (their progression towards meeting goals during the course of the activity). Teachers also wanted to see different feedback forms for group and individual assessments, since individual feedback forms are provided by the project, yet the AoI activities encourage group collaboration. Lastly, it was noted in the discussion that peer feedback should highlight pupils' strengths and weaknesses, so feedback should allow a space for constructive comments as well. In its current state, the peer feedback form does not have a space for constructive comments, but just positive ones. Teachers agreed that all of the evaluation forms should be combined into one, so they would then have an assessment that includes multiple different perspectives (i.e. peer, self, teacher feedback). This suggestion may also help teachers avoid overlapping tasks on the different evaluations. However, teachers acknowledged that this combined assessment would be extremely long.

During the focus group discussion, one of the teachers also proposed that all of the assessment tools should be online, and preferably on a Google document for easy access, yet many other teachers found that the online assessments were difficult to use in their classrooms. Moreover, when the teachers were asked when the evaluations should take place during the AoI activities, their opinions were divided. Some of the teachers believed that it was better for their pupils to be evaluated after

each phase of the AoI activity, so that the teachers could know exactly where their pupils were experiencing challenges. Other teachers thought that a summative assessment at the end would better evaluate their pupils' overall performance. Thus, although teachers found that it was important to evaluate their pupils with each assessment instrument, all of the instruments should be improved for easier implementation in the classroom. Regarding the award system, teachers responded that they need time in order to get accustomed to using this system and explaining it to their pupils. Teachers also agreed that an award system taken to an international level would be more competitive and more interesting for their pupils.

Overall, the teachers found the evaluation tools were beneficial and challenging for their pupils. Teachers were steadily trying to incorporate self-evaluation and peer-feedback into their lesson plans. In addition, teachers found the evaluation tools should be more descriptive and more visual for the pupils, so that pupils would be more willing to take part in these tasks. Also, teachers were in agreement that the pupils' learning processes should be emphasized on the feedback form. Assessing the final product of the activity does not always show the full picture of pupils' learning, as some teachers noted in the discussion. Another teacher inquired about whether other countries have a different way of teaching the same science material; they suggested that it would be beneficial for their teaching process to compare teaching experiences with teachers from other countries. Teachers' overall scores for implementing the process of evaluation in the context of the AoI project can be seen in Table 2 below.

Table 2 Teacher scores concerning the evaluation process ©UNESCO

	On a scale from 1 to 10	Q How would you rate the process of evaluation? Why?
Teacher	**Score**	**Reason given for rating (if any)**
Teacher 1	8	No reason provided
Teacher 2	6	No reason provided
Teacher 3	7	The whole idea is really good, but it is too long
Teacher 4	5	It needs to be further studied and developed
Teacher 5	4	Its application is really difficult.
Teacher 6	--	NB: Teacher 6 left before the rating took place
Average Score	**6/10**	

End-of-Pilot Survey

The main purpose for this end-of-pilot survey in January 2016 was to a clear picture of the pilot phases' successes and opportunities for improvement. This survey was conducted as an online questionnaire using Google Forms, which produced quantitative and qualitative data on the AoI pilot phase. The teachers reviewed the online training course, as well as the communication and logistical

support from the UNESCO Regional Bureau for Science and Culture in Europe and its partners. In total, 12 of the 15 participating teachers who were involved in the pilot phase completed the questionnaire and expressed high satisfaction with the AoI project.

75% of the teachers surveyed confirmed that they were "very likely" to use the IBSE method in future science lessons (25% were "somewhat likely" to use the IBSE method again). When it came to reviewing the accessibility of the platform for both teachers and pupils, most of the teachers surveyed (70%) agreed that the platform was easily accessible. The rest of the teachers said that it was particularly difficult to create a group and add pupils to the group on the online platform. The most difficult challenges were time management when it comes to IBSE's implementation in the classroom, and a lack of access to technological supports like computers and internet connection.
Compared to the responses from the homework assignment questionnaire administered to teachers prior to the implementation of the AoI pilot project, the responses to the end-of-pilot survey demonstrated a higher level of satisfaction in the project. For example, teachers' perceived usefulness of platform increased from 85 to 100 percent. Also, in the previous questionnaire, some teachers (15%) considered the concept of RRI itself to be unclear, but on the end-of-pilot survey, all of the teachers reported feeling comfortable with implementing RRI content into their classrooms.

