O1 FabCitizen stakeholder analysis

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Editors: Jan Pawlowski, Annika Nowak, Katerina Riviou
Contributors: Jan Pawlowski, Annika Nowak, Katerina Riviou, Federica Fiorio, Monika Mačiulienė, Gintarė Gulevičiūtė, Francesco Fieni

About this document

This document is the main outcome of IO 1. It contains the results of IO1 (O1.1. Analysis Planning; O1.2 Requirements and Stakeholder Analysis).
Based on an initial review of potential requirements and barriers, we have conducted 10 interviews in the participating countries, i.e. Germany, Greece, Italy and Lithuania. Based on the interviews, we have identified key aspects of how to introduce Citizen Science into schools. We looked at technological, educational and curricular aspects. The results will help to 1) develop the curriculum for teachers and students, 2) develop specific learning scenarios, and 3) plan the initial pilots in schools.

About The Fab Citizen Project

The main goal is to enable schools, in particular teachers, parents and pupils, to participate in high quality citizen science projects in both curricular and extracurricular contexts.
Citizen Science (CS) has raised a lot of attention in recent years. Its main goal is to involve citizens in different types of science projects, in particular to 1) improve engagement and 2) to increase research capacities, e.g. by shared data collection. Many projects have incorporated citizen science approaches. Whereas citizen science works well for educational purposes (e.g. in inquiry-based science education), the acceptance of CS on a scientific level ranges from low to questionable. Even though the European Association for Citizen Science has clear guidelines and support mechanisms, many CS projects are not taken seriously. This is the main starting point for the FabCitizen project: We aim at providing tools to increase the quality of CS projects, in particular in schools. For this purpose, we will integrate FabLabs as the main educational environment as they can provide both technological as well as methodological expertise.
We base our project on clearly defined requirements, amongst them

- In schools, CS projects need to be embedded into the curriculum in various subjects
- To ease the implementation, teachers need high quality (open) scenarios and learning materials
- CS projects need support in terms of methodological and technological expertise.

In the project, we will achieve the following main results:

- A Citizen Science competency framework describing knowledge, skills and attitudes to successfully engage in high quality CS projects
- A pedagogical concept incorporating aspects of service learning to connect
- A guide for FabLabs as the key infrastructure to educate and train citizens.
- More than 100 Open learning scenarios to train teachers, pupils and parents in early secondary school
- A collection of Open Educational Resources supporting the approach
- A good practice guide for schools and FabLabs across Europe

The project will provide guidance and concrete support to universities, FabLabs, schools and the surrounding communities to participate in successful, high quality CS projects. As part of our trials, we will initiate around 100 CS projects. In the long run, we create new methods and materials for broader engagement and quality improvement in CS.

1 Background

In the following, we describe our understanding of Citizen Science (CS) based on an initial review. As there is no common definition, this is necessary to communicate our understanding within and outside the project.

1.1 Conceptual foundations

As a **starting definition**, Mäkipää et al (2020) define Citizen Science as following: “Citizen science refers to partnerships between scientists and the public in their everyday lives in scientific research”. This very broad definition just defines the collaboration between scientists and the public. A more comprehensive definition (for Citizen Science in the Information Systems domain is given by Levy & Germonprez (2017): “Citizen science [...] is a partnership between [...] researchers and people in their everyday lives. Citizen science projects [...] involve a) [...] phenomenon of interest to both citizens and scientists, b) the intervention of citizens in the collection, collaboration, or co-creation of scientific endeavors for the purposes of scientific literacy education and a more informed public, and c) citizens themselves not being the direct subject of scientific inquiry”. This definition includes one of the key aspects when defining Citizen Science: the **purpose of public involvement**. Citizen Science has got different purposes. By conducting citizen science projects, it is possible to enhance the scientific literacy of participants , to engage citizens in scientific processes and to create “a more informed citizenry about science and technology in citizen’s everyday life” (Levy & Germonprez, 2017, p.23). Through citizen science one can gain knowledge about “*human behavior in new IS contexts”* (Levy & Germonprez, 2017, p. 31). Citizen science projects can strengthen the understanding of the mechanisms of science (Nistor et al., 2019, p. 11). In principal, the purpose can be seen as

1. Education and learning: people are involved to learn about science and scientific processes
2. Awareness and understanding: people are involved to be aware about ongoing research projects. Here, the involvement focuses on communicating scientific findings.
3. Capacities: In many cases, people are involved to collect data for scientific projects similar to crowd-based approaches. By involving a broad range of people, research capacities and the amount of collected data are increased.

In our context, we focus on the educational view of CS as our main target group are teachers and students in high schools and the community around those. Eitzel et al (2017) also discuss the different **roles of actors** involved in CS. Bonney et al. (2009) suggest that there exist different levels of citizen science involvement. A citizen science project can be :

- Contributory

    - “If a project is contributory, citizens primarily help collect and analyze samples or observations, which represents the way most citizens have contributed to citizen science projects.”(Levy & Germonprez, 2017, p. 26).
- Collaborative
    - “If a project is collaborative, citizens help develop explanations, have a say in data collection methods, and analyze and interpret data.” (Levy & Germonprez, 2017, p. 26).
- Co-created

Depending on the stage, the citizen involvement differs. In our context, we focus on the collaboration of researchers, teachers, pupils and their communities (such as parents or quarters around the participating schools).
Furthermore, there are different perspectives on Citizen Science. Levy & Germonprez (2017) discuss citizen science from three perspectives: sociological, natural science and policy perspective.

Generally, there are common phases / activities on how to organize and run CS projects. Bonney et al. (2009, p.979) propose the following model and steps for developing a citizen science project:

- Choose a scientific question
- Form a scientist/educator/technologist/educator team
- Develop, test and refine protocols, data forms and educational support materials
- Recruit participants
- Train participants
- Accept, edit and display data
- Analyze and interpret data
- Disseminate results
- Measure outcomes

Obviously, there exist commonalities to the scientific research cycle (for example the scientific investigation life cycle of Kembara et al. (2020). On a closer look appear differences as for example in the steps “forming a s/e/t/s” team”, “developing [...] educational support materials” and the “recruiting and training of participants”.

Based on this short analysis, we understand Citizen Science as “collaborative research efforts between scientists, schools and communities to improve research competencies and capacities”.

1.2 Related concepts

Citizen Science is not an isolated approach but relates to many disciplines and concepts which need to be taken into account.

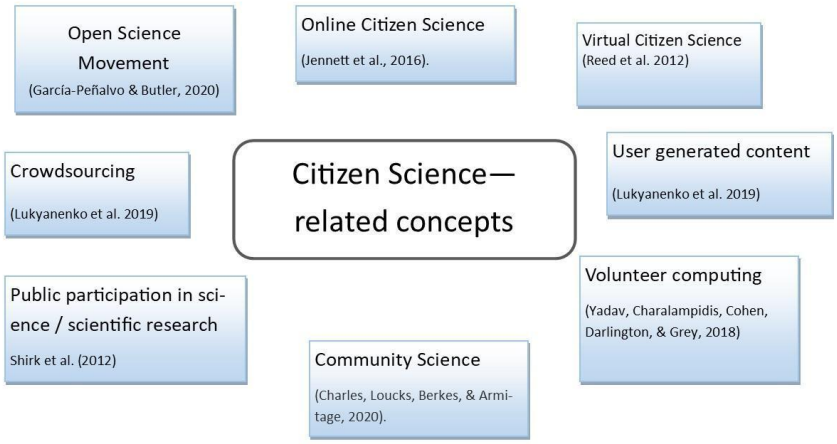

Figure 1: Overview if the related citizen science concepts (own created overview)

Concept relations

As we focus on education, one of the goals is to **improve scientific literacy.** As an example, Levy & Germonprez (2017) state that citizen science projects aim at increasing scientific literacy by the intervention of citizens. Obviously, a relationship between scientific literacy and citizen science can be identified. Glaze (2018) defines: “Science literacy exists in three dimensions that include (1) Bybee’s levels of literacy from illiteracy to multidimensional literacy; (2) domains of literacy, including the different fields of study that are possible; and (3) the value that is attached to the pursuit of scientific literacy at the individual and community levels”.

Furthermore, Citizen Science is related to the **Open Science Movement**. (García-Peñalvo & Butler, 2020, p. 2) García- Peñalvo state that “*open science is a movement that aims to make scientific research accessible to all citizens*” (García-Peñalvo & Butler, 2020, p. 2). Additionally to that, **related terms** for citizen science are “*crowdsourcing, participation and user generated content*” (Mäkipää et al., 2020, p. 4643).

Shirk et al. (2012) use the term “**public participation in scientific research**” to “*discuss initiatives from diverse fields and traditions*”. Shirk et al. (2012, p. 3) define public participation in scientific research “*as intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge*”. Public participation in scientific also includes Citizen Science (Shirk et al. 2012).

Shirk et al. divide **public participation in scientific research** into the following categories (Shirk et al., 2012, p. 5):

- **Contractual projects**

    - Communities ask researchers to "c*onduct a specific scientific investigation*" (Shirk et al., 2012, p. 5)
- **Contributory projects**
    - Designed by researchers and the public people can contribute data
- **Collaborative projects**
    - Designed by researchers but the public but public people also handle with data (project design, analyze data, disseminate findings)
- **Co-created projects**
    - Projects are designed by scientists and members of public who are working together
- **Collegial distributions**
    - "*non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and / or professionals*" (Shirk et al., 2012, p. 5)

Due to our understanding of citizen science and taking into the account the classification of Shirk et al. (2009), we want to conduct co-created Citizen Science projects with schools.

Ballard et al. (2015) examine case studies of "**youth-focused community and citizen science** (CSS)". Ballard et al. (2015) understand community and citizen science as "*activities as activities or programs in which members of the public collaborate with professional scientists on scientific research and monitoring in either scientist-led or community-led endeavors*".

Furthermore, Lukyaenko et al. (2020) identifies "crowdsourcing" as a related concept to citizen science. The advantage of crowdsourcing is that many online users engage in routine tasks to generate a business value (Lukyaenko et al. , 2020, p. 964).

