CITIZEN SCIENCE INITIATIVE FOR SCHOOLS: EDU-ARCTIC MONITORING OF METEOROLOGICAL AND PHENOLOGICAL PARAMETERS

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Abstract

Citizen science is sometimes described as "public participation in scientific research," or participatory monitoring. Such initiatives help to bring research into, for example, the classroom and engage pupils in well-structured observations of nature in their vicinity. The learning and practising of observation may increase the understanding of complex conditions occurring in nature, related to biology, ecology, ecosystems functioning, physics, atmospheric chemistry etc. For school curricula and motivation of pupils, practical hands-on activities performed by school pupils themselves by using their own senses stimulate faster learning and cognition. For this, the EDU-ARCTIC project developed the Monitoring System. All schools in Europe are invited to participate in a meteorological and phenological observation system in the schools' surroundings, to report these observations on the web-portal and to have access to all the accumulated data. The schools and pupils become part of a larger citizen effort to gain a holistic understanding of global environmental issues. The students may learn to act as scientific eyes and ears in the field. No special equipment is needed. Reporting of observations should be made once a week in the Monitoring System through the EDU–ARCTIC web-portal or the accompanying mobile app. A manual and a field guide on how to conduct observations and report are available through the web. Teachers may download reports containing gathered information and use them for a wide variety of subjects, including biology, chemistry, physics and mathematics.

Meteorological parameters are requested reported as actual values: air temperature, cloud cover, precipitation, visibility reduction and wind force, in all 19 parameters. It is also asking for reports on meteorological and hydrological phenomena, which occurred within the previous week: like lightning, extreme and other atmospheric phenomena, ice on lakes and rivers and snow cover, in all 23 parameters. The Monitoring System also includes biological field observations of phenological phases of plants, like birch, lilac, bilberry in all 26 parameters. The occurrence of the first individual of five species of insects like Bumblebee, Mosquito, Ant and butterfly, and then registration of the first appearance of the bird species: Arctic tern, Common Cuckoo, White wagtail and Crane.

An app for the Monitoring System has been developed in order to engage pupils more by making it more comprehensive to register the meteorology and the phenophases. Further, special webinars and Polarpedia (the project's own online encyclopedia) entries are developed to strengthen the Monitoring System. The EDU-ARCTIC Monitoring System gathered more than 2000 reports from schools, with an average monthly number of more than 80 observations. They are freely available via the web-portal, but password access is needed in order to enter registrations and data.

Keywords: observation system, citizen science, natural sciences, interdisciplinary, STEM.

1 INTRODUCTION

Citizen science currently receives much attention as a means to engage and educate the public in pressing environmental issues [1]. The basic idea behind it is that you need knowledge in order to gain awareness and that this process is facilitated by anchoring new knowledge to something you already know and care about, like your local surroundings [2, 3]. Another central aspect is that by contributing to collect data for research, the participating citizens get a sense of contributing to important matters beyond their egocentric sphere, which is one among a plethora of motivations for participating in a citizen science initiative [4]. Citizen science is therefore sometimes described as "public participation in scientific research," or participatory monitoring.

Citizen science initiatives help to bring research into, for example, the classroom and engage pupils in well-structured observations of nature in their vicinity. The learning and practising of such place-based studies about nature may increase the understanding of complex ecological relationships and

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conditions, related to almost any school subjects, and most apparently biology, social studies, physics, and chemistry. For motivation of pupils and completion of learning goals in the school curricula, practical hands-on activities performed by pupils themselves with their own senses generally stimulate faster learning, especially through peer interaction and embodied experience [5]. In a wider social context, some well documented individual benefits of place-based learning are, for example, increased academic learning, stronger ties to one's community, an enhanced appreciation of the natural world, and more commitment to citizenship [6].