In terms of the time duration allocated for each activity, half of the teachers disagreed about the actual length of certain activities (from 15 minutes up to 2 hours) on the initial survey. After implementing the activities in their classes, however, teachers responded on the end-of-pilot survey that they learned to adjust the timing of activities according to their own classes' learning needs, but that the timing still varied from those suggested on the AoI platform.
Finally, 70% of teachers reported on the end-of-pilot survey that all STEM subjects/domains were adequately covered in the AoI activities; this shows an increase from 60% of teachers believing all STEM subjects/domains were covered from the pre-pilot-phase survey ("Homework assignment").
Overall, this feedback reveals that teachers involved with the pilot program hold a generally positive view of AoI and its online platform. However, altering the timing of some of the activities on the platform, as well as amending some of the activity descriptions to more accurately reflect the science concepts being covered in the activities can be completed by the UNESCO Regional Bureau for Science and Culture in Europe to better facilitate the platform's use during the upcoming implementation phase.

The end-of-pilot survey also asked about the support provided for teachers through the online teacher's training course and the UNESCO Regional Bureau for Science and Culture in Europe team's support. With regard to the former, it was noted in the responses that almost all teachers found that the course contained sufficient materials. With regard to the support provided by the UNESCO Regional Bureau for Science and Culture in Europe, which is pivotal for inquiry-based education to be delivered better in schools, the feedback showed that all participants reported receiving efficient support in terms of well-designed, organized and clear communication. One of the comments given by a participating teacher said that "UNESCO staff was great to drive us along the way… of [the] AoI

project giving us clear information and instructions, [and] advising us about the deadlines". Therefore, the UNESCO Regional Bureau for Science and Culture in Europe staff should continue to collaborate with other project partners and teachers to expand the AoI support community.

Lastly, regarding any final thoughts on the AoI project, the responses showed that all teachers surveyed enjoyed teaching the content, said the project was a good opportunity to review their teaching strategies, and also reported that they found the project interesting. The following are some of the general feedback responses:

- *I think it can be a great opportunity for teachers to enrich their work, learning new contents and testing innovative methods of teaching and for pupils to enhance their participation using centered pupil lessons.*
- *The project is very interesting and I should soon become a trainer. I do not think it will be easy to adapt the assessment system of the Ark of Inquiry to the Italian school system, but I'll be happy to work together to reach this objective.*

All teachers stated that they were satisfied with their participation in the pilot phase. Many teachers also noted that they would like to implement the project again next year, and engage with the local community. Furthermore, teachers suggested that more activities should be translated into Italian for the next phase of the AoI project, which will be addressed later in the result findings. It was noted that more than half of the participants would be willing to train other teachers on inquiry-based science education methods, meaning that key individuals can be accessed in the future to expand the AoI IBSE teaching community across Italy. Therefore, the long-term implementation of this approach has the potential to be very successful. As they complete the AoI pilot phase, the UNESCO Regional Bureau for Science and Culture in Europe AoI project team thanked the 14 volunteer teachers and awarded them with certificates via E-mail on 15 March 2016. These certificates included the time that the teachers devoted to the exercise (354 hours in total, with an average of 25 hours completed by each teacher).

Findings and Results from Surveys

The aim of this section is to draw together the findings and results from the various forms of data collection discussed above. Firstly, an overview of the pilot phase will be given, followed by a discussion of key findings. The profiles of the teacher and pupil participants will be discussed, as well as the data from the questionnaires. Then, the effects of the 5 stages of the inquiry cycle will be examined in the context of the pilot phase, along with teachers' views on sharing activities, teacher support in the AoI project, and teachers' comments on future activities, language barriers, evaluation systems, and finally perspectives on the AoI network across multiple EU countries.

A. Profiles of Participants

In total, 15 teachers participated in the pilot phase, yet one teacher was not able to complete the full requirements of the pilot phase, and unfortunately needed to drop out. Therefore, 14 teachers participated in total (13 science teachers and 1 English language teacher who partnered with one of the science teachers)

In sum, 629 pupils, with the average class size being 16-17, were reached during the pilot phase. The AoI project team estimates that each teacher across Europe will teach an average of 30 pupils in a class. Therefore, the pilot phase has surpassed its goal of reaching 420 pupils with AoI activities by 209 pupils and accomplished 21% of the overall project goal of reaching 3,000 pupils in the pilot phase for all of Europe.

