D6.4 Replication strategies and roadmap

Report

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Executive summary

Deliverable 6.4 “EDU-ARCTIC´s Replication strategies and roadmap” contains indications how to maximize the project’s impact and wider use, based on its very important and comprehensive results in all WPs and project activites.

Current policies in STEM education and key barriers related to the replication of the EDU-ARCTIC project and its components, in the identified most prominent regions, are identified and potential relevance to EDU-ARCTIC explored, upcoming actions and programs as Horizon Europe elaborated on, time frames studied, societal implications and majority addressed, as well as recommendations made on development paths that lead to the projects results being sustainably implemented in Europe and beyond.

Ways to secure the sustainability of the partner network are elaborated on, including a proposed MoU between the current partners.

New partners of strategic importance are identified, such as the University of the Arctic as well as partners and collaborators in Eurore and beyond, existing or possible financing schemes through public and/or private financing explored for replication of the project, its components and tools.

First steps in the replication of the project results have already been taken by project partners, including project partners’ participation in INTERACT lll, an application for EEA funding and ongoing discussion between individual partners and other networks in and outside of the EU. High level diplomats have taken interest in the project’s results and are encouraging it to be represented at the upcoming 2020 Science Ministerial meeting in Japan.

The current and anticipated results are highly encouraging for the replication of the EDU-ARCTIC project.

The clear observation of the report is that EDU-ARCTIC is of high EU and Global relevance. The replication of its program and components is very realistic and appropriate, as the interest in and awareness of the importance of STEM professional and applicable educational material and tools at secondary school level, not least related to the Arctic, is fast increasing in Europe and globally.

Objectives of the task

The report is the summary of Task 6.4 *Replication Strategies*, M3 – M37, Task Leader: Arctic Portal, Participants: All partners.

The objective of this report is to summarize EDU-ARCTIC´s knowledge and experience in order to identify and ensure an applicable replication strategy of the results for wider use in Europe and beyond.

The replicaton strategies are designed to show how EDU-ARCTIC results (concept; approach; compontents and tools) can be applicable throughout the EU.

Further, the report elaborates strategies to disseminate and implement project solutions across the EU and considers its applicability in other countries, as well as its potential adaption to individual national / local requirements.

The task of the replication strategies is to take into account political, organisational, social, linguistic and cultural differences in different European regions and the identification of key barriers and drivers for wide scale deployment.

Major input for this task has come from WP3, WP4, WP5 and WP6.

The final strategy for replication is presented by means of a roadmap, describing various development paths towards the desired future taking cognisance of different time frames, society maturity and relevant policy actions and programs.

Project knowledge and experiences

Main Components

The EDU-ARCTIC project developed and initiated a mix of different tools to bring a fresh approach to teaching STEM subjects, including; online webinar lessons; a "citizen science" environmental monitoring program; teacher training seminars; the online "Polarpedia" portal and students' Arctic competitions.

European, as well as international students, have been provided with unique possibilities to get to know different research disciplines and the understanding of scientific research and - careers.

An important impact objective of the EDU-ARCTIC project was to permanently increase the number of girls pursuing STEM careers. This has been approached by using methods and language, sensitive to gender issues. The participation of girls in the Arctic Competitions is a strong indication – besides the results of the project surveys - that the objective has been met and highlighted by the Arctic Explorer Game App, based on a competition entry by a Faroe Islands female student.

Lastly, the project has built up the competences of teachers in STEM fields through online lessons both for students and directed at the teachers, support material and teacher seminars.

Reviews, questionnaires and teachers' testimonials indicate strongly that the material developed as part of the EDU-ARCTIC project is welcome and that it supports STEM educational needs with its tools and components while increasing the awareness of its needs through its outreach activities.

Overview of Workpackages – main related results

The **Work Package 3 *Preparatory of EDU-ARCTIC program*** was fully conducted within the first reporting period of the project. The implementation strategy was prepared, and preparatory actions finished successfully.

As part of **Work Package 4 *Educational Program**,* the EDU-ARCTIC project developed and initiated a mix of different teaching material, trainings, outreach in the form of competitions and tools to bring a fresh approach to teaching STEM subjects, including:

- 532 online webinar lessons;
- a “citizen science” environmental monitoring program;
- three teacher training seminars where over 70 teachers got dedicated support to advance their skills related to STEM education;
- the online “Polarpedia” portal in 16 languages with up to 486 terms;
- student Arctic competitions through which 16 teams of students and teachers got the rare opportunity to visit the Arctic.
- students were provided with unique possibilities to get to know different research disciplines and the understanding of scientific research and -careers.
- multiple communication channels were developed for internal and external communication and user support.

To support the replication of the Portal and the project’s components, detailed reports have been provided, including report D4.1 on technical support services.

Work Package 5 *Evaluation and impact,* evaluated the project’s actions and components’ usefulness and acceptance by:

- assessing pupils' STEM skills level after participating in EDU-ARCTIC in order to obtain values for impact assessment
- measuring pupils’ interest in STEM after taking part in EDU-ARCTIC in order to obtain reference values for impact assessment
- evaluating online lessons conducted
- evaluating the impact of the EDUCATOR FORA
- evaluating the Arctic Competition
- conducting Main EDU-ARCTIC survey (“during” and “after”) in order to assess fulfilment of project objectives and level of KPIs

Detailed summaries of results can be found in the chapter – *Impact and Evaluation of the project.*

Work Package 6 *Communication, replication & exploitation* aimed at elaborating and implementing a communication strategy with schools, teachers, civil society organisations, key industry partners and pupils in order to achieve the widest possible implementation of the EDU-ARCTIC program. This included promotion of the project among school authorities and educational officers in local, regional, national and international administrative services, as well as dissemination among civil society organisations and industry partners acting on STEM education. The main activities were targeted towards:

- a wide network of representative stakeholders;
- establishing an extensive network of over 1200 teachers and educators;
- development of scientific and educational connections with other institutions and projects;
- exploitation strategy for the project and individual exploitation plans by all consortium beneficiaries;
- networking report;
- replication strategies and roadmap for the sustainability of the project's components.