Especially the latter is important, given the many challenges humans have for achieving local and global sustainable use of natural resources [7]. To *act* in society, it is not sufficient to have theoretical knowledge. Practice-oriented knowledge (learning by doing) about nature empowers the pupils to act as environmentally literate citizens [8]. More empowerment helps youth distinguish between positive benefits and negative consequences to the sustainability of their actions (United Nations' sustainable development goals, SDG #12). As more empowered citizens, they are also more likely to enjoy individual benefits like life-long employability, societal participation and improved well-being, enabling them to lead healthier and more fulfilling lives (SDG #3) well beyond formal schooling [9]. Therefore, with a small initiative like the EDU-ARCTIC Monitoring System, we expect to sow seeds of curiosity in youth that will nurture tools and skills needed to engage in a society capable of making informed decisions that look for the common good (SDG #17).

The EDU-ARCTIC Monitoring System is a citizen science program (2017-2019) where all schools (or any citizen) in Europe were invited to contribute meteorological and phenological observations from the surroundings of their local community. All data were time- and place-stamped and accessible by everybody online through technology-mediated social participation. Thereby, the program generated immediate and not only long-term benefits to the volunteers, which is expected to affect (positively) participant motivation and outcomes [10]. In this paper, we give an overview of participation in the program, the data it generated and some preliminary data from our surveys of impact evaluation.

2 EDU-ARCTIC EDUCATIONAL PROGRAM

2.1 General information on the EDU-ARCTIC project

EDU-ARCTIC is an EU-funded project focused on using Arctic research as a vehicle to encourage young people aged 13 to 20 to pursue further education in science, technology, engineering and mathematics (STEM). Students participating in the project have a unique possibility to get to know what scientific careers are like and to learn more about different research disciplines while learning how to apply the scientific method, and also to learn crucial problem-solving skills. It may contribute to increasing the number of researchers in the field of STEM-related disciplines.

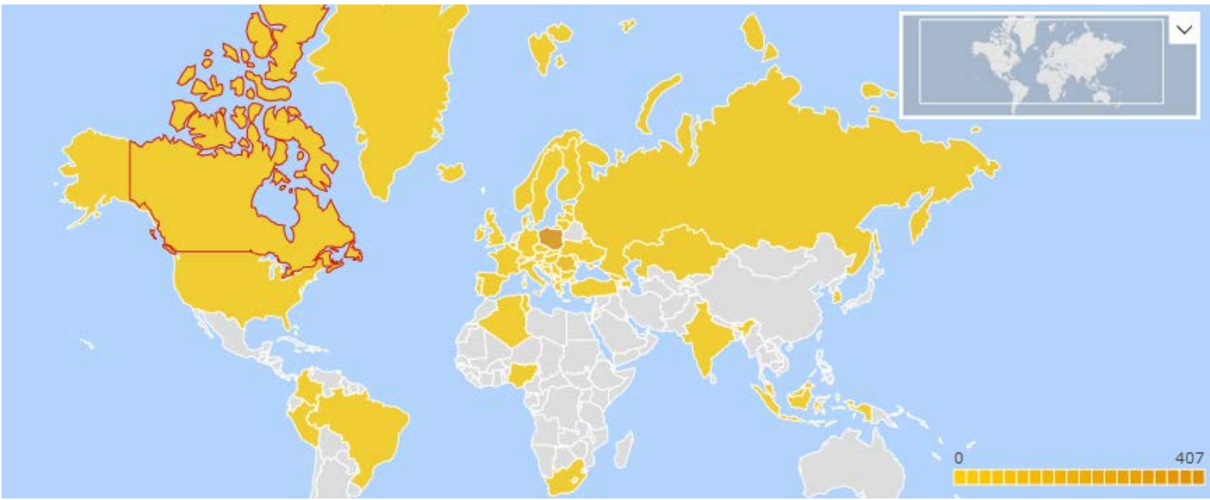

Figure 1. Distribution of teachers registered to the EDU-ARCTIC program by country (as per 30th April 2019). The darker colour (yellow) indicates presence of participating teachers.

The project is conducted by six organisations: Institute of Geophysics, Polish Academy of Sciences (Coordinator, Poland), American Systems sp. z o.o. (Poland), The Norwegian Institute of Bioeconomy

Research – NIBIO (Norway), Jardfeingi (The Geological Survey) (Faroe Islands), Universite de Versailles Saint-Quentin (France), The Arctic Portal (Norðurslóðagáttin ehf) (Iceland). The project, which is funded for 39 months, started in May 2016, whereas activities for schools started in January 2017. More than 1193 teachers from 58 countries have registered to the program already (Fig. 1).