Furthermore, the selection of classes was mainly 2nd year classes at the Advanced (B) inquiry level; therefore, it appears that the pupils already had a basic level of scientific knowledge when they were engaged with the AoI project. In terms of gender balance, there were 11 female and 4 male teachers (i.e. 26 % male). With regards to the interviews about the pedagogical scenarios, 3 out of 9 teachers were male (33%) and the gender distribution was evenly split for the focus group (6 males and 6 females). Genders of the participating pupils were not tracked; this should be included in the feedback for the future, to ensure all relevant data is noted for the project. The schools involved in this pilot phase of the project in the Veneto region of Italy were all secondary schools, despite that the AoI activities target both primary and secondary schooling levels.

B. Data from Teacher Questionnaires

The data in this section consists of the results from the teachers' "homework assignment" about IBSE prior to the implementation of the pilot phase, teachers' feedback derived from the implementation of 19 activities from the AoI platform during the pilot phase, and questionnaires from 9 teachers concerning 6 pedagogical scenarios. Furthermore, feedback from the focus group interviews on the evaluation and award systems with 6 volunteer teachers, and the end-of-pilot phase survey with responses from the 12 participating teachers is also outlined in this section.

The data from the "homework assignment" questionnaires helped teachers to evaluate their general background knowledge of IBSE and RRI, and managed to identify how AoI activities can be developed based on existing activities. Questions were included on these questionnaires that were also used on the end of pilot phase questionnaire, which was delivered to teachers after the implementation phase of the AoI pilot project. This gave information about teachers' perceptions about IBSE and RRI over the course of the whole pilot phase. For example: the statement "You are familiar with the inquiry cycle, RRI, and inquiry-based science education prior to this project", was included on both the "homework assignment" questionnaire and the end-of-pilot-survey questionnaire, in order to determine the participating teachers' comfortability with these concepts before and after the implementation of the activities.

In the interview process with the focus group of teachers, it appeared that the facilitator played a key role by hearing everyone's ideas and opinions. This environment of inclusion and support is a factor that could encourage widespread teacher involvement in the AoI project in the future. According to the feedback expressed by teachers in relation to the interview session and discussion, all participants found it helpful, with one participating teacher stating the interviews were, "interesting and useful thanks to a fruitful discussion and also… a good opportunity to review my teaching skills".

In terms of the limitations of the data set collected, there may have been a possible bias in that 80% of the teachers involved in the pilot phase were already familiar with the IBSE method or the AoI project. Including more teachers in the pilot phase who were not familiar with the IBSE method may have produced different responses and results. In addition, there were no descriptions included in the results about each school's individual environmental or contextual factors, which may have influenced the results teachers obtained from the implementation of the pilot phase activities. Therefore, potentially helpful information that could have been collected during the pilot phase includes: the gender balance of the participating classroom and school, characteristics and statistics concerning the school and its pupils, and other relevant demographic information schools wish to disclose about their schools. This could be lucrative information to include in the future Implementation Phase of the AoI project (WP6). Overall, it is clear that the quantitative and qualitative instruments used for this research were able to capture teachers' rich, in-depth perceptions on the pilot phase of the project; room for improvement in subsequent phases of the AoI project have been noted and are being evaluated for future implementation.

C. Effects of the Ark of Inquiry Learning Cycle and Platform Materials on Pupils' Learning Skills

Teachers reported that the inquiry cycle's 5 stages (orientation, investigation, conclusion, discussion and communication phases) encouraged pupils' interest in the world of science. Teachers' photos of their pupils completing the inquiry activities showed their pupils' enthusiasm and engagement in the material at hand. Pupils followed these 5 inquiry stages by solving scientific problems on their own and with their peers, and asking questions about the process. Some of the activities were performed outside of school grounds, so as to give pupils the opportunity to bridge the gap between their learning in the classroom and its application to real-world scientific problems. Connections to RRI also allowed pupils to think beyond the context of their science classrooms, and allowed them to apply their knowledge to problems facing the world today. Therefore, the 5-step inquiry cycle helps pupils to develop practical skills like critical thinking and analytical reasoning, which are higher-order learning skills that can be applied across curricula.