The main objectives and outcomes of the **Work Package 7 *Dissemination and Promotion of the EDU-ARCTIC program*** were:

- implementation of the dissemination strategy, developed at the beginning of the project, in order to reach the widest possible target audience at regional and national level across the EU and beyond
- wide usage of high-quality promotional and outreach material (leaflets, project video, roll-up)
- raised awareness by targeted key stakeholders through implementation of an advanced interoperable and scalable web portal and other informational and promotion tools
- preparation and distribution of project newsletters informing about possibilities offered by the project
- strong presence in social media
- presentation of the project at conferences and various events
- preparation of scientific publications concerning project results
- promotion of the project among the general public
- organisation of the EDU-ARCTIC Final Conference

Online lessons summary

Based on our experience in the EDU-ARCTIC project, including formal evaluations made by the participating teachers, webinars may be a useful and effective method of increasing interest of youth in science and scientific careers.

Webinars were found by teachers and their students to be an attractive and inspiring method of going beyond normal everyday school routine.

Identified barriers are pertaining mainly to language and the fitting of lessons to nationals' curricula and timetables. They require special preparations in terms of content, didactic methods, language and some technical aspects.

In total, 532 lessons were conducted (which represents 161% of the total of intended number of transmissions announced as per DoA in the Annex 1 to GA), with 5026 participating groups (schools). The list of online lessons conducted within the project is provided in the deliverable **D4.3 List of conducted transmissions**. The report presents a general overview of conducted lessons: thematic areas, numbers of conducted transmissions. General information on the purpose of the online lessons, their topics and the overall number of participants is provided.

Online lessons were recorded in order to render them accessible to schools at their own convenience. The recordings are available on the dedicated EDU-ARCTIC Youtube channel https://www.youtube.com/channel/UCAXMalFigsqOYQjjfbAc0BA.

The recordings are divided into 18 thematic playlists (here in alphabetical order):

- ANTHROPOLOGY (22 recordings)
- ASTRONOMY (11 recordings)
- BIOLOGY (53 recordings)
- CLIMATOLOGY (13 recordings)
- ENERGY (4 recordings)
- ENVIRONMENTAL POLLUTION (5 recordings)
- GEOGRAPHY (9 recordings)
- GEOLOGY (12 recordings)
- GLACIOLOGY (23 recordings)
- HYDROLOGY (6 recordings)
- MATHEMATICS (2 recordings)
- METEOROLOGY (8 recordings)
- OCEANOGRAPHY (5 recordings)
- POLAR EXPLORATION (10 recordings)
- POLAR RESEARCH (22 recordings)

- SEISMOLOGY (10 recordings)
- TECHNICAL SCIENCES (12 recordings)
- MISCELLANEA (5 recordings)

The report also provides feedback from participants, based on results of two surveys: the online lesson survey filled in after each lesson by participants and the main survey “After” (both described in detail in the deliverable D5.1 and implemented within WP5 – *Evaluation and impact*). The main conclusions from implementation of this activity are included, and recommendations on conducting the online lessons from pedagogical, organizational and technical points of view are provided. In the Appendix 1 of the D5.1 report, the detailed manual for interested external parties and researchers “How to conduct a lesson for EDU-ARCTIC” is included.

Online lessons for the preparation of teachers were also provided with very good results, intended for presenting the educational program or dedicated to particular tools of the project (Arctic Competition or Monitoring system).

Interest and testimonials by teachers show a clear and evident need for the conducting of STEM online lessons. This component of the EDU-ARCTIC project will continue to be available for a minimum of four years on the project’s YOUTUBE channel. It is also a clear result from the project that the lessons need to be supported by tools such as Polarpedia. An announcement system via a dedicated portal and/or newsletters is also highly valuable and would strongly support the replication of the components and encourage the developement of new sessions and relations to other ongoing projects or initiatives.

Newsletter summary

The newsletter report is the Deliverable D7.6 *3rd Report on Newsletters produced and published*. It pertains to Task 7.3 *Promotion tools*, described in the Annex 1 PART A of the GA, within Work Package 7 *Dissemination and promotion of the EDU-ARCTIC program*.

The EDU-ARCTIC newsletter was published periodically to inform those who signed up to receive the newsletter about important announcements, news and events related to the EDU-ARCTIC programme.

The total number of Newsletters, published during the project period, is 45, covering several topics in each newsletter (for example, short description of upcoming online lessons, launching of project apps). Eight announcements on specific important project issues (typically only one topic per announcement, for example, invitation to participate in contests or surveys) were also been published.

The report provides detailed statistics on the audience reached and the demographics of this audience with information and graphs.

The conclusion is that the outreach activity has been positively evolving for the duration of the project, rising from 223 registered users in 17 countries in January 2017 to 1244 registered users in 61 countries in June 2019, i.e. a five-fold increase or over 500 %. Consequently, it can be assumed that the applicability, acceptance of and interest in the project by international stakeholders has grown in strong relations to its activities and positive development, not least the increased availability of educational material and tools.

Polarpedia summary

The Polarpedia report is Deliverable D4.2 *Polarpedia Documentation* with an alphabetical list of Arctic glossaries and a list of educational resources.

In relation to the project's aim of encouraging interest in science, technology, engineering and mathematics (STEM) education among secondary school students, the project notably developed Polarpedia.

EDU-ARCTIC´s Polarpedia is a free online, accessible to all without registration, Polar research-based encyclopaedia. It is dedicated to educators, schools and students, across Europe and beyond on various issues related to the Arctic environment and societies.

Polarpedia is a component of EDU-ARCTIC's educational program, providing an extensive knowledge base and education support tool on the Arctic region with a direct link to the EDU-ARCTIC online lessons. It provides teachers and students with an educational support that can facilitate their work on scientific issues and expressions in English.

Currently 486 entries are available in English, which is the project's principal language. Many of the entries have been translated into a total of 16 other national European languages, due to high external interest and support of educators, whereas only five languages were initially planned.