More related concepts can be presented through the definition of levels of citizen science projects by Hakay et al. (2013). He defines the following levels of citizen science projects:

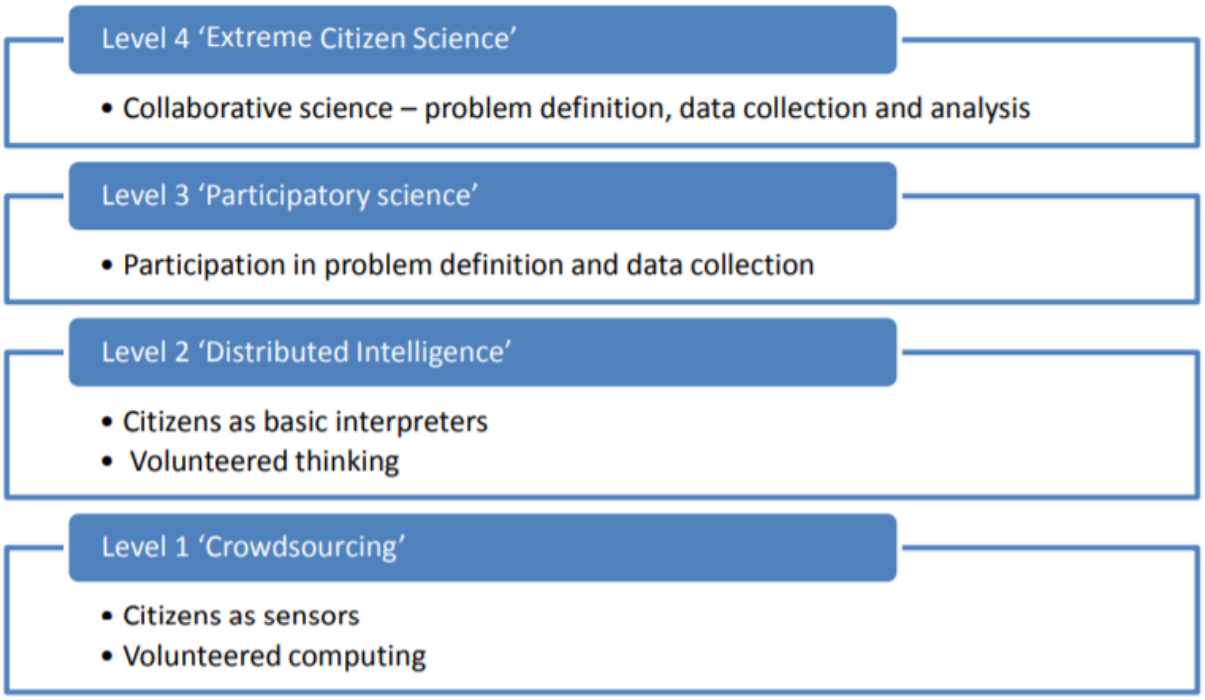

Figure 2: Levels of participation and engagement in citizen science projects (Haklay ,2013)

A related research design is "*participatory action research (PAR)* *is an approach to research that its' supporters claim can foster new knowledge, learning, and action to support positive social and environmental change through reorienting the standard process of knowledge production*" (Ballard & Belsky, 2010, p. 611). According to Baskerville (1999) the traditional action research "*has been extended into a form known as "participatory action research". An important change is the realignment of the roles of researcher and subject into more collaborative and synergistic forms*.". Obviously, in participatory action research and in citizen science people are involved as co-researchers. Therefore, citizen science can be seen as an extension of PAR because it involves society and wants to contribute to scientific knowledge.

Our understanding of citizen science: https://www.pnas.org/content/116/17/8089

Due to our understanding of citizen science and taking into the account the classification of Shirk et al. (2009) and Haklay et al. (2013) we want to conduct the range of co-created Citizen Science projects (Shirk et al. (2009)) / participatory citizen science projects (Haklay et al. (2013)) and 'extreme citizen science' projects (Haklay et al. (2013)) with schools. Therefore, a whole competency set is required as the competency "data collection" isn't enough for co-created / participatory citizen science projects.

Thereby, we have got a specific educational purpose and focus. Furthermore, as there does not exist an international definition for citizen science (Heigl, Kieslinger, Paul, Uhlik, & Dörler, 2019, p. 8090) , we orientate the citizen science projects on "quality criteria for citizen science projects

on “Österreich forscht”” (Heigl, Dörler, Batar, Brodschneider, & Cieslinski, 2018) for the following areas:

- What is not CS
- Scientific standards
- Collaboration
- Open Science
- Communication
- Ethics
- Data Management

The category ‘**What is not CS’** includes those aspects that cannot be assigned to CS. These are, for example, projects in which people with a strong scientific background are involved. In addition, it should be mentioned at this point that collecting data on people (citizen scientists) does not constitute Citizen Science. Another quality criterion is ‘**scientific standards’**. These include the choice of the right method, the choice of a suitable hypothesis and that in the end knowledge is also generated on the basis of the research question or the scientific goal. The quality criterion **collaboration** refers to the collaboration of scientists and citizen scientists. In order to achieve a balanced collaboration, it should be ensured that the interests of both the scientists and the citizen scientists are taken into account so that both benefit equally from the project. However, a very important key point here is that research CANNOT take place WITHOUT citizen scientists, otherwise it would not be Citizen Science. This means that the participation of citizen scientists is crucial for successful research.In short, the quality criterion ‘**open science**’ aims to ensure that research results are made available to the public so that they can also benefit from them. In addition, the research results should be understandable, findable and reusable. The format of the research results should be in open-access format. With regard to **communication**, it should be taken into account that different groups are addressed. In particular, care should be taken that the participants receive feedback from the scientists. The goals of Citizen Science projects must be **ethically** justifiable and also follow ethical guidelines. Finally, all Citizen Science projects should follow a **data management** plan that complies with European data protection rules(Heigl et al., 2020).

1.3 Requirements, Benefits and Lessons Learning

As a starting point, we have analyzed the needs and requirements for schools.

First, Asingizwe et al. (2020, p. 4) separates between different barriers regarding Citizen Science:

- Barriers to get involved
- Barriers to initial participation
- Barriers to stay involved

- Barriers for future participation

Many **challenges and barriers** have emerged in CS and related projects (cf. Burgess et al, 2017, Conrad & Hilchey, 2011, Nov et al, 2014, Pirkkalainen et al, 2014), examples are:

- Many CS projects lack methodological rigor
- Data fragmentation, inaccuracy, lack of objectivity
- There are not enough quality assurance mechanisms for data collection
- Lack of volunteer interest
- Lack of funding
- Lack of technological or methodological skills of the participants
- CS projects are not taken seriously in the scientific community
- Data analysis and interpretation is a specialists' skill

Another barrier is the language barrier which can appear in international citizen science projects (García-Peñalvo & Butler, 2020, p. 2).

Furthermore, (Geoghegan, Dyke, Pateman, West, & Everett, 2016, p. 66- 68) list the following barriers for citizen science projects:

- Data quality
    - Inadequate equipment (e.g. low quality sensors)
    - Mistrust data from nonprofessionals
    - Biases influencing decision to participate
    - Scalability of data
    - Partnerships with local authorities
    - Patchiness of data
    - Specific evidence need beyond the scope of citizen science
- Peer Review / Trust
    - Peer reviewer reservations during publication process
    - Citizen science frowned upon by colleagues
    - Institutional reservations about citizen science
- Requirement of specialist equipment/knowledge
    - Training required
    - Difficulties of recruitment and commitment of volunteers
    - Inaccessible sites
    - Unable to keep up with technological developments
    - Getting people to use technology
    - Crowded marketplace for citizen science projects in certain areas
- Time consuming Resourcing issues
    - Promoting citizen science
    - Communication
    - Slow process

    - Individual interactions
    - Mobilizing and maintaining citizen science projects
    - Volunteers threaten job opportunities/security of professionals
    - Lack of interpretation may lead to poorly-informed public demands
- Politics
    - Liability of organizers if don't act on citizen data
    - Unaware using citizen science data
    - Nobody championing citizen science on high level
    - Differing science and engagement objectives
    - Activities require legislative approval
    - Lack of interest in engaging the public through citizen science

Another challenge of citizen science is to conduct the projects and that the achievement of citizen science projects can be limited (Levy & Germonprez, 2017). This arises from the fact that the perspective, knowledge and interests of citizens and scientists differ. Therefore data quality issues can appear (Lewandowski & Specht,2015; Lukyanenko et al., 2016a) cited from (Levy & Germonprez, 2017, S.32).

Furthermore, considering the conduction of Citizen Science projects appear various **challenges**:

- The formulation / complexity of research questions (Bonney et al., 2009)
- Strengthen sustained volunteer engagement (Mäkipää et al. 2020)

However, there are also many **benefits** included in the concept of Citizen Science.As we focus on an educational perspective, CS provides many added values to STEM education (Perello et al, 2017, Nistor et al, 2019, Shah & Martinez, 2016). CS can improve STEM related learning outcomes, increase motivation and engagement but also incorporate environmental responsibility or engaged citizenship as well as data analysis and collection (Aristeidou, & Herodotou, 2020, Mandinach & Gummer,2013; Wolff et al, 2016).

Overview of the potential / benefits of citizen science :

- Creation of science communities to solve scientific problems(Levy & Germonprez, 2017, p.33)
- Enhance public scientific literacy (Levy & Germonprez, 2017, p.33)
- Search for the overlaps of citizens and researcher’s interests (Levy & Germonprez, 2017, p.33)
- Science learning outcomes (Barton, 2012; Bonney et al., 2015; Krasny et al., 2014) cited from (Ballard et al., 2015, p. 1)
- Studying a large amount of data (Bonney et al. , 2009)

Moreover, Bonney et al. (2016) lists the following achievable projects outcomes of citizen science projects (Bonney et al., 2016, p. 10):

- Interest in science and nature
- Self-efficacy for science and environmental action
- Motivation for science and environmental action
- Skills of science inquiry
- Data interpretation skills
- Knowledge of the nature of science
- Environmental stewardship

Obviously, "*Citizen Science is engaging, can lead to increased understanding of science content, and sometimes leads to knowledge of the process and nature of science*" (Bonney et al., 2016, p. 13). Furthermore, Aristeidou & Herodotou (2020) analyzed several citizen science projects Kloetzer et al. (2013), Jennett et al. (2016), Prather et al. (2013), Price and Lee (2013) and identified the findings of learning and scientific literacy. In the following an extract of their findings Aristeidou & Herodotou (2020, p. 7):

Extract of the findings of Aristeidou & Herodotou (2020)	**Categorization of output / skill**
Understanding of science procedures and risks	Scientific literacy
Increased topic-specific knowledge	Topic-specific knowledge
Understanding of how topic-specific science software and tools work	Scientific literacy & tool knowledge
Increased pattern recognition, identification skills, and data comprehension	Pattern recognition, data and analytics skills
Improved communication, digital literacy, and personal development	Communication, digital literacy, personal development
Positive change in scientific attitude	Attitude
Significantly increased epistemological beliefs about the nature of science	Understanding nature of science

Résumée: The combination of citizen science and data literacy is a key starting point for us. As many studies have discussed the synergies of those two concepts (Sagy et al. 2019, Twidale et al., 2013), surprisingly few CS frameworks specifically focus on data.