Teachers also commented that the learning materials on the AoI platform motivated their pupils to investigate science concepts, and that the pedagogical scenarios provided on the platform helped teachers to include all of their pupils in this process. Thus, the effective inquiry learning cycle and AoI

learning materials provided on the online platform lead to increasing pupils' interest in scientific activities, and a higher level of pupil involvement in the learning process.

D. Sharing Empirically-Sound Activities Can Lead to Improved Teaching Performance

The active exchange of reports and ideas among the teachers, and having teachers compare their feedback on the AoI activities was very positive. Although some of the same activities were selected for use in the classroom, the learning outcomes and teachers' feedback varied (see Appendix C). For example, some teachers reported experiencing solely positive learning outcomes in their classes, while others faced more challenges with the implementation of their selected activity. These differences can result from many unique contextual and environmental factors in various schools and classrooms.

As previously mentioned, sharing this type of contextual data through feedback on the platform could be helpful for teachers to design appropriate lesson plans for their specific class. If teachers could make comments and observations on the platform about activities they performed in class (shared via a comment section or other interactive interface), new teachers could read and ask questions about the activities from experienced AoI teachers. It could allow teachers to consider different demographic and contextual information related to their schools and how it affects the AoI lesson plan and timing. In addition, sharing teacher comments on the platform could provide empirically-tested information about lessons. Further discussions are required to develop ways that teachers could share their comments and feedback on the online platform. Therefore, the importance and value of teacher feedback has been highlighted by the AoI team, and the regular provision of feedback from teachers is encouraged. These efforts to share experiences between teachers and the AoI team can hopefully reinforce the future successful facilitation of AoI activities in schools.

E. Teacher Support Should Continue and be Expanded

Teachers involved with the pilot phase of the project have been motivated in introducing the IBSE method to their classes, and commented that the reason for their involvement in the project was to improve their own pedagogical skills and effective science teaching methods. Teachers all noted that they felt sufficiently supported by the Ark of Inquiry team throughout the pilot phase. Some teachers also noted that they hope to become an IBSE trainer to support new AoI teachers, which could help to expand the AoI project across the country. It is thereby necessary for teachers to continue to be given sufficient support, training, and accurate information channels to expand the project and implement IBSE in science classrooms.

F. Teachers' Ideas for Future Activities on the Platform

The AoI platform is the main learning tool for implementing IBSE in classrooms. Therefore, the platform needs to be easy to use; most teachers responded that the usability of the platform was high. However, a few comments from participating teachers noted the lack of a PC and computer

network in their classrooms and schools, which limited their pupils' abilities to complete components of the IBSE activities.

The Italian Ministry of Education has just launched a strategic plan to support the implementation of new equipment for science facilities in Italian schools[8]. Its implementation is expected, and can also provide pupils with scientific learning opportunities, especially in the context of this project. As a result, more pupils should have access to the online AoI platform in the future.
One question on the end-of-pilot survey asked participating teachers if they would prefer their pupils to also access the AoI platform; the majority of teachers responded that they would like their pupils to be able to access the platform, so as to navigate the activities on their own. Most of the respondents consider that the platform would be useful in encouraging pupils to study on their own time, outside of class. However, most of the teachers mentioned that the AoI platform has some issues, especially when they were faced with adapting the activities' inquiry levels for their classes. Therefore, the AoI platform needs to provide more learning materials for teachers and pupils. For example, a variety of AoI activities available at all of the inquiry learning levels with accurate and engaging summaries of the tasks would be beneficial. Teachers also mentioned that the amount of detail and steps needed to complete the activities in their classes was overwhelming, and including more streamlined tasks on the AoI platform could help to solve this issue. These next steps are in review by the AoI team for future implementation.

With respect to the selection of activities on the platform, teachers considered the topics to be interesting, simple and relevant to daily life, so as to raise the curiosity of their pupils. Although the AoI platform cannot yet permit the addition of new activities by teachers, they expressed an interest to add some more activities to the platform. This sharing of activities by teachers will be a focus for the AoI project team in the future, similar to how the "mystery box activity" was provided by the London Science Museum and how other activities concerning the IBSE method were shared by AoI's project partners. Furthermore, the existing activities could be enriched with teacher input due to empirically-tested data that teachers collect in their classrooms.