2.2 The EDU-ARCTIC main components

The EDU-ARCTIC project offers a mix of different interactive and innovative tools to bring a fresh approach to teaching STEM subjects:

1. Webinars: Online lessons with polar scientists working at research stations and institutes. The lessons focus on natural science topics, polar research and why they are key to helping solve important challenges in society. In each online lesson up to 23 school groups may participate simultaneously. Webinars are conducted in English and in a few other European languages. In the last school year (2018/2019) the EDU-ARCTIC Consortium introduced a series of thematic courses, dedicated to various topic, including "Citizen Science" course on the EDU-ARCTIC Monitoring System.
2. "Polarpedia": An evolving online encyclopedia that contains a glossary of scientific terms in 16 national European languages (English, Polish, Danish, Norwegian, French, Romanian, Bulgarian, Italian, Greek, Bulgarian, Russian, Albanian, Croatian, Serbian, Macedonian and German so far). It helps teachers and pupils to prepare for their participation in webinars by providing short explanations of scientific terms used by researchers conducting webinars. It contains photos, graphics and animations or videos, if possible. It is divided into 9 categories: Ice & Snow, Climate & Weather, Plants & Animals, Land & Geology, Atmosphere, Water resources, Space, People & Society, Places & Stories. Moreover, an additional part of Polarpedia contains educational resources for teachers and students in the form of online games, quizzes, worksheets, experiments, teamwork proposals and others.
3. Arctic Competitions: invitation to three editions of competitions were extended to all secondary schools participating in the program. Participants of the competition each developed their own innovation or research project in the form of an essay, a video or a poster. An international jury chose 4 to 6 winning teams per edition, who were invited on an Arctic Expedition to visit one of the scientific stations participating in the project (Svalbard, Faroese Islands, Iceland and northern Norway).
4. The environmental Monitoring Program, which is the focus of this paper and presented in detail below.

3 EDU-ARCTIC MONITORING SYSTEM

3.1 EDU-ARCTIC Monitoring System – general information

We developed the EDU-ARCTIC Monitoring System to bring STEM research into classrooms across Europe and engage pupils in well-structured observations of nature. All schools in Europe are invited to participate in a meteorological and phenological observation system in the schools' surroundings, to report these observations on the web-portal and to have access to all the accumulated data. The schools and pupils become part of a larger citizen effort to gain a holistic understanding of global environmental issues. Our aim was that young people learn to act as scientific eyes and ears in the field. No special equipment is needed to participate.

The program has a web-based interface allowing interested schools to report their observations in an open and accessible database. Reporting of observations should be made once a week (by Monday at 12:00 local time) through the EDU–ARCTIC web-portal or the accompanying mobile app. As a main rule, the students should play a crucial role, make observations and provide with data required for reporting to the portal. The mobile app was developed in order to enable students and other citizens to report on measurements conducted by them in a format most accessible to youth. A manual and a field guide on how to conduct observations and make reports are available through the web. Teachers may download raw data and use them for a wide variety of subjects, such as biology, chemistry, physics and mathematics. The program is dedicated to meteorological and phenological parameters. Within meteorological observations and measurements, there are reports on some actual values and reports on phenomena, which occurred since the last observation. Biological observations cover plants, insects, and birds monitoring.

3.2 Meteorological observations

The demand for weather and climate information continues to expand because weather affects everyone everywhere, and currently people perceive the weather to be changing. If the atmospheric system and climate conditions are considered, then the long term, spatially distributed, operational monitoring of meteorological variables including reliable observations and measurements is obligatory. It is crucial to have a relevant dataset of atmospheric observation data if analysing the variability and fluctuations of climate at any given location. Weather conditions are crucial drivers that have feedback on many environmental components and influence our everyday life. Astronomical factors primarily determine the climatic characteristics of the area, but there are differences in the mechanisms that cause regional differences throughout the areas.