1.4 Good Practices

As there are many large initiatives on Citizen Science, a variety of good practices has identified recommendations. As a starting point, the European Association for Citizen Science has clear **principles** for Citizen Science projects:

1. “Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding. Citizens may act as contributors, collaborators, or as project leader and have a meaningful role in the project.
2. Citizen science projects have a genuine science outcome. For example, answering a research question or informing conservation action, management decisions or environmental policy.
3. Both the professional scientists and the citizen scientists benefit from taking part. Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence e.g. to address local, national and international issues, and throughthat, the potential to influence policy.
4. Citizen scientists may, if they wish, participate in multiple stages of the scientific process. This may include developing the research question, designing the method, gathering and analyzing data, and communicating the results.
5. Citizen scientists receive feedback from the project. For example, how their data are being used and what the research, policy or societal outcomes are.
6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for. However unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratization of science.
7. Citizen science project data and meta-data are made publicly available and where possible, results are published in an open access format. Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this.
8. Citizen scientists are acknowledged in project results and publications.
9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.
10. The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities.”

These principles should be followed when designing projects but can also be used to derive competency requirements.
As further recommendation, Herodotou et al. (2018) have derived **design principles** for CS tools and communication:

- “Design principle 1 (theory): Engage volunteers as initiators of citizen science projects, to create personally relevant investigations.

- Design principle 2 (theory): Vary the investigations (types and topics) to accommodate different interests and motivations of volunteers who participate in citizen science projects.
- Design principle 3 (user experience): Develop mobile applications to scaffold data collection citizen inquiry projects.
- Design principle 4a (user experience): Scaffold the process of scientific inquiry from setting up a new investigation, to choosing tools for data collection or contributing to investigations set by others.
- Design principle 4b (user experience): Moderate interactions and facilitate participation through a set of mechanisms such as weekly email notifications.
- Design principle 5: Communicate key message of learning by doing.
- Design principle 6: Communicate key messages of 'doing and being part of a community'
- Design principle 7: Reward every visit to the citizen inquiry platform.
- Design principle 8: Value users and their time."

These principles will be taken into account especially in our piloting phase.

Esch et al. (2020) have provided **recommendations** based on previous experiences of citizen science in schools:.

1. "Stakeholders should consider academic standards, district- and school-based curricular priorities, and existing instructional materials in designing and implementing school-based CS [...]
2. CS work should be relevant to the local community in order to garner community support
3. School-based CS work should connect to broader CS initiatives that interact meaningfully with students
4. Professional scientists should be highly engaged with project work.
5. Teachers should be motivated to integrate CS into their science instruction and routinely relate CS work to diverse topics across the science curriculum
6. CS work should be meaningful, not just procedural, to teachers and students
7. CS should be part of the school culture" (Esch et al, 2020)

Furthermore, there are several **projects** focusing on the school context which provide input for our project, e.g. by re-using learning materials and scenarios. The project builds on approaches which have been tried out and validated in different contexts. In the preparation phase, we have done a review of Citizen Science projects also beyond the consortium - in particular, the large project EU-Citizen Science has provided the most useful references as they have surveyed specifically projects and corresponding training materials (Nold et al. , 2019). Three key statements provide a direction for our project:

- "CS training for schools and educational institutions should be greatly expanded and formally integrated into school curricula" (Nold et al., 2019). This statement motivates our

idea to link CS training to curricula and link to existing curricula / subjects to ease the integration process.
- “More collaboration between research fields (e.g. science and education) has been recommended to realise the full potential for learning in CS” (Nold et al, 2019). Our idea of cross-subject teaching and learning is also supported.
- “Schools Training is audience-specific training that is the most tightly focused training in that it targets teachers and young people in formal education. The most common request is for practical guides on how to do CS within schools.” (Nold et al, 2019).

The report also shows that school training is often limited to practical guides. More specifically, specialized competencies like data handling or even data ethics are not included.

Furthermore, we will not review specific projects intensively as this has also been conducted by the EU Citizen Science project - we recommend case studies documented in the comprehensive publication “The science of citizen science” (Vohland et al, 2020).

However, there are several similar initiatives which are relevant for our context.Furthermore, (Aristeidou & Herodotou, 2020) observed different online citizen science projects and provided an overview of these projects in the form of a table:

Research article	Citizen science projects	Approach	Research instruments/methods	Learning impact categories explored
Kloetzer et al. (2013) *(ESREA conference)*	Old Weather, BOINC, Eyewire	Bottom-up	· Self-reported learning (interviews)	· Nature of science · Topic-specific knowledge · Science knowledge · Generic knowledge
Jennett et al. (2016) *(Journal of Science Communication)*	BOINC, Old Weather, Eyewire, Transcribe Bentham, Bat Detective, EveryAware, KRAG	Top-down	· Self-reported learning (interviews) · Interviews (scientists)	
Prather et al. (2013) *(Astronomy Education Review)*	Galaxy Zoo	Top-down	· Zooniverse Astronomy Concept Survey (ZACS) (pre/post)	· Topic-specific knowledge
Price and Lee (2013) *(Journal of Research in Science Teaching)*	Citizen Sky	Top-down	· Scientific attitude instrument (pre/post) · Nature of Scientific Knowledge Scale (NSKS) Instrument for epistemological beliefs (pre/post) · Self-reported learning (interviews)	· Attitudes towards science · Nature of science · Topic-specific knowledge
Scanlon, William and Clow (2014) *(Educational Technology & Society)*	iSpot	Top-down	· User Identification check (false/right)	· Topic-specific knowledge
Mugar et al. (2015) *(International Conference on Communities and Technologies)*	Planet Hunters	Top-down	· Interviews (citizens) · Log data analysis	· Attitudes towards science
Land-Zandstra et al. (2016) *(Public Understanding of Science)*	iSPEX	Top-down	· Project questions (false/right) · Self-reported learning · Likert scales	· Attitudes towards science · Topic-specific knowledge
Kloetzer, Schneider, and da Costa (2016) *(Human Computation)*	BOINC AF	Bottom-up	· Self-reported learning (interviews) · Informal Learning in Citizen Science (ILICS) Survey · Forum interactions analysis	· Attitudes towards science · Nature of science · Topic-specific knowledge · Generic knowledge

Figure 2: Overview of online citizen science projects: methods and findings (Aristeidou & Herodotou, 2020, p. 7).

Finally, there are useful recommendations on the **evaluation** of Citizen Science projects. Kieslinger et al. (2018) specify clear criteria for evaluating projects regarding the following categories and sample criteria:

- Scientific dimension: e.g. scientific process, data quality, ethics, scientific impact
- Participant dimension: e.g. degree of participation, scientific literacy, motivation and engagement
- Social-ecological and economic dimension: collaboration, societal impact, sustainability, market opportunities.

As a summary, we have reviewed the state of the art and related recommendations of Citizen Science projects. This provides our project with a solid conceptual and practical base to build upon.

1.5 Intermediate Summary

In this section, we have reviewed the state of the art on citizen science (excluding competencies which will be handled in IO2). The following base approaches will be used in the project

- FabCitizen projects shall follow the recommendations of EACS (2015).
- Tools shall be based on the design principles of Herodotou et al (2018).
- Evaluations shall be based on the criteria of Kieslinger et al (2018)

Our review allows us to build on a solid base of scientific and practical recommendations.

2 Interviews

Based on the initial analysis, we aimed at thoroughly understanding requirements and barriers in schools. In the following, we show our study design and results.

2.1 Methodology

For our analysis, we have chosen a qualitative approach. As shown in the background section, there are no extensive analyses of how Citizen Science can be brought into schools. Furthermore, there are many differences (curricula, technical equipment, competencies, …) in the participating countries. For this explorative research task, we decided to do semi-structured interviews as well as focus groups. The interviews were - when authorized - recorded and transcribed. The full interview guideline is shown in Annex 1.

2.2 Overall summary

Demographic data (40 interviews, describe age, gender and background distribution as well as roles)

Categories of the analysis

Themes	**Major categories**	**Minor categories**
1) Experience with CS projects	Opinion about CS projects	
	CS projects at school	
	Example CS projects	Environmental projects Other projects
2) CS curriculum at schools	Current status	
	Possible topics for implementing CS	STEM-subjects
		non-STEM-subjects
3) DS curriculum	Current status	
	Possible implementation of DS-topics	STEM-subjects, non-STEM-subjects

4) Support for teachers	Education support	
	Monetary support	School-boosters club School budget Third party funding
	Introducing new topics	
5) Adaption of curriculum	Project courses	
	Supplementary hours	
	Project days	
	Other possibilities	
6) Citizen Science Skills	Interest	
	Self-efficacy	
	Motivation	
	Knowledge of the nature of science	
	Data	
	Skills of science inquiry	
	Responsible citizenship	
	Basic skills	
	Social skills	
	Additional skills	
7) Barriers & interventions	B: Lack of resources - High workload for teachers	Intervention:
	B: Lack of skills	Intervention:
	B: Lack of interest in scientific projects	Intervention:

	B: Lack of active involvement	Intervention:
	B: CS is not a school issue	Intervention:
	B: Lack of interest in research / science	Intervention:
	B: Lack of benefits	Intervention:
	B: Lack of community interest	Intervention:
	B: Presence of the topic	Intervention:
	B: Missing long-term agreements	Intervention:
	B: Missing finances and sponsoring	Intervention:
	B: Linguistic barrier	Intervention:
	B: Long project duration	Intervention:
	B: Missing contacts to schools	Intervention:
	B: Other barriers	Intervention:
8) Needs	Schools	IT-infrastructure / educational support / other
	Teachers	IT-infrastructure / educational support / other
	Students	IT-infrastructure / educational support / other

For the country results, please use the following structure

- *Key findings (across countries)*
- *Curricula (CS and data science)*
- *Summary of requirements*
- *Summary of competencies*

- *Summary of barriers and interventions*
- *Summary of needs / teacher support*
- *Country specific aspects*

The quotes have to be signed with the country codes.
Example: Expert DE7 affirms: "...." OR Some participants have got experience with CS-projects (DE8, DE2) [...]