The report includes documentation of the Polarpedia, including: the terms currently available in English in alphabetical order; number of translations in other languages; list of educational resources in forms of Games and Quizzes; analytics and analysis of Polarpedia users and technical parameters.

Analytics indicate that the number of users of Polarpedia is constantly increasing. Search is the most common way of finding the program and its individual terms. The users have visited from almost all the countries of the world with Albania, Poland, Bulgaria and the USA topping the list.

As the analysis of the analytics strongly indicate the importance of increased internal references and optimization of search, to increase the page visits and extend the time spent per users, modifications are being implemented to aid the users in better understanding the scope of Polarpedia, identifying related terms to their search as well as pointing to the terms of highest user interest.

Polarpedia can be accessed on the [Edu-Arctic.eu]() main website or directly via [polarpedia.eu]()

The Polarpedia component of EDU-ARCTIC has proven itself to be a highly valuable teaching support tool which is used beyond the project as analytics indicate. It is thus of high replication value. It is therefore very important to secure its availibilty for the future.

Impact and Evaluation of the project

Evaluation of project results and their impact on end-users was a very important part of the project and its potential replication. At the beginning of the project, key performance indicators (KPIs) were identified in order to quantify the project's impact. Each KPI was connected with project objectives.

The general results are very positive, as all Key Performance Indicators proposed for the project were achieved. Moreover, the presented results show clearly, that KPIs have been achieved at a level exceeding primary assumptions.

The logical conclusion from the above is to suggest that such initiatives as EDU-ARCTIC do make a difference and that replication of its strategy, approaches and results may very well advance STEM education in Europe and beyond.

The following surveys were implemented:

1) **ongoing survey on online lessons** (total number of collected surveys is 4567)
2) satisfactory **surveys after the EDUCATROS' FORA** (54 collected surveys)
3) surveys dedicated to 3 editions of the **Arctic Competitions** (89 surveys collected)
4) **entry skills assessment** surveys for newly registered teachers (255 surveys collected)
5) **after skills assessment** survey (73 surveys collected)
6) **"Main survey – During"** (130 surveys collected)
7) **"Main survey – After"** (80 surveys collected)

The results of measurements of Key Performance Indicators or KPIs can be found in the D5.4 Report on impact assessment. The results were based on three main documents: "EDU-ARCTIC entry and after" skills assessment (two surveys) and "After EDU-ARCTIC survey - Main survey". Additionally, in order to assess the number of schools implementing and interested in the EDU-ARCTIC program, project deliverables D6.1 "List of schools registered to the program," D7.8 "List of events and publications presenting the project" as well as google analytics for the portal were used.

The summary of results for all KPIs is presented in the table below:

Indicator value (KPI)	Results and means of verifications
1. Utility of educational tools proposed and implemented in the project during online lessons (70% of teachers who took part will assess utility of at least one tool on a grade of 5 or 6).	**ACCORDING TO „AFTER EDU-ARCTIC SURVEY – MAIN SURVEY":** For each tool more than 90% of teachers assess its utility on 5 or 6: Online lessons: 94% Polarpedia: 93% Monitoring system: 91% **It can thus be concluded that the KPI has been achieved.**
2. Visual attractiveness of educational tools proposed and implemented in the project (70% of teachers who took part will assess visual attractiveness of at least one tool on a grade of 5 or 6).	**ACCORDING TO „AFTER EDU-ARCTIC SURVEY – MAIN SURVEY":** For each tool more than 90% of teachers assess its attractiveness on 5 or 6: Online lessons: 98% Polarpedia: 95% Monitoring system: 94% **It can thus be concluded that the KPI has been achieved.**
3. Frequency of using educational tools proposed	**ACCORDING TO „AFTER EDU-ARCTIC SURVEY – MAIN SURVEY":**

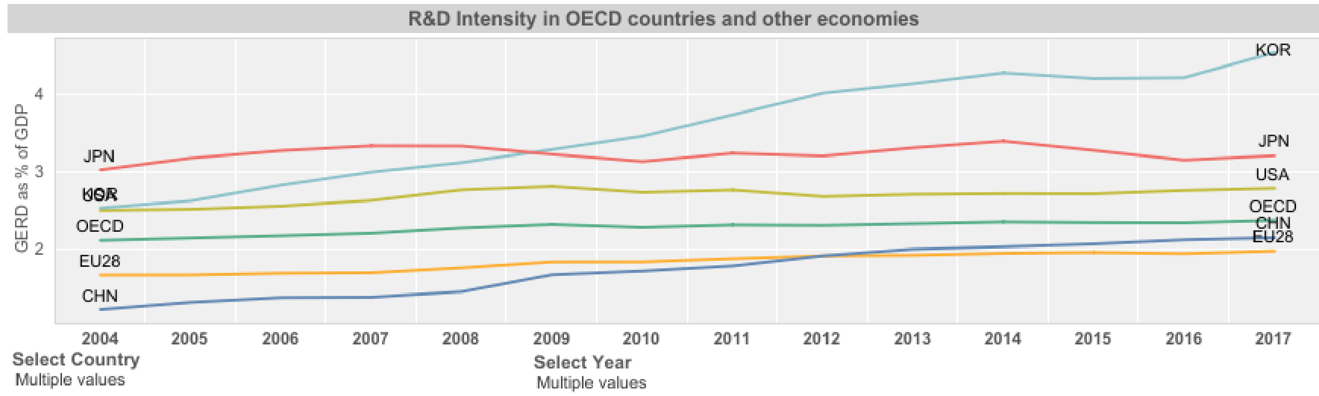
and implemented in the project (70% of teachers who took part will assess frequency of at least one tool on a grade of 1, 2 or 3).	Each tool was used by more than 70% of teachers on average once a month and more often: Online lessons: 76% Polarpedia: 80% Monitoring system: 47% **It can thus be concluded that the KPI has been achieved.**
4. Enhancement of knowledge about science and scientific research, as well as their place in the modern world (+ 15% compared to input level)	**ACCORDING TO „SKILLS ASSESSMENT SURVEY“:** The average increase is: 24% for schoolgirls, 23% for schoolboys (**24% for all pupils**). **It can thus be concluded that the KPI has been achieved.**
5. Enhancement of knowledge about nature, geography, natural resources, history, social and political specificities concerning polar regions and increase of sensitivity to environmental issues and climate change (+ 15% compared to input level)	**ACCORDING TO „SKILLS ASSESSMENT SURVEY“:** The average increase is: 30% for schoolgirls, 28% for schoolboys (**29% for all pupils**). **ACCORDING TO „AFTER EDU-ARCTIC SURVEY – MAIN SURVEY“**: the increase of knowledge has been declared by teachers for 95% of schoolgirls and 95% of schoolboys (average for all pupils is 95%) **It can thus be concluded that the KPI has been achieved.**
6. Establishing strong links between the worlds of research and young people/ society in order to increase their ability to understand scientific messages and scientific language (+20% compared to input level).	**ACCORDING TO „AFTER EDU-ARCTIC SURVEY – MAIN SURVEY“:** the increase of ability to understand scientific messages and scientific language has been declared by teachers for 95% of schoolgirls and 96% of schoolboys (average for all pupils is 95%) The average increase of ability to understand scientific messages and scientific language is 27% for schoolgirls and 26% for schoolboys (**average for all pupils is 26%**). **It can thus be concluded that the KPI has been achieved.**
7. Implementation of innovative tools by way of an e-learning portal and effective methods of teaching science on a regular base in schools in at least 10 European countries (Minimum 500 schools from 10 European countries)	**ACCORDING TO ONLINE REGISTRATIONS ON THE EDU-ARCTIC PORTAL:** The total number of schools registered to the EDU-ARCTIC program is **766**. They are located in **59 countries**. At least 700 schools are located in 35+ European countries. For details see D6.1 List or schools registered to the program. **It can thus be concluded that the KPI has been achieved.**