In order to ensure the use of the platform, and teachers' involvement with the platform, updates about the AoI platform and project should be conducted frequently. With regard to updates about the platform and project, most of the teachers responded that they would like to be updated about the project and platform "every month", while the second most commonly chosen option was "every two weeks". Other teachers proposed the use of social media accounts such as Facebook and YouTube, rather than Twitter or LinkedIn, in order to stay in touch and involved with the AoI project on a daily basis.

[8] Directorate for Education. Centre for Educational Research and Innovation. *Review of the Italian Strategy for Digital Schools.* Francesco Avvisati, Sara Hennessy, Robert B. Kozma, and Stephan Vincent-Lancrin, OECD 2013. France. doi: 10.1787/19939019.

G. Using English in the Science Classroom can Allow for Cross-Curricular Learning

Overcoming language barriers in the science classroom was one of main issues that teachers and pupils faced within the AoI project and platform. However, some teachers commented that because the activities were interesting and effective, they would like them to be translated into Italian for their future science classes.

It is interesting to note that other teachers see the use of the English language in the science classroom as an opportunity to introduce cross-curricular studies between English language learning and teaching science. These teachers commented that teaching science in English spurs effective language acquisition for pupils, and is a good link to Content and Language Integrated Learning (CLIL) classes. Some teachers also commented that pupils can easily overcome language barriers using the activities on the AoI platform because the science learning materials are fun and interesting. Therefore, learning from activities on the AoI platform could be a good opportunity for pupils and teachers to use English in a dynamic classroom setting, especially since it has been reported that the Ministry of Education has supported linking science classes and English classes[9].
The activities suggested by teachers for translation into Italian from English can be seen in Table 3 below, in no particular order.

Table 3. Activities recommended by teachers to be translated into Italian from English, in no particular order

Activities recommended by teachers for translation into Italian from English	
Acids	The effects of global warming on endangered bred species?
pH scales	Where does my food come from?
Water shortage	What does your home produce?
In the showdown	Craters on earth and other planets
Plant adoption	Carbon detective in transport
Light bulbs	Build an atom
Estimating the destiny	Bases
Which soap is the best?	

H. Evaluation Systems Need to Assess Both Pupils' Progress and Learning Outcomes

The evaluation and award systems use various types of assessment instruments (21 pages of assessment instruments in total, with 5 types of assessments possible for each activity). The teachers felt that the evaluation instruments were beneficial to some extent; however, they felt that it was too much to assess each inquiry stage. Teachers also mentioned that the wording of the self-assessments in particular did not make pupils reflect deeply about their own learning, since the terms

[9] OECD Directorate for Education. OECD 2013.

used were too simple. The assessments also lacked a space where pupils could reflect on their own learning process and progress throughout the lesson, since the assessments focused heavily on the learning outcomes/final step of the experiment or activity. Teachers also commented that there were an insufficient number of categories in the 3-star rating system on the peer and self-assessments.

Therefore, it was suggested that these assessment instruments should be combined to reduce the amount of assessment tasks, and to include a section on the peer feedback form that could capture pupils' learning processes as well as outcomes. Furthermore, teachers suggested that rather than doing a simple self-reflection, students could further develop their online AoI profiles (by adding a profile picture and a summary of their completed work) so as to create ownership over their work; teachers believe that this will increase pupils' motivation surrounding the AoI tasks.

It was also found that the evaluation system did not include a pedagogical scenarios check list for concepts such as the integration of RRI into lessons, and ensuring girls' inclusion, which AoI needs to emphasize in the future. These are necessary because teachers reported that the pedagogical scenario tools created a more positive assessment culture for teachers and pupils. Furthermore, use of the scenarios ensures that all pupils are participating in class activities, so that they can be accurately assessed using the evaluation tools. Assessment and pedagogical contexts should be seamlessly linked with each other.

I. The Ark of Inquiry Network Across EU Countries

The teachers were interested in seeing how other teachers in European countries follow the same procedures of teaching the AoI activities. With this in mind, the development and monitoring of an online forum for teachers would be a helpful way of bringing teachers together to share and discuss their experiences for the future, as suggested by the participating teachers themselves.

Recommendations and Suggestions

This section contains recommendations and suggestions for the subsequent phases of the AoI project in Italy, and as it expands internationally. Overall, the AoI project is determined to; increase the participation of primary and secondary schools, help to create a space for teachers to expand the IBSE community, provide training opportunities for more teachers to join the AoI platform, improve evaluation systems and languages on the platform, and to expand the project internationally in order to increase IBSE in Europe.