2.3 Country results: Germany

The citations and the categorization of the quotes can be found in the following document: https://docs.google.com/spreadsheets/d/1_rTTPdc1AhpMihI9oYhfQKsu-ck_oA56/edit#gid=232244630

Description of the results from the interviews about citizen science

1. Experience with CS-projects
    1. Opinion about CS-projects / Experience

According to participant Nr. 1 "*CS-Projects are projects which should get more attention*" (DE Nr. 1). Furthermore, some participants already had experience with Citizen Science projects, for example the projects "*Sparkling Science", "plastic pirates*"(DE 8, D2). The plastic pirates is an environmental project and the sparkling science project is a project which summarizes various projects from different disciplines.

Expert Nr. 3 states that Citizen Science is a " *holistic approach to how you live with science and a progress of knowledge".* Other interviewees had little experience with citizen science or had no contact with citizen science so far (DE 2,7, 4, 9).No interviewee had a negative experience with citizen science projects (DE 1-10).

b. Example citizen science project

The interviewees mentioned different citizen science projects which they know: "*stratosphere balloon*"(DE 1), "*hybrid power plant / wind turbine*"(DE 2), "*Observation of the breeding behavior of song bird*" (DE 8), "*getting data from natural observations and analyze it*"(DE 3), "*plastic pirates*"(DE2).

Other interviewees didn't know an example citizen science project(DE 4,5,6,7,9). Expert 7 states that it is imaginable to implement these concrete projects "*into a framework like "youth researchers*" (Jugend Forscht - competition in Germany). Another idea is to integrate citizen

science projects into "*project courses*" and "*technical papers"* which are "*first steps towards scientific research*"(DE 4).

c. Experience with citizen science at schools

Some interviewees did not have direct experience with citizen science projects, but with projects "which can get into this direction"(DE 2). Expert 2 assumes that "*engineering lessons could get in this direction*" and also would like to conduct a citizen science project "*with a stratosphere balloon*"(DE 2).

Expert 3 conducted several citizen science projects, as for example projects from *nature, they were dealing with plans and flowers, [..] Another was about a river. Then they went to the school, make a theoretical class, and then they went to the river to find elements and to pick up data.**".*** Expert 3 made the experience that ***"****pupils had different ideas, quite innovative from our scientific point of view, all old scientific point of view. And they really had a social impact. And they also were more motivated with the sort of outputs."(DE 3).*

Other experts did not had certain experience with citizen science projects. Expert No. 1 states that "*they work in various other student projects where they get active themselves and implement projects. But we haven't done that special (citizen science) yet*. " Expert No. 4 had a similar experience and conducted a "*course that builds a small model house. ...with real building materials....[...] in the context of a project course at school"*(DE 4)

Also Expert 6 & 9 were "*not already involved*" in CS projects, but DE 9 states that "*there was something in biology, physics or in another subject where I am not active*."

Resumée: Some interviewees have got some experience with CS-projects (3,5,8). Other already have conducted projects which are closely related to Citizen Science(1,2,4). And some other interviewees haven't got any experience at all. And Interviewee 2,5,7 would be really "*happy to conduct such a project*".

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2. CS curriculum at schools

Expert DE 1,3,5,6,7,8,9 don't think that a curriculum for citizen science exists. Indeed at the school of expert 5 citizen science projects are brought to school, but there is no anchored curriculum of citizen science. Expert 3 also shares the opinion and says " *I am not aware of it".*

Although according to Expert 9"*many principles that are important for Citizen Science projects ... are anchored in our curricula. In mathematics, it is of course also common to collect data ... ...*

to go through different forms of representation ... and ... to interpret them. [...]", expert 9 states that: "I could not say that I have ever seen this (curriculum CS)".

Expert 2 that in the Q1(upper school) there are conducted excursions to a company. There the students "*simply do chemical experiments on site, where the data is analysed quite quickly*" and expert 2 says that "*I know that the biologists of course also do surveys internally without scientific support in the tidal flat excursion* ".

Expert No. 7 affirms: "*However, the core curriculum is developed in an internal school curriculum, which can then have possible focal points. [...] There is a column where you can enter the special features that the chemistry, physics, computer science and mathematics departments have agreed on for each grade." (DE 7)* and sees a possible way for implementing Citizen Science.

*E*xpert 9 tells that there is no curriculum for citizen science "*but many principles that are important for CS projects are anchored in the curricula[...] (e.g. in mathematics to collect data, represent data and to interpret,[...] or in history - how do scientists work)*".

Other related topics or projects to citizen science are *"technical paper / projects courses*" in the upper school or small building projects with real building materials (DE 4).

a. Possible ways for implementing citizen science

i.Project courses & technical papers (Facharbeiten)

Expert DE4 declares that there is a *"school which runs project courses. Instead of writing their first academic papers, which they call "Facharbeiten", they like to run project courses and then mark the corresponding work on site and the documentation for it and assess it like a Facharbeit."* Expert No. 2 could imagine that *"really in the advanced course subjects, that there is still time for such things." (DE 2).*

ii. STEM-subjects

Expert DE 1,5, 6, 9 see a possible way for the implementation of citizen science projects in STEM-subjects, as for example "***biology, physics, computer science****, [...] mathematics where you have to calculate a lot with values. Ultimately, you can certainly implement a lot of beautiful projects*. (DE N. 1), *"in the field of natural sciences (biology included)*"(DE 6) and *"STEM field and [...] biology when it comes to environmental issues[...] bird or insects, censuses or any other animals or plants, collecting some statistical data there. "*(DE 9)

iii. non-STEM / various subjects

For Expert 6 it is also possible to integrate CS-projects in non-STEM subjects as for example "*in the broadest sense with sociology has to do[..] or social sciences would be predestined for it"*(DE 6). Expert 5 assumes that a "*interdisciplinary approach is of course important".*

According to expert 3, 8 there are various possible options for CS-projects. Expert 8 says:**"***There is not always only when I have to observe a flower myself, it is* ***not always just biology*** *class or natural history, but you can also do it in* ***drawing class*** *or in* ***gymnastics*** *class when you go hiking outside o****r there are different options***. **"**. Expert 3 shared this opinion and says: "***Any discipline*** *I think any discipline where you can introduce the scientific method, it can be useful for citizen science****."*** Furthermore, according to expert 8 *"it always depends on the project".*

iv. other options (competitions, extracurricular places of learning)

Expert 7 sees the possibility of cooperating with "*extracurricular places of learning* [...]" what "*would only work if we could offer it on a mandatory basis every school year*" (DE 7).

For expert No. 4 competitions are a useful tool:

> "*So what is very popular in the direction of the youth research competitions both youth, "youth experiments "for or younger students and"youth researchers" I mean from 16, up to the Abitur.*"(DE No. 4)

Resumée: There does not exist a curriculum for citizen science in Germany. But first approaches of Citizen Science projects can be seen in the context of technical papers (in german: "Facharbeiten"), projects courses in the upper classes. Furthermore E. No 7 was the only one who said that there is a possibility for integrating new topics as there is a "special column" where one can enter special features for different subjects (e.g. mathematics, chemistry…). Furthermore, most of the experts see possible implementations in STEM-subjects and some experts also say that it can be implemented in various subjects. Furthermore, E. No.2 states that it could be realized in advanced course subjects.

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3. Data science in the curriculum

Are there data science concepts (e.g. data acquisition, analysis, interpretation, ethics) in the curriculum?

a. Not sure about it

Some experts were not sure about this question or whether there exist some concepts. For Example Expert No. 1 is not sure about it as she hasn't been so busy so much with this topic.

b. Concepts in STEM-subjects

Several experts see data science concepts in STEM-subjects(DE 2,3,8,9), as in " *In mathematics, it is of course also common to collect data ... ... to go through different forms of representation ... and ... to interpret them."* (DE 9) or in physics that they "*evaluate the readings*"(DE 2). Expert 3 shares this opinion and thinks "*there are these competences in mathematics and in science [....] and technology*." (DE 3)

*Expert No. 2 says:"These scientific propaedeutic measures, evaluation methods, are a very central building block of physics lessons**"**. (DE 2)*

Expert no. 5 conducts experiments in his lessons and states: *"So a central point in the natural sciences and the sciences is actually the creation of diagrams from data sets" (DE 5).*

Additionally to that,*"there might be something like that now for mathematics classes or computer science classes"*(DE8).

In mathematics can be found several data science concepts as "*data series, data representations, box plot, diagrams, evaluation of diagrams*"(DE 9)

c. Concepts in non STEM-subjects

Some of the experts also see data science concepts in non-STEM subjects (*DE9).*Expert no. 9 sees data science approaches in the subject history as they look "*at how scientists work [...] where do scientists actually get the information*".Furthermore, in history is dealt with "*different diagrams and forms of presentation*". Expert 2 shares the experience that there is a kind of data analysis project in the introductory phase *"people walk across the schoolyard and time it, so to speak. That's a classic data analysis and in the end a straight line comes out of it and with the accelerated movement a parabola comes out in the graph".*

He adds that *"these scientific propaedeutic measures, evaluation methods, are a v**ery central building block of physics lessons"**. (DE2)* In his subject "physics" Expert No. 2 also evaluates their readings and also appends: "*there is something like that in chemistry. In biology, there are certainly also measurements in terms of carbon dioxide content or oxygen content and so on. So, there's data analysis there as well."*

d. Concepts in project courses and other answers

Other data science concepts can be found in project courses, technical papers and in competitions. In technical papers "*there are of course always research questions*" (DE7). "*Popular are the competitions "youth researches and youth experiments"[...] Data evaluation is there very essential*"(DE4).

Expert 8 assumes that "*in the higher schools and I could imagine, especially in a bit more technically oriented higher schools or high school or something like that.*"

e. Where could the data science competencies fit?

First,"*there are always different variants (were data science competencies can fit) [...] and maybe geography would be also relevant*" (DE1). Data Science competencies could in different topics as "*plants, dust pollution*", or subjects *"geography, physics*" or in projects as the "*stratosphere balloon projec*t" (DE1)

Furthermore, *expert 1 " could imagine that in geography... or mathematics you could also imagine that there is something.... But I would limit it to science for now." (DE2)* Expert No. 8 shares this opinion as *"there might be something like that now for mathematics classes or computer science classes.".*

Resumée: Data science competences can be found in different subjects (STEM-subjects and non STEM-subjects) and also in the context of project courses, competitions and technical papers (upper class).

Possible options for the fit of data science competencies are seen in the topics plants, dust pollution, in the subject "geography, mathematics, computer science and physics" or in projects as the "stratosphere balloon project"

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4. Support for teachers

a. How are teachers supported when introducing new topics / subjects?

Expert 3 is not sure if *"the teachers get suppor*t". Moreover, the support is "*strongly dependent on the school*"(DE 4).