8. Introduction of the EDU-ARCTIC program in schools in at least 10 European countries (Minimum 3.500 schools from at least 10 European countries).	**ACCORDING TO THE DISSEMINATION REPORTS FROM PARTNERS AND TEACHERS:** The number of teachers, who participated in events, where the EDU-ARCTIC program was presented is at least **4133** (see Deliverable D7.8 List of events and publications presenting the project). **ACCORDING TO THE GOOGLE ANALITICS FOR THE EDU-ARCTIC PORTAL:** Total number of individual users of the portal (program.Edu-Arctic.eu) in the last school year is **6478**. As the portal is dedicated to teachers (unlike the main website and Polarpedia, which are visited by general public), we assume that at least 75% of the users are teachers and educators (which means ca. 4850 individual users). The users were from **103 countries**. **It can thus be concluded that the KPI has been achieved.**
9. Increase of the number of young people interested in STEM and scientific career (+ 25% compared to input level).	**ACCORDING TO „AFTER EDU-ARCTIC SURVEY – MAIN SURVEY":** the increase of interest in STEM and scientific career has been declared by teachers for 94% of schoolgirls and 95% of schoolboys (average for all pupils is 94%) The average increase of interest in STEM and scientific career is 26% for schoolgirls and 25% for schoolboys (**average for all pupils is 26%**). **It can thus be concluded that the KPI has been achieved.**
10. Increase of the number of girls interested in scientific careers (+ 20% compared to input level).	**ACCORDING TO „AFTER EDU-ARCTIC SURVEY – MAIN SURVEY":** the increase of interest in STEM and scientific career has been declared by teachers for 94% of schoolgirls The average increase of interest in STEM and scientific career **for schoolgirls is 26%**. **It can thus be concluded that the KPI has been achieved.**

Current standing, policies and barriers related to STEM

The fourth industrial revolution involves rapid change of technology, creating both opportunities and threats for modern society. The importance of STEM education is very much linked to societies' need for both technological and scientific advancements.

The figure below is drawn from the OECD Main Science and Technology Indicators Database in August 2019, comparing EU with Korea, Japan, USA, China and OECD average.



Source: OECD estimates based on OECD Main Science and Technology Indicators Database, August 2019.

”The latest available data on expenditure on Research and Development (R&D) for OECD countries and other major economies published in the OECD Main Science and Technology Indicators shows that R&D intensity (expenditure on R&D as a percentage of Gross Domestic Product, GDP) in the OECD area rose slightly from 2.34% in 2016 to 2.37% in 2017. This was largely driven by growth in the United States, Japan, Germany and Korea, offsetting a decline in Canada and several other European economies such as France, Italy and the United Kingdom. In 2017, Korea and Israel continued to be the countries with the highest R&D intensity, at 4.55% and 4.54% of GDP, respectively.”[1]

As can be easily observed from the above, Europe is behind OECD average in research, science and technology intensity and in need of stronger STEM education policies and tools, such as the EDU-ARCTIC project has developed.

In what follows, current standing and policies of key countries or regions are explored as they are all potential replication areas for EDU-ARCTIC.

EU policies

The European Commission has funded studies such as the *STEM Alliance* regarding STEM education in Europe. This study highlights major issues regarding the low attractiveness of STEM studies and careers, or the unmet labour-market needs in STEM-related sectors that are expected to grow even more in the future. It also reveals that European countries are falling behind in mathematics and science. Another study or report, *Scientix,* explains “To cope with the fast pace of technological innovation, European education systems need a better vertical integration of their STEM policies with better relations between schools, universities and companies recruiting STEM profiles. Researchers are developing new paradigms and

[1] http://www.oecd.org/sti/msti.htm

technologies, companies are industrializing these discoveries: both are activities based on new devices and skills sets that teachers must master and convey to their students to prepare them for the job market.”[2] See also further information on Scientix in the section „Potential partners of strategic importance.“

The European Committee of the Regions is calling for measures to promote STEM education in Europe, especially among girls and women (July 2019). With an opinion prepared by Csaba Borboly (RO/EPP), President of Harghita County Council, the EU's assembly of local and regional representatives calls on the European Commission and the Member States to support STEM-related initiatives at local and regional level, to ensure necessary investment and to tackle shortages in this field in the planning of cohesion policy. [3]

Strategies and initiatives are being implemented in many European countries to increase the popularity of STEM studies and careers. It is considered vital to engage the gifted and talented with challenging STEM activities and it is also considered important to reduce the gender gap in STEM.[4]

The newly presented Horizon Europe program is aiming to drastically increase financial support to research and development with an exceptionally strong innovation and SME´s support component, which, if accepted and implemented, would strongly encourage and stimulate STEM interests in Europe.