Pupils and students may develop an improved understanding of the complex processes within the atmosphere, ocean, land, water cycles, and their interactions by practicing of observations. Monitoring System created within the EDU-ARCTIC project gives the expanded opportunity for spatially distributed observations of meteorological phenomena conducted by students around the globe as never before. It makes it easier to understand the temporal and spatial variability of weather phenomenon and climate but also provides a tool for sharing information to other users in a manner that is timely and easy to understand and use. The proposed Monitoring System was also created to show students that the meteorology is an engaging and challenging profession. Students have a chance to conduct direct, timely, accurate, and detailed meteorological observations, and then reporting and processing data.

For comparison of every collected value between different locations and their temporal variability, the results are displayed on the maps and also reports in .xls format can be generated. By clicking on the displayed icons on the map, various submitted data may be checked at each school location. Most meteorological parameters in the Monitoring System must be reported as actual values: air temperature, cloud cover, precipitation, visibility reduction, and wind force. There are also meteorological and hydrological phenomena, which occurred within the previous week: lightning, extreme and other atmospheric phenomena, ice on lakes and rivers, and snow cover. The parameters were specially chosen to be inexpensive to conduct with no special equipment needed.

The air temperature has to be measured by an ordinary thermometer outdoor, in the shade, protected against precipitation and direct sunlight, ~2m above the ground. Total cloud amount is the fraction of the sky covered by the cloud of any type or height above the ground, and for the EDU-ARCTIC monitoring purpose students have to choose one of the following cloud cover: none, partly cloudy, complete cloud cover. Depending on the duration of precipitation students choose: none, showers, and continuous precipitation. They are also asked to name the type of precipitation: drizzle, rain, snow, hoar-frost, hail. In the case of meteorological visibility, students are asked to measure the distance at which an object or light can be clearly seen. They should choose between different types of visibility reduction: none (good visibility, more than 10 km), mist (restricts visibility to between 1 to 10 km), fog (restricts visibility to 1 km or less), and smog. In case of wind force they have to choose between: none (calm conditions), light wind (weak wind that lightly moves leaves on trees), gusty wind (moves branches on the trees, dust and loose paper raise), hurricane (strong wind that causes damage to nature and households). There are also parameters that might have been noticed since the last observation (previous week): lightning (none, lightning inside clouds, lightning strikes the ground); extreme atmospheric phenomena (none, flood, whirlwind, avalanche); other atmospheric phenomena (none, aurora, rainbow, glazed frost). Students should also be involved in hydrological cycle observations, including lakes and rivers activity, ice cover and snow cover. It helps to understand its impact on the distribution and supply of water. These observations to report are as follows: ice on lakes (none, lake surface is freezing, lake surface is melting, complete ice cover); ice on rivers (none, partly covered, complete ice cover); and snow cover (none, first snow, snow accumulation, stable snow cover, snow melting).

The obtained results give the distributed information on weather conditions and allow for determining the magnitude of their variability both spatial and temporal, its extremes, and help to understand the complexity of the climate system and climate patterns. Having a spatial display of the results helps to understand how the natural factors such as latitude, altitude, the reflectivity of the Earth's surface, distance from the sea and external forcing such as solar radiation, contribute to this complexity and changes. The students in the Monitoring System learn how meteorologists put much effort into monitoring, assessing and predicting these changes and helping policymakers develop strategies for dealing with them, especially in climate-sensitive sectors such as agriculture and water management.

3.3 Phenological observations

When are the flowers blooming, when will the fruits ripen, when do the migrating birds arrive back in the spring migration? The scientific method to collect this information is defined as phenology. The use of the term phenology is acknowledged to be given by Charles François Antoine Morren that used the word in 1853. The definition of phenology that is used since 1970's is proposed by the US/International Biological program Phenological Committee: "phenology is the study of the timing of reoccurring biological events, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of the same or different species." [11]. The observation is based on denoting the date of the happening of various precise defined phases (phenophases) of periodic biological phenomena, i.e. budburst of birch, first ripen blueberry, first mosquito bite, the arrival of cranes. There are signs of phenological observations from Asian and Mediterranean civilisations long back in history [12].Though the ancient observations of blooming cherries in China from 947 BC and the registrations from Japan for about 1200 years make some of the longest time-series in phenology. During 17th and 18th centuries, several groups started to systematically observe and register phenology. Most of them were scientifically based. In 19th century, more and more private persons became interested in phenological observations, both as independent observers or in organized groups, and this became like a citizen science function. The phenological observations make a basis to be combined with meteorology and other sciences to reveal and understand the connections in nature, including agriculture and forestry, climate influence and impact of humans.