The teachers help themselves by sharing different materials and "*through exchange with colleagues*"(DE 9)

b. Adaption of the curriculum possible?

The curriculum "*does not allow much leeway*"(DE6). Expert Nr.1 states also that there is *"limitation by the curriculum in general"*. Expert 9 underlines the unflexibility of the curriculum:

"*The topics that we deal with in class are first of all relatively narrowly defined... We have to orient ourselves to a curriculum from the state... where it says which competencies and topics are to be taught in class.*" (DE9). "*The departments at school [...] make a roadmap for the school*", according to DE 9.

Due to the missing flexibility of the curriculum, "*it is very difficult to tinker additional projects into the lessons*"(DE 6)

Although the curriculum is "quite rigid"(DE 6, 2) there are options to take a look at *" how it (additional projects) fits into the curriculum [...] content areas in the subject areas that fit in." (DE 2).* Expert 8 sees the curriculum "in many ways" as "a matter of interpretation." He argues: "*You can read a curriculum very, very strictly and I just have to work on the topic, I have to work on the topic and the topic, or interested, committed teachers can do any project where this topic is worked on as a by-product*" (DE 8). there it is important to see where one "*can find a link. [..] To go through the curriculum and see if there are any citizen science projects that fit in thematically, where you can tie in*". Expert 9 is convinced that this is an option "*that would work quite well*"(DE 9).

Furthermore, it also depends on the school themselves, because *"there is just a global curriculum and there is just what the schools make of it" (DE5).* DE4 also shares the opinion that it *"strongly depends on the schools, because the teachers need the backing of the school management and if [...] is convinced [...] then they have very many possibilities."* In other schools are offered *"research projects [..] and project courses in biochemistry and physics in which the students can work on a research question that interests them outside the curriculum"(DE 7).* Additionally to that there are *"always a small number of hours that - these are called supplementary hours - are hours that the school itself is allowed to allocate for certain subjects. And they make it possible for the school to set priorities.*"(DE7).

Finally it also depends on the teacher *himself how much effort and how much work he wants to have. And there are very dedicated teachers who do a lot there*"(DE8).

Within the "*differentiation secondary levels*" the teachers are *"free to design within the curriculum"*(DE 4) among other things the "*electives*" are an option to be able to "*freer to design according to student's interest*"(DE 4).

c. Is there education, monetary support or support groups?[2]

Expert 6 and 1 are not sure about support for teachers as they " haven't heard anything about this" (DE 6) and DE1 does not "really know what kind of training opportunities there are for teachers in this area."

Expert 1 compromises that there are "*educational days that I know that are being held*". The educational days are "*certainly also specialist days for the various subjects, where the experts*

join forces, so to speak, for a day or a speaker is booked again, but I don't think there is any further training explicitly for this or now. "(DE 1).

Furthermore, DE2 notes that there are certificate courses and comments: "*We do an in-service training for a subject so that we can teach that in lower secondary school, for example.*" (DE 2) Furthermore, there are teachers "*selected [...] who have the confidence to coach and train other teachers, to do these certificate courses and then they meet and do this training programme over a year. That is definitely support*." (DE 2).

Additionally to that,"*when [...] a new subject is introduced into the curriculum, for example, astronomy was introduced into physics in the changeover to G9, there are of course further training programmes for it. If you want to somehow implement Citizen Science or Data Science as new, [..]I think that there are a lot of overlaps and that you can implement it without a lot of training opportunities.*" (DE2).

Another support if any new topics are introduced in school is "*always some kind of books, workbook and information materials that you can get or just training*."(DE 9)

Regarding financial support, there are different possibilities. Expert Nr,.7 states:"*There's always financial support from the school's booster club. Of course, it always depends on the individual school, how the support association is equipped in terms of financial resources.*"(DE 7). Additionally to that there is "*the usual school budget that we can use to a certain extent, which is provided by the school authorities. But that still goes through the school management, then in each case, and not through the individual teacher."*(DE 7) Another option is to "*raise third-party funds*" or to "*write applications / proposals to certain organizations.*" (DE 7).

Resumée:

In general, the curriculum is quite rigid and difficult to adapt. Some possible adaptations of the curriculum are given through project days, a small number of supplementary hours, through "elective subjects" in the middle school and finally it also depends on the teacher how much effort he/she wants to put in the lessons.The adaption of the curriculum depends on the design of the lessons, the type of school and also the effort of the teachers.

The training days, certificate programmes and also monetary support differ between the schools. But in general, the option exists in the context of ongoing education to visit training days or certificate programmes. Monetary support is possible in three options: over the school booster's club, the usual school budget, which depends on the individual school and at least the possibility to raise third party funds.

7.CS skills

What are useful skills for pupils and teachers (based on https://www.citizenscience.org/wp-content/uploads/2018/11/USERS-GUIDE_linked.pdf)?

1 = strongly disagree , 4 = agree, 2 = disagree, 5 = I totally agree, 3 = neither agree nor reject

Important information: **The values in the table are the median of the data list.** (A link to the original file is provided here:https://docs.google.com/spreadsheets/d/1S3m3gboqG_TzNkYDgrhOlG87a5sCxO6qFwZMaoEwybk/edit#gid=0)

Interest in science and environment

Ratings: Students 4.5 Teachers: 4

The competence “interest in science and environment” was rated for students (4.5) and teachers (4) quite high.

But nevertheless some discussions appeared as expert 3 does not “*really see that it's a competence because the competence, it's the interest or is getting knowledge on science. Because a competence is a mix of knowledge, skills and attitude. And this first, I wonder if it's really what you wanted to as a competence*”(DE 3). But also admitted: “*You mean for generating interest, so if citizen science could make this increase the interest in science and environment through the acquisition of knowledge and skills, is that a competence*.”(DE 3).

Expert 2 sees the interest “*more for advanced level; can start at intermediate level* [...], *more important in the upper school. Ultimately, the reflective approach is important, but that can start in the middle school”* (DE 2) and Expert 7 sees it similar "*4, upper classes 3, orientation stage*” (DE 7)".

One issue which occurred was the mix of environment and science in one question. Due to expert 8 “*science and the environment cannot be equated with one question. If I take part in Citizen Science projects, I can be very interested in science. But I don't have to care about the environment. Yes, because not all of them are citizen science projects, nature projects or something like that. ”* (DE 8).

Other experts considered the environmental aspects as quite important because “*With Fridays before Future, we also had pupils who got involved, and I would say that this is always a big issue. Environmental issues, both for students and for teachers. And with climate change after Corona, it's always going to be the next big problem, probably, that we have to learn to solve as a society.*” (DE2) Expert 2 states that there are at school “*climate saviours and some who simply made sure that teachers switched off the lights and things like that in secondary school or middle school* “(DE2).

According to expert 7: "*science propaedeutics is what we want to teach in the Gymnasium Upper School. That is to say, I would say that it is of considerable relevance for pupils in the upper school. Because there it is always a bit more in the direction of a scientific orientation of learning and working. That is, I would perhaps enter 4 or so. Whereas for the intermediate level or the orientation level it's perhaps more like 3.*"

The competence was seen as important for "*students [...] and for teachers as well* "(DE 11).

Expert 6 states about interest: "*I think it is important that students develop or further develop it. Maybe on her school career, too. I totally agree that it is important. Right now, of course, the topic of the environment is currently on the agenda, so that students are offered the opportunity to do something themselves, especially in the relevant subjects. So not only read texts from any subject area, but also perhaps have the opportunity to make a contribution. In a way. And that in all grades. So the earlier you arouse interest. The better it can be expanded over time"* (DE6) and also adds: "*I think it's important that teachers keep an interest in such topics.*".

One option to generate interest is that there are "*sustainable results [...]and materials, [...]and knowledge" (DE4)*

Furthermore, the teachers should "*lead the ways as a role model for these projects [...] If the teachers are unmotivated, it won't work out well for the students either.* (DE4), *but it should already be there, the interest"* (DE4).

Finally the "interest" also depends on the age group according to E5 and E1: *[...] My students are between 10 and 17 years old. And now I say schoolchildren in general, the younger ones up to before puberty or up to puberty, but they are basically open to everything. That includes the environment and science first. It gets more difficult [...] if you start late, [...] 8th and 9th grade.And with the younger students I say up to maybe seventh grade*" (DE5).

Furthermore, interest is considered as important because *'interest in science and the environment': that is precisely what we want to convey in high school teaching in grammar school. In other words, I would say that in high school this is already of considerable relevance for students. Because there is always a bit more towards the scientific orientation of learning and working*" (DE7).

E9 also fully agrees with this competence and believes "*that practical experience and somehow addressing a different channel with the students [..] is always good, that it always arouses interest, that it always arouses motivation and that the students naturally also have experience of self-efficacy, if they don't have any*." (DE9)

Resumée (for the competence interest):

- considered as very important from most of experts (DE1-2, DE4-9)

- “science and environment” should be maybe split up in 2 areas (DE8)
- Teachers should act like role models for generating interest (DE4)
- practical experience can increase interest (DE9)
- Easiness of generating interest depends on the age (DE1, E5)
- science propaedeutics is an element of school (DE7)

Self-efficacy

Ratings: Students 4.75 Teachers: 4

Projects can increase the self-efficacy of students which expert No. 5 had experienced with “*an intimidated boy in class [...] who blossomed through such a project*”.

The level of self-efficacy, according to E11[...]*is very important, but I don't think it's so important for teachers. Rather no, more like a 3. Because I believe that this trust of course the data that is collected when it is really used for science and not just recorded in an attempt in a protocol, in a folder or in a textbook is of course an incredibly trust-building measure. That made the case important to the teacher”* (DE11).

“Self-executing” projects could lead to an increased “self-efficacy” and this is *“a worthwhile goal to achieve that confidence in one’s own abilities increases in this regard*” (DE2).

E6 fully agrees that “*it is important that the student experiences [...] that they can do something or change something with their own abilities. I would also totally agree with teachers.*” but is undecided about her/his subjects “*languages [..] especially when it comes to science*”.

Looking at self-efficacy it is “*very important that the students who are involved can see what they are actually able to achieve, because many, many students believe they are not really concerned with what they can really do. Definitely. For the teachers, I think that is no longer so important at this point. They have their job and know what they can do “*(DE4).

The teachers should be able to “*motivate here and [..] to give them a little courage, but don’t think they need that for themselves anymore*” (DE4).