The EDU-ARCTIC project results should therefore be replicated and serve as strategical bench setting in the upcoming Horizon Europe from 2021-2027.

EDU-ARCTIC integration into INTERACT lll is notably a very strong reference to make.

Local examples – Nordic countries

Iceland is an example of a country with a very high standard of living based on its natural resources sich as fishing, renewable energy and increasingly tourism. Today in Iceland only 16% of students that graduate from universities do so in the field of STEM[5]. This is extremely low compared to other European countries where Austria and Greece have the highest rate at around 30% of students graduating with a STEM degree.

Awareness of the lack of STEM education in Iceland is rising and the need to encourage both young boys and girls to pursue their education in the field of STEM as well. A report published

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[2] http://www.scientix.eu/documents/10137/782005/Scientix_Texas-Instruments_STEM-policies-October-2018.pdf/d56db8e4-cef1-4480-a420-1107bae513d5

[3] http://www.stemcoalition.eu/publications/strengthening-steam-education-eu

[4] http://www.scientix.eu/documents/10137/782005/Scientix_Texas-Instruments_STEM-policies-October-2018.pdf/d56db8e4-cef1-4480-a420-1107bae513d5

[5] https://www.stjornarradid.is/lisalib/getfile.aspx?itemid=03be6340-3bfe-11e9-9436-005056bc4d74

by the Iceland Chamber of Commerce (Viðskiptaráð Íslands) offering 10 suggestions for action to empower innovation in the Icelandic community expresses that if Iceland wants to keep up with the technological evolution of the next 15-20 years the country needs to focus more on STEM education[6].

In Fenno-**Scandia,** Finnish schools are frequently ranked as the best in the world much higher than in other Nordic countries despite the cultural similarities. The results from the international students test PISA rank Finland number one out of 40 developed countries, while Norway was ranked 26, Sweden 21 and Denmark 12. The reason for the difference might lie in the policy making. For example, in Norway the educational policy is made by politicians whereas the most recent educational reform in Finland was made by academics. The ministry of education in Finland simply monitored the process.[7]

The Nordic Council of Ministers published a "Handbook on how to make Science, Technology, Engineering and Mathematics (STEM) more appealing to girls and young women". The report expresses that the Nordic countries are lagging in terms of attracting young women to STEM education, the main reason being the gender-segregated choice of study and the gender-segregated labor market. In subjects such as biology, biochemistry and environmental sciences, women represent the majority of students, whereas in physics, mathematics, computing and engineering, women are generally under-represented. The lack of teachers with the right skillsets for science and technology subjects is also a major challenge. According to a Danish study, only about half of the teachers who teach science and technology subjects had them as their main subjects during their teacher training programme. The same problems have been pointed out in a Swedish study where roughly 25% of the science and technology teachers have training in these subjects. [8]

In the **Northern Periphery and Arctic Programme 2014-2020,** one of the focus points is "Strengthening research, technological development and innovation". The justification regarding that focus point is that "more robust and dynamic local economies are the key to cope with the challenges within the Programme area. This implies among other things a higher innovation performance and a better utilization of the existing innovation infrastructure."[9] For the aim of the action to be accomplishable, the region needs more people with STEM education as a basis for advanced scientific and technological thinking and innovation ability.

[6] https://vi.is/%C3%BAtg%C3%A1fa/sk%C3%BDrslur/2019_01_23_nyskopunarheit.pdf

[7] https://sciencenordic.com/finland-forskningno-politics/big-differences-in-finnish-and-norwegian-teacher-education/1380188

[8] https://norden.diva-portal.org/smash/get/diva2:968893/FULLTEXT01.pdf

[9] http://www.interreg-npa.eu/fileadmin/Programme_Documents/Approved_Cooperation_Programme_Jan2016.pdf

International examples – China, Korea, Japan and USA

China. In February 2017, the Ministry of Education in China made its first governmental recognition about the importance of STEM education in China by announcing officially that STEM education should be added into the curriculum of primary schools[10]. Published by the National Institute of Education Sciences, the 2017 White Pater on China STEM education revealed that there were only 11 scientists and engineers on average among every 10,000 in the nation´s workforce. By October 2018, the talent gap in the strategically important artificial intelligence or AI sector surpassed 1 million[11]. In May 2018, the launching ceremony and press conference for the 2029 Action Plan for China´s STEM education was held in Beijing, China. The 2029 Action Plan aims to allow as many students as possible to benefit from STEM education and to equip all students with scientific thinking and the ability to innovate. Universities have started to impose the taking of STEM courses at high school level as a prerequisite for enrolment. In response, both private and public schools in China have begun to carry out STEM education programs. An increasingly recognized problem facing China in regard to adequately accomplishing this Action Plan is the lack of specialized STEM educated teachers.[12]

There is an increased interest from Chinese educational authorities in international cooperation for the production and customization of teaching tools and online courses supporting the teaching in the fields of STEM. Discussions are already onging to use the results of EDU-ARCTIC as a platform for new STEM on-line courses, competitions and field trips for highschools in Shanghai and potentially wider in the country, starting 2020.