3.3.1 Monitoring of plants

The species of plants in the Monitoring System were selected to be relatively easy to identify by the project participants and occurring in most parts of Europe. There are actually not so many plants that are distributed from Malta through whole Europe up to Svalbard. Further, we tried to choose species that is so common that there exist some literature about them in the various national languages of the countries. Then the phenophases were selected so that they are relatively distinct and clear to observe for young people. Another aspect is that the species' phenophases should have evident relevance for and be influenced by environmental parameters. We also wanted the selected phenophases overall to allow the most comparisons within and between species for meteorological gradients in Europe.

Table 1. The plant species and their phenophases used in the Monitoring System.

Species	Latin name	Phenophase
Birch	*Betula pubescens*	Started to flower
		Opened buds
		Leaves started colouring
		Leaves started falling down
Black alder	*Alnus glutinosa*	Started to flower
		Opened buds
		Seeds ready
		Leaves started falling down
		All leaves fallen down
		Opened buds
Lilac	*Syringa vulgaris*	Started to flower
		All leaves fallen down
		Opened buds
Rowan	*Sorbus aucuparia*	Started to flower
		Ripen berries
		Leaves started colouring
		Leaves started falling down
		All leaves fallen down
		Started to flower

Bilberry	*Vaccinium myrtillus*	Ripen berries
		Started to flower
Rosebay willow-herb	*Chamerion angustifolium*	Seeds ready
		Started to flower
Dandelion	*Taraxacum officinale*	Seeds ready

3.3.2 Monitoring of insects

The insects in the Monitoring System were chosen to be common indicators of ecosystems and easily found in the vicinity of schools throughout Europe. There are three pollinators (bumblebees, and two species of butterflies), one group of ground living (ants) and one group of flying (mosquitos) insects. The two species of butterflies are long living and survive as adults through the winter into next summer. The bumblebees and ants are living in organized communities where the queen lives for one year or longer. The mosquitos have a shorter lifespan, though some can survive as adults through the winter. For the insects, we chose to use the phenophase of the first occurrence in the year. For all, except mosquitos, this is the first visual occurrence, and for the mosquito, it is the first bite on human skin. We chose the bite, because there are several groups of insects that can be mistaken as mosquito.

Table 2. The insect species and their phenophases used in the Monitoring System.

Species	*Latin name*	Phenophase
Bumblebee	*Bombus sp*	First observation
Mosquito	*Culex sp*	First bite
Ant	*Formica sp*	First observation on ant-hill
Common brimstone butterfly	*Gonepteryx rhamni*	First observation
European Peacock butterfly	*Aglais io*	Fist observation

3.3.3 Monitoring of birds

The birds chosen for the Monitoring System all have migration routes covering most of Europe. Some of the species are representing birds that migrate relatively long distances, like the Arctic tern migrating between the Arctic and the Antarctic. White wagtail is migrating the shortest and parts of the population can overwinter in southern Spain and Mediterranean coast. The main didactic point is to show an environmental connection between continents with birds that use Europe as nesting place, but migrate to other continents i.e. Africa and Middle East for overwintering. We also selected the birds that can be easily identified, and have iconic connections to folklore in many areas of Europe, for example as cultural indicators from which to predict how weather will be during the coming season. The phenophase we used for birds is first visual or sound (like cranes and cuckoo) observation.

Table 3. The bird species and their phenophases used in the Monitoring System.