E5 states : “*Of course, that also has something to do with the personality of the teacher and goes with a continuity. Only if I now assume that I want to start doing a science project now and I do that is such a cold start in some eighth grade, I will say. Then I have to think really carefully about how I approach it. With the little ones. I throw it down a few chunks and then they ask and then they're kind of the eighth graders who move,*”

“Because from my point of view ..., that is what we want to do with competence-oriented teaching, 'to enable the students to act things, to act problems themselves and to solve them themselves, to experience that they can do it. That's what I would feel is central. For teachers maybe only 4”.(DE 7)

The extent to which a learner has confidence in their abilities. Well, well. What's in it for the teacher? He can then find out ... Do the teachers themselves take part? (DE9)

Well, I don't know a teacher who has this amazing self-efficacy experience. Of course, there is also the same thing that the students will notice when he participates, although I don't know whether this is as relevant for an adult as it is for a student. Maybe then I'll be more likely to set a 4, but motivation will certainly make it. As I said, it's always nice for teachers to do something different. Well, I'll tell you about the classic lessons in another way. Then you will definitely want to do it again. (DE9)

I think there are 4 again among the teachers and four among the students. If you say that across the board, I do believe that there are students who really have those who are learning very, very much going on. I am currently taking me to school, not all of the pupils work together voluntarily. That means, if the students participate voluntarily, I would also say 4. If they do not participate voluntarily, I would go to 3 times.(DE8)

Resumée for the competence “self-efficacy”:

- dependent on the age
- for students a little bit higher rated than for teachers
- Important skill to be taught at school (DE7)
- Needs continuity (DE5)
- Many students have got a lack of confidence in their skills
- can be achieved through projects

Motivation

Ratings: Students 4.25 Teachers: 5

E7 differentiates the importance for STEM-interested students (4) and for not STEM-interested students (2-3).

Moreover, E8 criticizes that the topics "*science and the environment*" are mixed up and would "*pull apart*"(DE8). Furthermore, E8 assumes that "*the teachers [...] don't start mint careers and civic science now*."

Furthermore, motivation is considered as important, "*because motivation or basically the exchange with each other can also be motivating or an important part*" (DE2). Motivation also depends on projects: "*If it's a cool project, then that also motivates you afterwards. So that is certainly just as important and should also be a goal* "(DE2).

E11 also shares the opinion: *"motivation is the central factor in getting students excited about fulfilling the natural sciences and that is what I think are goals to be pursued. I would actually rate it with 5, because that is the be-all and end-all and should definitely be increased.*" and also sees motivation for "*teachers [...] very important*". And to *"work practically as a teacher*" can increase the motivation (DE11).

Obviously, there is seen a strong relation between projects and generating motivation: "*My thesis is simply that such projects may even initially stimulate the existing interest or interest at all.*" (DE5). The approach is to take a "*scientific question [...]and to go through this whole process of science*"(DE5).

From E7 point of view "*motivation that is what we want to do with competence-oriented teaching 'to enable the students to act, to act, to solve problems themselves and to experience for themselves that they can do it . I would perceive that as central. For teachers maybe only 4*."

E7 would make a distinction between " *students who choose advanced courses in the MINT area and [...] those who just experience a basic scientific education at school"*.Therefore he rates motivation with a 3.

With regard to teachers, E7 assumes "*they are no longer pursuing a STEM career. They have become teachers or they pursue them in the sense that they have become MINT teachers. That means, I might write a 3 there now.*"(DE7).

Nevertheless E9 underlines that practical experience can "*arouse interest [...] and motivation*" and also that the "*students have the experience of self-efficacy*."

Furthermore, E10 thinks "*implementing citizen science at school and letting the students some freedom really to design the research question, to extract the data, to do experiments, …. So, it's a powerful way to teach scientific inquiry and it names the same learning by doing methodology. If you do it then you really love it, my opinion.*" (DE10)

Finally, E1 assumes: "*I don't find that as relevant as the other points in STEM careers. So I don't know if that always has to be the focus, something about motivation. I would probably definitely say 3 or 2 at 2: 3 for students and 3 for teachers.*".

Resumée for the competence "motivation":

- Motivation is an important issue
- Motivation for conducting STEM careers is seen as less important (DE1,E7) because not all students choose a STEM career and teacher also do not pursue a STEM career anymore (DE7, E8)
- Projects can increase the motivation (DE11)

Knowledge of the nature of science

Ratings: Students 4 Teachers: 4.5

The competence "*knowledge of the nature of science*" was rated high for both students (4) and teachers(4.5) whereas the importance for teachers was rated a little bit higher.

Furthermore, E3 states that the competencies "*motivation and knowledge of nature or physics [..] get a high leve*l" in citizen science projects. Furthermore, she says that "*Knowledge-related topics could be splitted into grades*"(DE 3).

E2 was one of the experts who rates the importance of knowledge of the nature of science lower "*because not everyone who participates should end up in science. I mean, it would be nice, but I would say that would be a nice side effect, that the knowledge about scientific knowledge would gain, how does it work, that they are there*" (DE2). He adds "*It would be nice if it got out*" and gives "motivation [..] more priority". (DE2).

On the other hand expert 11 rates it as very important as he says: "*How does science work? How are the processes? Rethinking, hypothesizing, checking, changing case, adapting is totally important. I had just said that students don't always have that in their heads. They expect clear answers from science and do not recognize. [...] Likewise with teachers."* (DE11)

Besides, E6 sees the knowledge of nature of science as important not "*down to the smallest detail*", "*especially now through Corona we have seen that it makes sense, especially if you want to take part in discussions and have a qualified opinion on what is happening, that you need basic knowledge, yes how science works and that there is also that research also lives from the fact that you make mistakes, for example, and then continue researching at the point. And not everything that is published automatically has to be the biggest breakthrough, because of course there is pressure on the people who work in research. Of course, it's always about money.*" (DE6)

About the significance for teachers does E6 state: "*I would say that I fully and completely agree, because I always have the task of conveying certain things somewhere, also in general education, in my opinion. Even there are not necessarily details, but at least here is understanding for them. So that I can pass this on to the students, yes, I should already have an understanding of this myself.*" (DE6)

"*To have seen the principle once, I would do that too*." But it is the question whether they got it "*internalized these things*" and can reproduce it (DE4) and *"that you might see as a marginal product, so to speak. So somewhere in the middle*".

Furter, E5 & E7 rate the knowledge of the nature of science as "super important" for both students and teachers. E5 states: "*We won't necessarily just train researchers, but of course you can really demonstrate scientific work with such projects*". (DE5)

For students E7: " *would also enter 5. So the scientific method, i.e. recognizing the problem, forming hypotheses, checking the whole thing in an experiment if possible and then verifying or falsifying hypotheses, is what we also want to convey at this point. I think it's important that students take it with them*". (DE7) E9 assumes also that knowledge of the nature of science and "*the live experience of how science works*" is very important as he puts a 5 for students. According to E9, *the teacher, usually an academic, may not necessarily be such a new experience. Maybe bet with 3. I wouldn't want to commit myself to that, simply because I believe that of course scientific work and the implementation of research projects are not necessarily new to someone who has studied.* (DE9)

Furthermore, "*for the students above all and this is very important now, I find that they understand how science works, that science is not even fixed, but can also change, depending on new data. So I think that's super important on the part of the students. Therefore quite high.*" (DE 11)

Additionally, E1 suggests that this competence "*can also come in the process.*"

Resumée for the competence "knowledge of the nature of science":

- Important to understand "how science works"

Data

Ratings: Students 4.75 Teachers: 4

According to E8 the ethical aspect "*depends on the project*" (DE5).

In context of the carried out citizen science project by DE 3 "*the data competence was also very developed during the project and the skills called social competence, This is especially in the output and in collaboration all over the project because it was co-created. So they work it very much on this. It's quite high"*(DE 3).

Experts 1,3,4,9 considered data competencies as very important and that "we should train" these competencies (DE2). One reason for the importance is that "*Evaluating the interpretation of data and analyzes are very important, because you are confronted with data everywhere in everyday life and the interpretation can also be very different, depending on how you present yourself or how you are presented. But I would also say that it has a very high complexity in a very high complexity. So certainly only from grade 8 9 10 up to upper school. [...]"*(DE11).

Data competency is seen as "an essential component" (DE2) and at the school of E2 "*they motivate as many students as possible to take part, and in the end they have the competence to evaluate data, that's great.*"(DE2). E6 also does some kind of data competencies in class: "*Actually, I do that in class. When I look at a statistic in class somehow. Then I have to know that in order to be able to evaluate how the authors came to the data.[...]*"(DE6). As a student, " *I have to be able to collect data myself in order to understand how the process works.*"(DE6). E7 also states as other mentioned teachers that he "did something this morning". Also also concerns "*that in in North Rhine-Westphalia is also a bit dictated by the media competence framework, which is now also to be taken into account in the curriculum.*"(DE7). Therefore he states: *I would say, you should definitely enter at least a 4 for both. Because that is now becoming much more important in the course of an increasingly digitized world. That means, maybe we even put in 4 to 5.* (DE7)

Furthermore, E4 states: "*It's nice for teachers, but for the students who mainly do that, I think that's right at the front."* (DE4).

Besides it is important to have realistic expectations: "*When you work with the intermediate level, you can't have such high expectations. That's why I would say 3 to 4! And with older pupils? Of course, they already have other competences, and the upper level would also mean that they can develop such processes themselves*." (DE5). Furthermore, E5 shares his experience of the Citizen Science project in which he took part. "*that (data competency) was more or less predetermined. Well, the methods were actually also for the comparability of the data. That is always important. Of course, the students understand that somewhere without it. But of course you can always develop some additional ideas, but they have already worked out so well in other ways*."(DE5)

Moreover, E9 see data competency as very important because "*they (students) naturally develop a completely different understanding of how it works. Where does the data come from*

that are being worked with? How do you work with it? “(DE9) whereas E9 classifies the importance for teacher lower (at the level of 3), “*because it's just something that he should have done before.*”(DE9) E8 sees it the other way round “*for the students 3 to 4, for the teachers 4 to 5.*” (DE8).

For E1 the importance of data competency depends on the projects and “ *it is certainly important to know how science works in order to be able to classify data [...] and maybe for the interpretation at the end.” (DE1)* and considers it finally as *“already important” and “super important”.*

Resumée for the competence “data competency”

- Connection possible to the media competence framework (DE1, E7)
- Important to know to classify and interpret data (DE1)
- Important that the students get a better understanding (DE9)
- For teachers seen important, but differs among the interviewees
- Important in a digitalized world and everydaylife (DE1,3, 4, 7, 9)

Scientific inquiry skills

Ratings: Students 5 Teachers: 4

The median of the importance of “scientific inquiry skills” is very high for students (4) and high ranked for teachers (4).