Korea. The Korean government has been supporting and encouraging STEM education by emphasizing STEAM education (Science, Technology, Engineering, Arts and Mathematics) in its educational policy. The policy announcement "The second basic plan to foster and support human resources in science and technology (2011-2015)" underlines that. The Korean Foundation for the Advancement of Science and Creativity (KOFAC) has managed, at national level, systematic STEAM educational programs by cultivating and supporting leading groups, reinforcing teachers' capabilities, developing and distributing content, promoting interactive and exploratory activities for students, and institutionalizing and building infrastructure. According to the article "STEAM Education in Korea: Current Policies and Future Directions"

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[10] https://medium.com/@EdtechChina/chinas-stem-education-in-action-observations-initiatives-and-reflections-a20d6cd43a0c

[11] http://www.chinadaily.com.cn/a/201901/14/WS5c3bf77aa3106c65c34e43f6.html

[12] https://medium.com/@EdtechChina/chinas-stem-education-in-action-observations-initiatives-and-reflections-a20d6cd43a0c

the number of schools that implement STEAM education is in total 21.1% portraying the necessary need to implement STEAM into the national curriculum.[13]

One of the EDU-ARCTIC partners is working with KMI in Korea on Arctic statistics with the intention to introduce to familiarize the Korean public and stakeholders more with the Arctic. The implementing of EDU-ARCTIC results in the material as well as in their Arctic summer school is being explored.

Japan. There is no comprehensive national STEM education policy in Japan, but awareness of the importance of STEM education and training is present both in the academic and industrial leadership. Generally, the country´s youths score high in maths and science subjects at various international examinations, the principal reasons probably being the standardized national curricula, rigorous teacher training and retraining, routine reviews of subject content, study hours as well as mechanisms for implementation. The quality of public education is generally regarded as quite high. There is, however, evidence of a steady decline in STEM popularity, aspiration and enrolment in STEM subjects at the senior secondary and university level. Japan also faces the same problem as China regarding the lack of teachers with in-depth knowledge of STEM subjects. Only 6.6% of teachers have secondary level teaching licenses in science and 5.5% in mathematics, much less than those who have teaching license in Japanese 11.9% or Social Science 16.9%. The Japanese Science and Technology Agency (JST) has initiated a number of programs to educate and train teachers in STEM subjects.[14]

In Fall 2020, Japan will host the third Science Ministerial, co-lead by Iceland. Arctic knowledge and turning information and data into knowledge is to be a key topic and EDU-ARCTIC results will be highlighted.

USA. In March 2018, the Department of Education published a Regulatory Action outlining a comprehensive education agenda that includes support for families and individuals to choose a high-quality education that meets their unique needs, promoting STEM education among other things.[15] Then, in December 2018, the report *Charting a Course for Success: America´s Strategy for STEM Education* was published, setting out a federal strategy for the next five years based on a vision for a future where all Americans will have lifelong access to high-quality STEM education, with the United States as the global leader in STEM literacy, innovation, and employment. The report represents an urgent call to action for a nationwide

[13]http://www.arpjournal.org/download/usr_downloadFile.do?requestedFile=2017122091496550.pdf&path=journal&tp=isdwn&seq=154
[14] https://acola.org/wp-content/uploads/2018/12/Consultant-Report-Japan.pdf
[15] https://www.govinfo.gov/content/pkg/FR-2018-03-02/pdf/2018-04291.pdf

collaboration with learners, families, educators, communities, and employers—a "North Star" for the STEM community as it collectively charts a course for the Nation's success.[16]

According to the report *Charting a Course for Success: America´s Strategy for STEM Education*, STEM employment in the U.S. continues to grow at a faster pace than employment in other occupations and STEM workers command higher wages than their non-STEM counterparts. Those who have STEM degrees enjoy higher earnings, regardless of whether they work in STEM or non-STEM occupations. "Despite the value and importance of STEM skills, not all Americans have equal access to STEM education or are equally represented in STEM fields. Women, persons with disabilities, and three racial and ethnic groups—Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives—are significantly underrepresented in S&E education and employment. As also reported in the indicators, although women make up half the population, they comprise less than 30% of the STEM workforce. Similarly, underrepresented racial and ethnic groups make up 27% of the population but comprise only 11% of the STEM workforce. People with disabilities and veterans also face barriers to participating in STEM education and occupations. Americans from all backgrounds may experience geographic disparities that affect access; for example, of the 24 million Americans who lack access to basic broadband services, 83% live in rural or Tribal communities. Although improved access to STEM education on its own will not create equal representation within STEM fields, equitable access is an essential priority for the Nation."[17]

The EDU-ARCTIC project was introduced to key policy makers and stakeholders during the Washington Science Ministerial 2016, where it received high acclaim for its concept. In October 2019, the US Arctic Commission will visit the CIAO Karholl station, one of the partner stations of EDU-ARCTIC, and receive a presentation on the project results and replication potential in the USA.

Sustainability of project's results after its closure

As has been reported extensively in this report and other project deliverables, the EDU-ARCTIC project developed and initiated a mix of different tools to bring a fresh approach to teaching STEM subjects. The partners will keep the relevant project components available online for a minimum of 4 years. Project material has also been uploaded to the Scientix repository. The partners are seeking ways to build on and sustain the good results through new projects, new

[16] https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf
[17] https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf

partnerships and by maintaining presence on the Scientix network. Following is an overview of the main components and results that can be replicated:

1) The project website

The website will be kept online by the Arctic Portal indefinitely or for a minimum of 4 years after the end of the project and will continue to be promoted through its channels. This provides ongoing visibility of and accessibility to all project components, including Polarpedia, recorded lessons, library and news section, and maintains their search ability on the Internet as proven the main way for visitors to access them during the project. The core components as well as news, future reports and/or research papers and other relevant material, the project partners aim to maintain directly or through associated websites and projects as has been indicated the partners intend to seek further funding to sustain the valuable cooperation and material developed during the project.

2) The EDU-ARCTIC portal

The portal will be kept online by American Systems and stored on servers of IGF PAS for a minimum of 4 years after the end of the project. This provides ongoing visibility to all project components and maintains their search ability on the Internet. The project partners aim to provide some additional extensive activities (e.g. online lessons) and intend to seek further funding to sustain the valuable cooperation and material developed during the project.

Two partners (IGF PAS and NIBIO) are included in educational tasks in the Horizon 2020 INTERACT 3 project, starting 01.01.2020 and running for four years. Therefore, additional online lessons will be organised in the framework of the EDU-ARCTIC program with participation of various Arctic stations involved in the INTERACT network. Project partners IGF PAS, NIBIO and AP have applied for funding through the EEA funding scheme which, if successful, will develop material helping sustain the component.