Species	Latin name	Phenophase
Arctic Tern	*Sterna paradisea*	First observation
Common cuckoo	*Cuculus caronus*	First observation
White wagtail	*Motacilla alba*	First observation
Crane	*Grus grus*	First observation

3.4 Monitoring System mobile app

During EDUCATORS' FORA (international meetings in 2017 – Oslo, Paris, Warsaw, dedicated to gathering feedback from active EDU-ARCTIC teachers), teachers shared their ideas how to engage pupils and make them more involved directly in the project. Monitoring System was evident as one of the areas with huge potential for direct students' participation, and consequently, creating a mobile app became an aspired stage of the Monitoring System development.

Today emerging technologies are reformulating the practice of education. In order to deal with current education challenges, combining education and technology is necessary for effective learning, with two-way benefits: users can access any information from anywhere, but also feed all sorts of databases, which matches perfectly the idea of citizen science, underlying the concept of EDU-ARCTIC Monitoring System.

App-equipped wireless devices give users worldwide the ability to act as remote sensors for all sorts of data as they go through their daily routines. Mobile apps offer miscellaneous functions: allow data entry in the field, enhance instant visual recognition of phenomena, and facilitate mapping observations. While designing and planning this tool, key necessary features were taken into account to make sure that the app meets expectations of demanding "mobile-fed" generation; consequently, the following elements needed to be provided:

- quality images and descriptions – the app became an opportunity to disseminate Monitoring System Manual; the manual was adjusted to app conditions, offering "help" section with the dedicated relevant part of manual, helping to identify a phenomena, plants' phenophase or migratory bird etc.,
- push notifications (weekly customized reminders),
- screen-responsive design (variability of display depending on the size of the screen, including a crucial part-scalability of world map with visible measurements),
- cross-platform coverage (2 most popular European systems – ANDROID and IOS were covered.),
- interoperability with modern connectivity standards (allowing offline work, turning location services on in order to submit the measurement).

The app added additional value to the Monitoring System: it was no longer limited to registered teachers and one location (school coordinates) per reporting user. Instead, it allowed Monitoring System to be open to users from all over the world, providing measurements from various locations (e.g. summer holidays, trips etc.).

The app is available for free and its functionalities were designed to be as simple as possible. However, in order to deliver real value and provide a high quality of data, measurements by non-registered users are marked distinctly from those provided by registered teachers (grey vs blue marks on the map with measurement results). This allows us to remain precarious about and eliminate potential dubious/questionable submissions of data. The app offers direct access not only to our illustrated monitoring manual (enabling more citizens to place their science-based insight into wider context and importance of observations), but also history of user's measurements and map with results (the user's own measurements marked in red). Such an approach fits with current societal trends of personalisation and customisation, which enhance user experience allowing users to control their interaction. In the case of the Monitoring System app, the "sharing culture" ingrained in generation familiarized with social media is harnessed by the possibility of adding individual photos of observations.

The app facilitates – through its many easy-to-apply interphase qualities – the element of sustained ongoing engagement – a key success factor in mobile apps, especially those aiming at supporting the collection of environmental data. We may so even reach the "sharing culture" of young, notorious technology enthusiasts because the app exploits **gamification qualities** based on undisturbed presence and demonstration of undertaken activities; supporting regular submitter' engagement. For each measurement, users can gather 2 to 5 so-called 'EDU-COINS' points (2 for adding at least one parameter, and up to 3 photos with 1 point each). Their results are presented on a public scoreboard. Additionally, users can exchange their points for rewards (backpacks, jigsaws, photo albums etc.).

This way the EDU-ARCTIC Monitoring System is enriched with another type of positive motivation, strengthening imparting skills to execute assignments and enable young people to utilize their leisure hours in exploring productive things and arouse curiosity to learn more willingly.

4 METHODS OF EVALUATION OF THE IMPACT

Within the project assessment of the impact of participation in the EDU-ARCTIC program, we collected measures on students' interest in STEM and their knowledge. The technique used for collecting data is CAWI surveys. CAWI (Computer Assisted Web Interviews) research technique is an interview in which participants fill in an online questionnaire or survey received via the Internet. Currently the CAWI method is one of the most popular and fastest-growing research methods. With a sense of anonymity and the opportunity to participate in the study at a time convenient for the respondent, it allows to collect more accurate data. The surveys consist of questions about changes in pupils' behaviour, openness and scientific courage due to participating in EDU-ARCTIC.