First, DE 5 states that “*you [can] also practice well as a teacher"* (DE5) and E7 ranked it as *“5 (for Chemistry teacher)*” (DE 7).

Furthermore, there are similarities among the competencies, as DE 3 states: “*Some of these competencies for me are really equal to previous competencies as for example "Use scientific and technological information to solve problems" is quite related to scientific inquiry skill*s.” (DE 3). Furthermore, expert 1 states: "*I find it difficult because some things are a prerequisite and some things come in the process. especially in the skills of scientific inquiry.*”(DE1) and adds:” *if I have someone who maybe also accompanies this very well e.g. I find it super important.* “(DE 1). But it is also the case that “*Designing things yourself may have been neglected in other projects.”* (DE Nr 5).

Furthermore, it also depends on the age group (DE Nr.5) and states it depends on the age group.”*More like 3-4 for the intermediate level. High school students have different skills* ” (DE 5).

E11 believes that “*that science teaching is often done on a theoretical level in schools that involve practice and the design and circumvention of data experiments. In fact, we often ended up not having a practical exam, but rather theoretical exams. But nonetheless, I think it's very important to do that. Therefore with her and for teachers as well. So I see the rare difference between being a student and being a teacher.* “(DE11)

Besides, Expert 6 would also agree that “*I should have acquired the knowledge if I have witnessed such a project being carried out. Yes, right now. Design the studies yourself. So I don't think so. But ask questions, then be able to deal with them. Experimentation argue that definitely. So designing a study yourself sounds very ambitious to me. That would tend to be more like a 3. Most of the time it is just that it is mostly driven by researchers or teachers. So the study is usually already determined. That's probably what you're getting at.*” (DE6)

E4 also sees it as important and adds: “*One would like to know what. How does it actually work? How is the process going? Which questions can I answer with it? Yes this is important. Teachers are there. So with us teachers are supervisors. In principle, the task is set in such a way that they definitely make sure that social interaction works well. Do I ask whether they explicitly need a progress in knowledge now? With us, the focus is on the students.”* (DE4).

Furthermore, E5 makes a distinction between the age of students, because "*older students have got other competencies that they can develop these things by themselves [..]*" (DE5) and it “*is possible to work this out with the students (by teachers)*”(DE5).Furthermore, “*method of measurement is something that the pupils understand from a certain age.”* (DE5) and “*also possible that teachers train that if they did not do it for some years*” (DE5).

In the point of view of E7 the importance of skill “scientific inquiry skill” differ among the teachers. According to E5, in his point of view “*as a chemistry teacher [..] it is very relevant at this point [...] because the chemistry teacher who cannot experiment will of course not arouse enthusiasm for experiments in students, that is very clear and then experiments will simply no longer take place. Because they are somehow a central aspect of the scientific method, I think experiments are important in class”.* (DE7). In the view of expert 6: “*For teachers I would say exactly the same. No, especially when it comes to designing studies. I do, I think, depend on the support of researchers or people with the appropriate skills.*” (DE6). For the teachers, E9 rates the importance lower because the “*teachers are usually the one who's already learned these things. One or the other might find new insights and find it very exciting and for others it might be something that they have already done often.*” (DE9)

In the view of E9 “*for the student it will certainly be a great experience and a new experience. Asking scientific questions, designing studies from data, experimenting with information. Yes,*

these are all things that will certainly advance the student and which will also provide such a practical insight. Give him things that might otherwise be treated very theoretically. (DE9)

E9 asummes "*that children like to learn that and it is always good is not to follow one track, but to address different student channels and make different offers, because there are always different types of learners. There are different types of people. There are more visual learner types who can look great at the text or at the image and learn a lot from it. There are more haptic types who have to touch something. And I believe that projects like this can simply appeal to a large number of students at very different levels.*"(DE9). Obviously, one important point is the way of teaching different types of people and to address them in the adequate manner.Furthermore, different channels should be addressed like "p*ractical experimentation, arguing that it's more of the communicative competence that a student might have. Talking about procedural skills, doing something practical. There are very different things that are involved.*" (DE9)

Moreover, E8 also rates the importance for students lower because "*the students do not get so deeply into the topic that they question these processes or fully analyze and understand them, therefore the students would give 2 to 3 and the teachers would give a 4.* "(DE8).

In the point of view of E10, "*implementing citizen science at school and letting the students some freedom really to design the research question, to extract the data, to do experiments, [...] is s a powerful way to to teach scientific inquiry and it names the same learning by doing methodology. If you do it then you really love it*"(DE10).

Resumée for the competence "scientific inquiry skills"

- Scientific inquiry skills is seen closely related to conducting CS-project
- Practical experience can help to acquire scientific inquiry skills
- For students seen more important than for teachers because the teachers should already can do it (based on their studies)
- Scientific inquiry skills can also come in the process (DE1)
- Teachers are supervisors / role models (DE4)

Responsible citizenship

Ratings: Students 4 Teachers: 5

According to DE 1: "*responsible citizenship comes in the process.If I have a high interest in the project, then I have something in the back of my mind that it is good for*". Furthermore,

responsible citizenship "*was a hot topic*" since it was "*in the press*" (DE1), as for example in the context of "Fridays for future" (DE5).

Finally, "*it's important for teachers to demonstrate this as well*"(DE1).

In the view of E11 responsible citizenship is an important topic "*when it comes to environmental issues, which concerns a reflection of one's own actions and in society somewhere[...] and a central theme of the matter*".

E11 suggests that environmental issues play an important role in the context of the competency "responsible citizenship": *especially when it comes to environmental issues, which concerns a reflection of one's own actions and in society somewhere, I think, is a central theme of the matter."* As one example he lists the "Plastic Pirate Project" and tells the participants: "*Someone who has dealt with plastic waste around the Ruhr for one week during the project week will not throw away any more waste afterwards. Hopefully. So definitely. 5. And for teachers, I think a 4 would be enough.*"(DE 11). Moreover, E9 consent to the statements of E11: *"In principle, I do think that when it comes to environmental issues, sustainability goals are of course something that gets stuck (in mind)."*

However, E2 disagrees and states: "*Responsible citizenship doesn't have to be all about the environment [..] it could just as well be to find out connections, I would attach less importance to that*."(DE2). E8 also criticizes the same point: "*It's all geared towards the environment.So if you have two environmental projects, of course. But if the other Citizen Science project is you: No. So that's very difficult thing, because responsibility and behavior change. If this is an environmental project for students, I would say. 3. For teachers, maybe the 3rd is in"*. Obviously, there is the possibility to learn responsible citizenship in environmental and non-environmental projects.

But all in all, responsible citizenship is seen as important. E4 sees it "*particularly important when you think about upper-level courses, because the young people then arrive relatively quickly in their role as citizens, and I find that just as important with teachers*". (DE4). E5 also "*prioritizes it for students and teachers high, "especially since it was a topical issue. And it was actually also in the press afterwards or during the time when we started it. And then [..] came Fridays for Future*"(DE5). E7 agrees with the importance "*because that's one of the things we want in class. So I would put 5 in both of them.*" (DE7).

Furthermore, E9 draws attention to the fact that it "*also depends on what kind of project you are carrying out. And in which subject area this takes place.[...] I would tell her a 4.*" (DE9) and also considers this as an important issue for teachers as "*So we are all totally responsible citizens. We're also doing a 4! Maybe it's something different for teachers when you really deal with a topic live,e.g. Collects plastic rubbish from some small river, then maybe that awakens a different point of view for me*." (DE9).

Besides, citizen science project activities and "*everything that can somehow influence social interaction in a positive sense, in any case, both for students and teachers, [..] is important*" (DE6).Furthermore, citizen science projects can reach long term effects: "*students who has dealt with plastic waste around the Ruhr for one week in the project week, will not throw away any more rubbish afterwards. Hopefully. "*(DE11)

Resumée for the competence "responsible citizenship

- responsible citizenship comes in the process (DE1)
- teachers should also demonstrate it (DE1)
- central topic in the environmental projects (DE6, E11), e.g. Plastic Pirates (DE11)
- responsible citizenship should not be limited to the environment (DE2, E8, E6)
- * particular important for upper level courses (DE4)
- hot topic also in the context of Fridays for Future (DE5)
- what teachers want to to in class (DE7)
- Teachers are responsible citizens (DE9)

Basic digital knowledge

Ratings: Students 4.5 Teachers: 4

The competency "*basic digital knowledge is considered as very important for students*" (4.5) and as very important for teachers.

Basic digital knowledge is seen as important" *because it's a project that you do for research at the beginning and for evaluations at the end.*" (DE1). Furthermore, "*technology usage definitely plays a role. Students here might have a basic understanding of how to use technology, but when it gets more complex, the students have to learn more"(DE11).*

Most of the experts (DE.g. E6) "fully agree" with the importance of the digital knowledge. Other state that the students "have to "*learn to deal with some kind of data and then I have to be able to process it with it. "(DE4) as for example in a possible "stratosphere balloon project" (DE4).*

In the context of the conducted citizen science project E5 "*collected things with computer data [..] worked with GPS device , mobile phones and took focus*". Therefore he also considers it as important. E9 also highlights the technological aspect: "*I think that you always use different*

technologies in some form, but always specialize in that project, then I would say yes." (DE9). Regarding the stages of competency, E7 states: "*If it is about basic knowledge, then you can enter a 5 for both. 'Specific knowledge': Certainly not required for everyone*" (DE7)

According to E9 digital basic knowledge can take "*place in class If you were to work with a spreadsheet, for example. We also do that in computer science classes, for example. It is not necessarily something new for the students, depending on what you are talking abou*t" (E9).

With regard to the teachers, E9 also considers it as important: "*So it can be things that you already know, from your everyday life or from your everyday school life. But it can of course also be very special technologies that you had not previously had in hand. Then it is certainly exciting to see how. Yes, there is also a 4.* "(DE9)

Resumée for the competence "basic digital knowledge"

- fully agree
- important for the research in the beginning and the evaluation (DE1)
- technology usage is important (DE9, E11, E5)
- basic knowledge yes, but not specific knowledge (DE7)

Social competence

Ratings: Students 4.5 Teachers: 4

The social competence for students was rated from half of the experts as super important (DE1, 6, 7, 9, 10) and from others as important (DE5, 11, …).