1. Promote the Involvement of More Primary and Secondary Schools

Only secondary schools were involved in the pilot phase of the AoI project in Veneto, Italy. Therefore, the UNESCO Regional Bureau for Science and Culture in Europe should develop a strategic plan to reach and encourage primary school teachers to get involved with the AoI project in the future. This plan can then be applied to the implementation phase of the project in the future as it expands

beyond the Veneto region. For example, by emphasizing the effective learning methods obtained through the use of the inquiry cycle, the pedagogical scenarios for RRI, the gender guidelines, and the use of the AoI platform found during the pilot phase of the project, more primary teachers may want to become involved with AoI. New channels of communication to reach primary school teachers in particular should also be explored by the AoI project team.

2. The Ark of Inquiry Platform Should Offer a Space for Teachers to Share Information

2-1. Teachers Should be Able to Share Experiences on the Platform

Teachers are willing to exchange more information about IBSE through online knowledge-sharing platforms (i.e. a "comment section" on the AoI platform for teachers). This may allow teachers to update lesson plans, activities, and add their own activities to the platform, thus expanding the project internationally. Furthermore, it will allow new teachers to take contextual and demographic data into consideration when planning their AoI lessons. As those factors were not tracked during the pilot phase, they could possibly be included in teachers' feedback in the implementation phase of the project, as these factors may alter how different teachers integrate the activities into their classrooms.

2-2. Updates about Ark of Inquiry Activities Should Occur Frequently

Communication with teachers about AoI activities should occur through E-mails, LinkedIn or Facebook posts, and other social media notifications. Teachers mentioned that sending these notifications out to all community members approximately every 2 -4 weeks would be an efficient way to connect all participants in the AoI community, and allow for the consistent use of the AoI platform

3. Ark of Inquiry Team Should Continue to Emphasize IBSE to Participating Teachers

Having teachers acquire effective IBSE teaching skills is a main focus of the UNESCO Regional Bureau for Science and Culture in Europe, as well as the AoI community in Italy, which includes other teachers and project partners. The continued focus on proper IBSE training should continue in the implementation phase of the AoI project. This will help to expand the project's reach to the rest of the country of Italy, and eventually, internationally. The training will come in a variety of formats, such as face-to-face training, and well as online training components. Clearly, the focus on using and learning about IBSE methods in the classroom was a critical component of the pilot phase's success. Therefore, the strategies for training teachers in IBSE should continue to be prioritized by all stakeholders involved with the AoI project for future implementation stages both nationally and internationally.

4. Evaluation Systems Should Assess Pupils' Learning Process and Learning Outcomes

Pupils' learning outcomes and processes should be assessed through a quantitative as well as qualitative approach. This approach should focus on the learning process by including pupils' interests or improvements during the activities, as the existing evaluation instruments could not assess those processes sufficiently. The award system should be increased from a 3-star system to a 5-star rating system, so as to better capture pupils' progress during the lesson. Another teacher suggestion was to combine the six assessment instruments available into fewer assessment instruments. The teacher-pupil dialogue report could be incorporated with the self-report, peer-feedback report, and formative assessment report.

5. English Language Learning Should Be Challenging, But Attainable

5-1. Collaborate with Other National Organizations and Projects that Teach Science in English

The AoI project will encourage teachers to teach STEM in English because it was reported by teachers that pupils enjoy completing new, hands-on activities in English. According to the new Education Strategic Implementation in 2015, Italian schools need to incorporate extra hours teaching STEM subjects and IT classes in English. Therefore, secondary schools that teach STEM in English could be easily introduced to the AoI platform; pupils review English grammar in the 1st year, and could therefore start with the Basic level (A level) activities, and continue through the Advanced (B level) and Expert level (C level) activities. In addition, the AoI project team should maintain contact with professors who research Content, Language and Integrated Learning classes (CLIL), so as to increase collaboration and project expansion. At the same time, the AoI platform should add lists of English terms, which could help to reduce language barriers.