During the period 7.01.2019.-20.02.2019., after two years of running the program, we conducted a survey assessing the general impact of the project and all particular activities implemented within. We obtained 80 answers from teachers and educators from 19 countries, who participate in the project. The survey was available to teachers, who were active in the program for at least one full year. Teachers were invited to fill in the survey, but it was not obligatory. The survey was divided into 2 parts: (1) TECHNOLOGY including 3 questions about the various modules of the EDU-ARCTIC portal and (2) FACTUAL including 6 questions about the impact of the project on pupils (e.g. interest, understanding, knowledge). The results of the part of this survey dedicated to the Monitoring System are presented in the section 5.

5 EVALUATION DATA

The evaluation of the solutions proposed within the EDU-ARCTIC project is crucial in order to assess its impact and to propose changes required by end-users, if necessary. The evaluation process in the project is ongoing as of May 2019. In this paper the results of some parts of the "Main Survey – After", using key indicators described in details in [13], dedicated to the Monitoring System are presented.

The first part of the survey addresses questions on (1) utility of the Monitoring System in conducting various educational activities, (2) visual attractiveness of the Monitoring System and (3) frequency of using it. To assess the utility and attractiveness of the system, teachers were requested to give marks on a scale of 1 to 6, where 1 is the lowest and 6 the highest. The results are presented in Fig. 2.

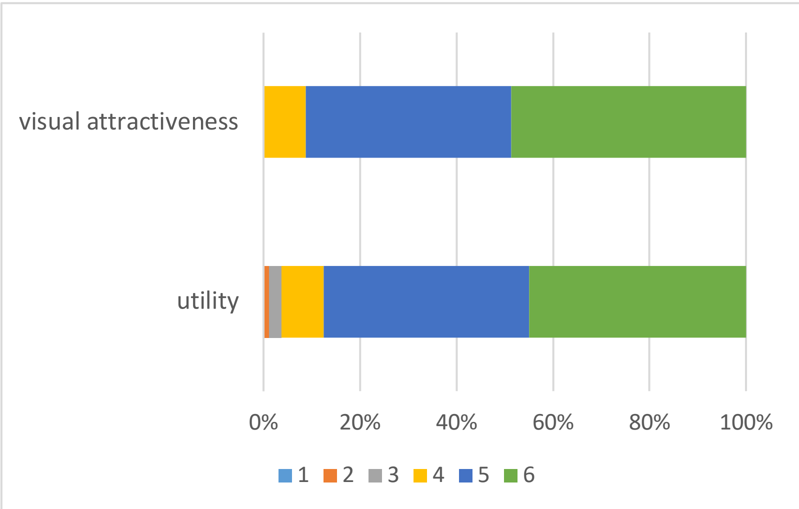

Figure 2. Visual attractiveness and utility of the EDU-ARCTIC Monitoring System marked by teachers on a scale of 1 to 6, with 1 as the lowest and 6 as the highest grade (total of 80 answers).

The second part of the survey addresses impact of the Monitoring System on (1) students' knowledge about issues related to the Arctic, (2) the level of understanding of scientific issues and scientific language among students, (3) the level of interest in STEM and scientific careers among students. The results of this part are presented in Fig. 3.