New partnerships as proposed are likely to bring added interest to the component and help sustain it result and ongoing development.

3) Recordings from the online lessons

Recordings from online lessons held during the project will be maintained online, viable and searchable. The Consortium intends to seek opportunities to provide new online lessons, which may be recorded and made available online in connection not the current. An option for researchers from various institutes, who would like to disseminate their research results will be also open and Consortium will offer both technical help and IT infrastructure to conduct additional online lessons.

Short videos were promoted via social media (mainly the EDU-ARCTIC Facebook channel) and during online lessons. The videos will be kept online on dedicated YouTube channel and additionally stored on servers of IGF PAS for a minimum of 4 years after the end of the project.

The Consortium has and intends to continue to promote these resources in various repositories, e.g. in Scientix repository. It will help to provide ongoing promotion and long-lasting visibility of these resources.

Previously mentioned projects i.e. INTERACT 3 and projects under development will contribute new material to the online lessons component and attract interest to those previously held as part of EDU-ARCTIC.

4) Polarpedia

The website component will be kept online by American Systems and stored on servers of IGF PAS for a minimum of 4 years after the end of the project. This provides ongoing visibility and maintains its search ability on the Internet as proven the main way for visitors to access the terms during the project.

Lack of new terms and new translations may cause a decrease in interest of using Polarpedia. The continued uptime and online availability will counteract the barriers as more hits improve the search results and consequently increase the visits. Project partners seek to attract new funding to sustain this tool and the development of more terms. New potential partners as the University of the Arctic and in Asia may help sustain the component.

5) Games and quizzes

Games and quizzes were promoted mainly via social media. The resources will be kept online on Polarpedia portal for a minimum of 4 years after the end of the project. Moreover, the Consortium intends to seek opportunities to promote these resources in various repositories, e.g. in Scientix repository. It will help to provide ongoing promotion and long-lasting visibility of these resources. Additionally, some of the resources may be used in collaboration with INTERACT project, which offers educational resources on the Arctic to schools of all levels.

6) Monitoring system and Monitoring system mobile app

The monitoring components of EDU-ARCTIC are very important outreach tools and thus a highly important integral part of the project and as such important to be sustained and developed further in line with the previously mentioned components.

The system will be kept online by American Systems and stored on servers of IGF PAS for a minimum of 4 years after the end of the project. New measurements can be added and all registered users will have access to all gathered data.

The mobile app will be available in Google Store for a minimum of 4 years after the end of the project. Moreover, the Consortium intends to seek opportunities to promote it in various repositories, e.g. in Scientix repository. It will help to provide ongoing promotion and long-lasting visibility of the app.

7) The mobile application "Arctic Explorer Game"

The app was promoted during the Final Conference on 23-24 May 2019. The mobile app will be available in Google Store for a minimum of 4 years after the end of the project. It has been promoted in various repositories, e.g. in Scientix repository, helping to provide ongoing promotion and long-lasting visibility to the app.

The app is a very interesting and interest stimulating component of the project and its science communication. It should be explored further in direct correlation with the further development of the monitoring components and Polarpedia. The replication should be approached as a state-of-the-art science communication and outreach tool based on and/or adapted to the latest technical platforms, including 3 D and thus applicable as both educational and science communicating tool. The consortium partners are already exploring the opportunities.

Results – Implementation strategy and funding

The manifest conclusion to be drawn is that the EDU-ARCTIC project is of high future relevance and the replication of the EDU-ARCTIC program and its components both realistic and appropriate, as the interest in and awareness of the importance of STEM professional and applicable educational material and tools at secondary school level is increasing in Europe and globally.

As observed from the overview above - *Current standing, policies and barriers related to STEM* – the international interest and awareness of the importance of STEM education is growing fast globally, with consequent policy settings. However, there are not many available holistic programs, componets and tools dedicated to STEM education with special emphasis on the Arctic in multiple languages like EDU-ARCTIC, currently available. This fact underlines the high prospects for the European and even global replication with a top down approach.

The Consortium is obliged to exploit the project’s results up to four years after the project closure, which results from the Article 28.1 of the EC/REA GA. Efforts have been made to ensure the online availability of project components and results.

The consortium has also explored opportunities to seek further partners and funding, individually or in partnership, in order to sustain and replicate the project's high positive results, notably via new spin-off projects, and to implement the program into national educational initiatives, in or even outside Europe.

The project does not have an option for follow-up funding from the EC.

Other options include applying for a relatively small grant within the ERASMUS+ strategic partnerships programme. Such a project could only offer a budget for travel to transnational meetings and some smaller dissemination activities.

National funds for the follow-up are not an option to maintain the current partnership, as in many national projects, the outputs should be in national language and activities should be limited to national end-users. However, this could also be a solution for teachers and schools from partner countries. Some additional institutions, which may offer grants for Arctic science education programs, include e.g. NPA, NORA, National Research Councils, Dialog – program of the Polish Ministry of Science and Higher Education, EEA. Private funding may also be an option but likely requires the establishment of a Non-for-profit foundation. Funding opportunities have and will be checked by the project partners.

From the early stage of the project's implementation, some beneficiaries entered negotiations with important institutions regarding further cooperation. The main aim of such cooperation is to further develop the project's content and involve more organisations in the exploitation and dissemination of polar research results.

Possible replication paths

The current project partners are preparing the signing of an MoU to secure the sustainability of the network.

First concrete steps in the replication of the project results have already been taken by some project partners, including individual project partners' participation in related projects such as INTERACT lll for which on-line lessons in EDU-ARCTIC format will be provided. An application is pending for EEA funding, aimed at partially similar activites as in INTERACT lll as well as the development of 3D narrative videos dedicated to polar issues, which could make the bases for new high tech science communication and outreach tools, including monitoring, for both education and public outreach.

Discussions between individual partners and other networks in and outside the EU are also ongoing ,including institutions and science outreach centres of highest standard in China and Korea.