5-2. Recommendations for the Translation of Activities into Italian

As it is difficult for pupils who have not studied English in secondary and primary school to understand some of the AoI activities, the AoI project is preparing for some activities' translation into the Italian language. The activities selected for translation into Italian from English are "Build an Atom", "Carbon Detective in Transportation", "pH Scale", "Where Does my Food Come From?" and "Which Soap is the Best?". These activities were selected because they were fun for pupils, easy for teachers to implement in the classroom, and closely followed certain stages of the inquiry cycle. Furthermore, these activities represent various levels of inquiry-based learning (from Basic to Advanced to Expert), and encourage pupils to complete further scientific investigations on their own time, outside of the classroom. For example, in the "Build an Atom" activity, the learners are asked to complete the periodic table of elements and upload it online so that they can share the results of their work with others. These activities also introduce links between classroom learning and real-world scientific applications (i.e. learning about carbon footprints and environmental impacts in "Carbon Detective in Transportation"), which expands opportunities to learn about RRI concepts in the classroom.

6. Reinforce the International Network to Share Pedagogical Knowledge and Gain Practical Feedback

The findings from AoI's pilot phase can be expanded into different countries by using and maintaining the platform. Maintaining the platform through adding new activities, editing older activities, and encouraging a community of teachers involved with the project can lead to the expansion of the AoI's new science class network to a global level. In order to do so, it is important to provide space on the platform for feedback from teachers, and continue to engage teachers in various training methods for the future of the project.

Conclusion

This report has examined the progress of the AoI project during the pilot phase in the Veneto region in Italy. Overall, the pilot phase can be considered a success, with highly motivated teachers leading to effective learning outcomes. More importantly, this pilot phase shows key insights into how the platform was used and what the challenges are for teachers. Teachers' feedback on the activities that they performed with their classes showed that the experience was generally positive; considerable efforts were made to emphasize the importance of the inquiry cycle and RRI. Furthermore, many teachers implemented activities that linked their classes' learning to the real world. This link resulted in pupils connecting their learning with the local and global community, and allowed teachers to focus on empowering girls in the science classroom. However, the pilot phase also exposed some challenges concerning the platform. For example, an overabundance of tasks for the completion of an activity on the platform resulted in lesson timing being different from what was listed online. Furthermore, a lack of IT equipment (PC and web access) limited some schools. Another issue was the need to revise the assessment tools to be shorter, more concise, and to provide better insight to the learning process.

Nevertheless, it was proven that learning skills were gained by following the inquiry cycle, due to the fact that the content was relevant to daily problems and, thus, tended to encourage pupils' engagement. The AoI project is still in the development stage, so these recommendations should be taken into account to advance the project for future implementation. In order to proceed to the next phase, the AoI team should consider integrating Content, Language and Integrated Learning classes (CLIL) classes for the advanced and expert levels of inquiry activities, and will perform activity translations for popular inquiry activities on the platform. Another recommendation is to provide additional teacher training, which is planned for the upcoming implementation phase of the AoI project. As the project evolves, more feedback will be collected, which can be continuously utilized for improvement.

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APPENDIX A: Teachers' Profiles

Teacher Name(s)	Name of School	Subject Taught	Total Academic Hours Taught
Bianchi, Marialuisa	Istituto Istruzione Superiore Andrea Scotton	Natural Sciences, Earth Sciences, Biology	29
Bottazzo, Katia	Istituto Istruzione Superiore Andrea Scotton	Chemistry, Laboratory	29
Biondi, Laura	Istituto Caio Giulio Cesare	Science, Mathematics, Chemistry, Physical and Natural Sciences	36
Passaler, Sara	Istituto Caio Giulio Cesare	English	36
Cividin, Alessia	Istituto Comprensivo Marco Polo, Trieste	Technology	17
Donega, Mattia	Liceo Linguistico e Scientifico "Santa Caterina da Siena"	Mathematics, Physics	15
Franzogna, Sandra	Liceo Scientifico Girolamo Fracastoro	Chemistry, Biology, Earth Sciences	47
Sinigaglia, Daniela	Liceo Scientifico Girolamo Fracastoro	No response	40
Mattiuzzo, Maura	Istituto Comprensivo Calvino, Jesolo	Mathematics, Science	18
Puttin, Elisa	Istituto Comprensivo G. Ponti Trebaseleghe	No response	18
Righetto, Costantina	Istituto d'Istruzione Superiore Marco Polo	Natural Sciences	20
Rosati, Francesca	Pascoli Padova	No response	11
Saccoman, Massimo	Istituto Tecnico Tecnologico Silva – Ricci, Legnago VR	Chemistry	18
Tavolin, Marco	Istituto D'Istruzione Superiore A. Pacinotti, Mestre	Physics	17