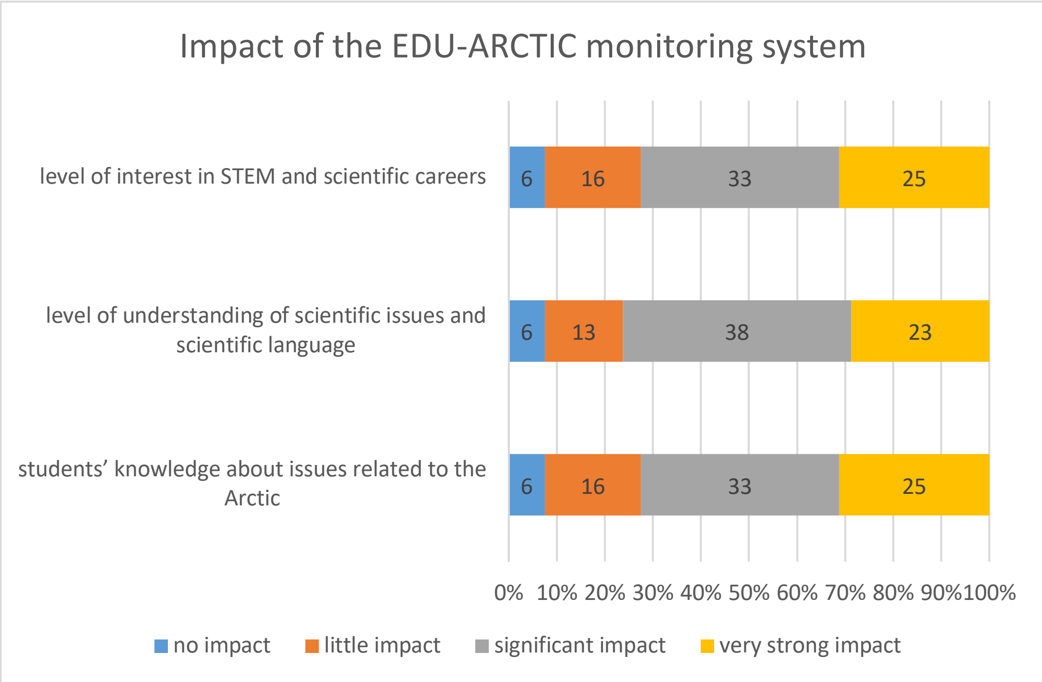

Figure 3. Opinions of teachers on the impact of the EDU-ARCTIC Monitoring System on the interest, understanding and knowledge of their in-class pupils (13-20 years of age). Numbers of answers in each category are given in the colour fields (Total of 80 answers).

6 RESULTS AND DISCUSSION

The Monitoring System was assessed positively by the majority of teachers in terms of its utility, with the highest grades (5, 6) given by 89% of responders. Only a few teachers gave additional free comments to the question, showing a.o. that they participate in so many projects, that it is difficult to engage in all activities. One teacher suggested that implementation strategies for how they can use studies in situ about climate change would be useful in his/her practice. We believe this would be a valuable addition to future educational projects like EDU-ARCTIC; providing teachers with guidelines for place-basing the teaching of what they learn in the project. In terms of visual attractiveness 91% of teachers assessed it with two highest grades (5 and 6), which means that in practice no further improvements are required in this context. No further suggestions were given by responders. We therefore deem both the technical and the visual layout of our system as highly successful.

The Monitoring System was used by teachers more rarely than other EDU-ARCTIC components. The biggest group of teachers (33 persons, 41%) declared to use it on average once per month. 26% of responders use it rarely – less than once per month and only 11% use it regularly – a few times per month. However, as this component was constructed in such a way that it required actions only once per week (each Monday), the frequency indicated by teachers may be considered satisfactory. Within 27 months of operation 2168 reports from teachers were obtained (on average 80 reports monthly).

Taking into account the mobile app, despite its potential, the opportunities to involve students and other citizens in direct observations and reports remain insufficiently exploited. Probably this is due to the low recognition of the app among other actors than teachers. Our main dissemination activities considered teachers, who not necessary distributed this information to their students.

As for the Monitoring System's impact on students knowledge, understanding and interest, all the three parameters were assessed generally positively. Only 7.5% of teachers considered that it has had no impact on their students. The biggest impact reported was in terms of understanding of scientific issues (48% of teachers assessed it as 'significant' (next highest score) and 29% as 'very strong impact' (highest score)). Similarly positive impacts were reported for students' knowledge and their interest in STEM and scientific careers (both 41% significant and 31% very strong impact).

7 CONCLUSIONS

After two years of implementation, we consider the Monitoring System offered by the EDU-ARCTIC program as an effective way of enhancing students' interest in STEM, scientific careers and their knowledge about environmental issues. It was also positively assessed by its main users (teachers of young people aged 13-20) in terms of utility and visual attractiveness. However, the frequency of usage and the number of users is rather low. Especially the potential of the mobile app is not sufficiently exploited and additional promotion could be dedicated to make that tool more popular.

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