Potential partners of strategic importance

Even though the current partnership of the EDU-ARCTIC is well-balanced and competent, there are a number of potential new partners of special strategic importance to the replication of EDU-ARCTIC.

Strengthening the cooperation with higher level educational organisations is of strategic importance as STEM education at secondary level is increasingly recognised as highly important preparation for university enrolment. The consortium has already established initial contacts with the University of the Arctic (www.uarctic.org), an organization of circumpolar international importance. UArctic's President Lars Kullerud attended the EDU-ARCTIC Final Conference held in Paris, May 2019, where he expressed firm interest in further collaboration, suggesting the creation of a "thematic network", one of UArctic's chief structuring devices of research, on Arctic STEM education. This appears to be a realistic goal since several partners of EDU-ARCTIC are already members or associate member of UArctic. The latter will hold its next general congress in Reykjavik, Iceland, in October 2020. It would be highly important and appropriate to introduce the outcomes of the EDU-ARCTIC project at the conference and seek to sign a formal collaboration agreement for its replication under UArctic.

EDU-ARCTIC partners have been actively collaborating with the Scientix Ambassadors network (more than 00 educators from over 40 countries) and the project and its results have been introduced within it. It should be considered as a strategic priority to strengthen this collaboration further. Such cooperation will be important in the quest to have Arctic and Science based STEM education and education material considered in upcoming funding calls. Moreover, educational resources produced by the EDU-ARCTIC project (games and quizzes and videos from online lessons) were submitted to the Scientix resources repository. Scientix has reviewed and published **159 resources**. The descriptions of these resources are also available in 8 official Scientix langauges. The resources are available at: http://www.scientix.eu/projects/project-detail?articleId=577260. Publishing the EDU-ARCTIC educational resources in the Scientix repository is crucial for their exploitation after the project's closure. It helps also to disseminate them wider as Scientix regularly promotes new resources via portal and via **Scientix Digest**, which is being sent out to more than **2450** online subscribers worldwide.

Other partners and/or collaborators of potential strategic importance would include the Association of Early Career Polar Scientist (APECS; see for instance www.apecs.is) and organizations of scientific coordination and outreach such as the European Polar Board (EPB).

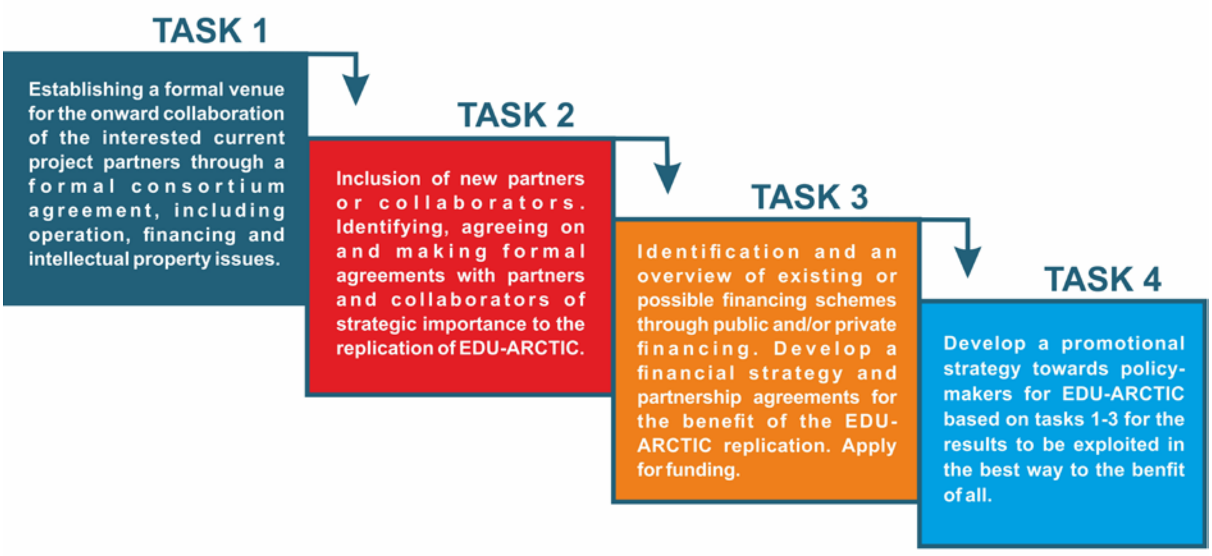
Road map

In an ever-changing and increasingly complex world – *a world of opportunities and threats* – it is more important than ever to prepare the youth to use knowledge and skills to solve problems, to make sense of information, and to know how to gather and evaluate evidence in order to make decisions – *turning information and data into permanent knowledge.*

”These are the kinds of skills that students develop in science, technology, engineering and math—disciplines collectively known as STEM. If we want a nation where our future leaders, neighbors, and workers have the ability to understand and solve some of the complex challenges of today and tomorrow, and to meet the demands of the dynamic and evolving workforce, building students' skills, content knowledge, and fluency in STEM fields is essential. We must also make sure that, no matter where children live, they have access to quality learning environments. A child's zip code should not determine their STEM fluency.*”*[18]

In this context, online education, proposed within the EDU-ARCTIC program, may effectively contribute to bridging gaps in STEM education in economically and geographically underprivileged regions.

As a Roadmap for the successful replication of the EDU-ARCTIC project, its results and components the following main tasks are identified:



<u>Task 1</u>

Establishing a formal venue for the onward collaboration of the interested current project partners through a formal consortium agreement, including operation, financing and

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[18] https://www.govinfo.gov/content/pkg/FR-2018-03-02/pdf/2018-04291.pdf

intellectual property issues.

Task 2

Inclusion of new partners or collaborators. Identifying, agreeing on and making formal agreements with partners and collaborators of strategic importance to the replication of EDU-ARCTIC.

Task 3

Identification and an overview of existing or possible financing schemes through public and/or private financing. Developing a financial strategy and partnership agreements for the benefit of the EDU-ARCTIC replication. Appling for funding.

Task 4

Developing a promotional strategy towards policy-makers for EDU-ARCTIC based on tasks 1-3 for the results to be exploited in the best way to the benefit of all.