APPENDIX B: Example Report from an AoI Activity Implemented in the Classroom

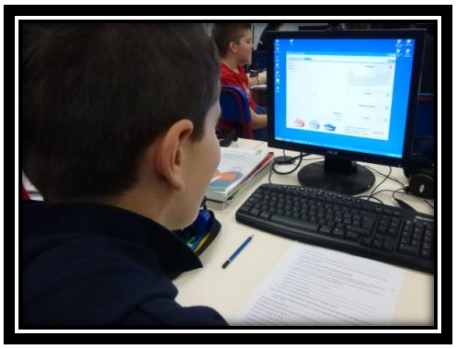
The following information in this appendix outlines one teacher's responses to the questions posed on the report for the activity "Build and Atom". The teacher provided feedback about the activity, the phases of the inquiry cycle, and her pupils' engagement, etc.

Feedback on the activity performed: My pupils had some problems with the language; we had to translate and prepare some papers in Italian. Orientation and conceptualization: we read the web page together; I also invited the class' English teacher to collaborate. I think they should try to use simpler English patterns in activities for 12-14 years old. The hypothesis scratchpad was impossible for my pupils; we did in Italian in our notebooks. For the investigation's phase, conclusion and discussion I prepared some papers. The Phet simulation is very good. And the activity was very successful. The discussion with the table to complete: we did in the notebook.

Orientation: 1 hour
Conceptualization: 1 hour
Investigation: 2 hours
Conclusion: 1 hour
Discussion: 1 hour

It took longer than expected, of course I have a class with 26 pupils and some 3 of them with special needs (they enjoyed the project) but I suggest the following:
- Write in a simpler English
- To integrate the Conceptualization's part (Conceptualization it's a little boring) with the following link:

Would you use this activity in your classroom again? Please explain. Yes, but I would only use the part of investigation and conclusion. This is because with the PHET simulation I achieved better results in the test, even with special needs



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APPENDIX C: Activities Selected by Teachers during the Pilot Phase

Teacher Name	Name of AoI Activity Utilized	Number of Pupils Taught	STEM Domain
Bianchi, Marialuisa /Bottazzo, Katia	Build an Atom	14	Physics
	Food	64	Biology, Chemistry, Physics, Mathematics
	Which is the Best Soap?	68	Chemistry
Biondi, Laura /Passaler, Sara	Estimating the Density of an Endangered Plant Species in a Named Ecosystem	20	Biology, Physics, Technology, Mathematics
	In the Shadows	20	Physics
Cividin, Alessia	Electricity: an Alternative Approach to Ohm's Law	55	Astronomy, Physics
	How are the Light Fixtures in a House Connected?	55	Physics
	Where does my Food Come From?	24	Biology
Donega, Mattia	Sinking and Floating	6	Physics
	Traffic Accident: Who is to blame?	17	Physics
Franzogna, Sandra	Should the Vegetable Oils be used as a Fuel?	26	Not Listed
Franzogna, Sandra /Sinigaglia, Daniela	How to Make Perfect Hard Boiled Eggs that are Easy to Peel?	26	Biology, Chemistry, Physics
	Which Soap is Best?	26	Chemistry
Mattiuzzo, Maura	Carbon Detective in Transport	17	Chemistry, Mathematics
	Craters on Earth and other Planets	21	Astronomy
	Where Does my Food come From?	17	Physics, Biology
Puttin, Elisa	Build an Atom	26	Physics
	Temperature in the Air: Molecule Movements in the Gases	23	Chemistry, Physics
	Which Soap is the Best?	23	Chemistry
Righetto, Costantina	Build an Atom	18	Physics
	Our Daily Bread	18	Chemistry
	Which Soap is the Best?	21	Chemistry
Rosati, Francesca	Build an Atom	26	Physics
	Sinking and Floating	27	Physics
Saccoman, Massimo	Build an Atom	28	Physics
	Carbon Detective in Transport	60	Chemistry, Mathematics
	pH Scale	19	Chemistry
Tavolin, Marco	GearUP	22	Engineering
	New: Motion With and Without Air	20	Not Listed
	Traffic Accident: Who is to Blame?	20	Physics