About the subtopic "critical thinking" E2 stated:"*Hence "critical thinking", that goes without saying, that shouldn't come out in the end, they can do that. Yeah, maybe a 3 or a 2*"(DE2). E9 also states that the social competence should be a prerequisite for teachers as she states: "*hopefully we already have them*" and is not sure whether citizen science projects "*promote teacher's social skills*" (DE9).Furthermore, for teachers it is also considered as important and "*they should be able to organize it accordingly.*" (DE4)

Furthermore, E4 highlights the importance of teamwork: "*but the ability to work in a team is always very much in demand, especially in a school context. It's like that and double-edged. So when I have a project that one or two students can get excited about and do it as a team of two,*

that's always good. If you can do it completely on your own, that's just as good. I think it's important [...] "(DE4).

E9 rates the relevance as high and believes "t*hat reflection and critical thinking plays an important role and [..]if it's something you haven't done before, then of course it can be profitable again*."

Resumée for the competence "social competence"

- reflection and critical thinking play an important role
- teamwork important at school
- should be a prerequisite for teachers
- critical thinking should be also be there before

Economic, moral and ethical aspects of science

Ratings: Students 4 Teachers: 4

The competence "*economic, moral and ethical aspects of science*" was ranked in the median over all experts as important for students (4) and teachers (4).

First, E2 see the ethical aspects as "a basic attitude. Further he notes: " *you can't say that I always behave that way. It would be desirable to achieve the goal again, but I think that can only be achieved slowly. So that would be desirable, meaning a 3, perhaps."* (DE 2).

Further, E11 notes:"*I do not find the fact that it is economic, moral, ethical and very different economic aspects that decisive, but especially the moral ethical aspects I would occupy with three and for teachers and students.*"(DE11) and considers the moral ethical aspects as more important than the economic aspects. E7 has got the same point of view and states: " *I find the 'moral, ethical aspects of science' somehow even more important than the economic ones. So now I would say: Certainly a 5, for the economic one more like a 4. And the same for the teachers*" (DE7).

On the other hand, E6 agrees with the economic aspect as she states: "*After weighing the possible consequences of alternative options. Yes, that may also depend on other specific projects. How deep you go into the matter. Yes, and then in the sense that I think that is the economic aspect. [...]I then I would agree "*(DE6).

Moreover, E4 also considers this competence as important and state about teachers: "t*eachers should already do that and that it is not yet to be done. Then they should learn. But express that in a suitable number. So I use the information to solve problems and completely agree and the use of quantitative skills and abilities in the field of statistics is a bit difficult to assess.*" (DE4)

E5 questions himself "*whether that is enough to really change something in the long term".* He suggests to conduct "three to four" projects to achieve long-term results.[...]" He continues: " *if I put that into concrete terms, do one or two projects in elementary school in the middle school and then another one in the upper school. So if you have such comparable projects, i.e. in your school career, it would be good to have experienced three or four such projects, then it can be sustainable, also for the student*s".

E9 considers this competence as important because: "*Most things or everything actually relates somehow to something that is in my environment. And it's actually always about looking, how do my actions affect what happens around me?*"(DE9). Further she continues: "*it depends on what kind of project you are doing. But when I always think of any environmental issues, which I then increasingly take place in such projects. Yes, then I have to look again- What happens if I throw my bag of chips into the bush, what alternative do I have to this action? What are the consequences or what are the consequences if I do something else?*"(DE9). Obviously, it is important to reflect the ethical and moral aspects. Furthermore, Expert 9 has got especially an environmental focus about these project as she says: "*Climate, what consequences does it have if I drive three meters to school by car, I don't know, and let mom drive me every day? Or isn't there a way to maybe ride a bike or run? So I do believe that it always plays a role in these projects*" (DE9).

Furthermore, E1 also states as E9 that it depends on the project: "*What kind of project is that? Is that something that I have already dealt with before, where I have already thought about it? Or is that something that again creates completely, completely new insights into some topic?*" and states "[...]*it commits to responsible personal opportunity civic action*." (DE1)

Moreover, E8 ranks the importance lower for students (2) as "t*his is too much meta-level for students [..] and for teachers I think that they are already given skills*" and ranks it for teachers with 4.

Resumée for the competence "economic, moral and ethical aspects of science"

- moral, ethical aspects are higher rated than economic aspects (DE7)
- often an environmental / climate focus (DE9)
- teachers should already do that (DE8, E4).

Troubleshooting

Ratings: Students 4 Teachers: 3.25

First, E11 thinks about problem solving: "*Solving With the help of technology, quantitative skills were subject, I would definitely rate statistics according to them, but also here, when it comes to statistics, data analysis, I think, mathematical skills are important and therefore only for the older age groups, so from grade 8 upwards. And with the teachers, at any rate, you."*(DE11)

Moreover, E2 tells:"*Problem solving, scientific and technological information to live ...". [Reading pause] Yes, these are tools of the trade again. Ultimately, learn "problem solving" or maybe look for a 4.*"(DE2)

E6 states: "*Yes, that's what I also want to practice. So I fully agree. Yes, well, of course, that the skills are only established over time. And that of course I have more opportunities with high school students than in secondary school..*"(DE6)

According to E4, "I*n the recent past a lot of studies and statistics have been carried out and then [..]Especially for students you shouldn't just go there and basically believe any number that someone has told you, but also learn to question a little bit. What does that tell me, what is this value supposed to mean?[..]I think that's very important, but I always think it's already discussed in mathematics.*"(DE4) and also adds: "*and the use of quantitative skills and abilities in the field of statistics I so a bit difficult to assess.*".

Expert thinks: *"Well, that was now for secondary level 1, that's a lot. That is already quite demanding, I would rather say yes, so 3 maybe. In the intermediate and advanced levels. Of course it can also be four or more, greater than or equal to four or so. " (DE Nr.5) and adds: " but even here, when it comes to statistics and data analysis, I think mathematical skills are important and therefore only for the higher age groups, from grade 8 upwards.".*

As far as this area of statistics is concerned, E7 would say at this point: "*Basic knowledge of understanding statistics, for example from reading diagrams or something, which we actually encounter in everyday life, since it is definitely a 5. If this is now 'Scientific Statistics', i.e. 'What possible statistical analysis methods are there?', then that is likely for students rather not relevant for everyone. That means, maybe a 3. And with teachers I simply assume the basic knowledge and the statistical analyzes are maybe more like a 3."* (DE7)

According to E9: "*Problem solving is a declared aim of teaching, especially science teaching*". (DE9)

"*How closely meshed are these projects? Then I ask myself the question ... a solution to a problem means yes, I have a problem and I don't have a predefined solution, but first I have to*

see which way I can go now to answer this question that arises for me . If you now have such a project, of course, that is very tightly structured, which is actually already given, what do I do now? I don't know if that then promotes problem-solving ability. So it certainly shows a way again. How can I solve this? But that depends a little on how much leeway there is to go different ways there. Hard to say. So maybe I would only put a 3 down. OK. Simply because I have no idea how these projects are structured.

E9 thinks: "*Then maybe I would make a 4 out of it. Similar with the teachers*." (DE9) E4 even sees it as very important. Moreover, E8 states: *"Using problem solving scientific, technological, black-and-brown to solve problems. That depends on the project again. I think that's too general. That's why there would just be a 2 now."* (DE8). E1 sees it "*super important too. [...] I would say four in problem solving.* (DE1)

Resumée for the competence "troubleshooting"

- Statistic and data analysis from grade 8+ (DE5, E11)
- Problem solving / troubleshooting formulated to general (DE8)
- Statistics is hard to assess (DE4)
- Depending on the project (DE8)
- Problem solving is an important aim of teaching (DE9)

Knowledge of scientific concepts

Ratings: Students 4 Teachers: 4

In E11 point of view: "Scientific concepts is of course a very theoretical area and from my experience so easily in practice the motivation, the enthusiasm for the practical work is greater than for the big theory behind it. There may be a 3 squat for teachers and students."(DE11). Furthermore "*it depends on the projects and how it is structured. Precisely what then wants to convey knowledge there.*"(DE6).

Moreover, the teachers "*should be able to contribute something in advance. So there I would assume. So of course you will certainly learn again."*(DE6). Furthermore, E4 assumes *"that when you talk to a subject teacher that they are already familiar with it" (DE4).*

Further, E4 see it project-related because: *"so if I have a project like you describe the weather balloon, then I would have to see that the concepts that I need right now or the science that I am involved in, that I get to know the concepts and that at least I know that there is also a different form of work in other disciplines. [...] Yes, I would definitely agree."* (DE4). According E5, this

competence area“*would be something specific about what you do [...]whether you're doing it in the forest or on the coast, doesn't really matter.*“(DE5)

E7 differentiates the importance between teachers and students: “*So 'Scientific Concepts' with students: With students it is more about science propaedeutics , so the initiation of it. In other words, 'knowing explicit concepts', I don't think that's so relevant, it's more like 2 to 3. For teachers, it's more relevant. I would enter a 4 there*.” (DE7)

Moreover, E9 sees it as important “*because in principle it is probably the case in most cases that these projects really convey very specific knowledge, which is totally new for the students and is totally practical. But especially in subjects like biology or geography, or in all subjects in general, it always happens that you look at very specific examples on some topic. And in the event that this continues. That this is something that was already part of the lesson anyway, in a relatively specific form. Because then the students might already know a little something. And so do I with the teachers. So if it's really something very specific, then I believe that there can be a lot of new things. But it doesn't have to. Depending on what kind of topic that is.*” (DE9)

Resumée for the competence “Knowledge of scientific concepts”

- a very theoretical area (DE11)
- enthusiasm for practical projects is higher (DE11)
- depends on the project / topic (DE4, E6, E9)
- important because the projects convey specific knowledge (DE9)

Explaining scientific phenomena and predicting changes

Ratings: Students 3 Teachers: 4

The competence “explaining scientific phenomena and predicting changes” was the lowest ranked competence for students.

One argument for the lower ranking was that “t*hat’s no longer our claim*” (DE5), but other experts considered it as important (DE11). The importance raised with the age of the students as E6 stated: *“I could imagine that in turn with older students*.”

E7 gave a higher ranking than the median value and argued: "*Yes the ' scientific phenomena 'that are somehow associated with the curriculum content, students should of course somehow notice. If we see it as a whole, then maybe I would enter a 4 and for teachers a 5.* (DE7).

Expert 9 was unsure about this competence as he said: " *Hard to say, it also depends a lot on what I am doing. I think I would set a 4, because in any case it is somehow a very practical experience and somehow has a cause-and-result relationship. I believe that drawing on a practical example is always profitable. Probably with teachers too.* (DE9)

Furthermore, DE10 stated: "*Well, with a citizen science project, of course you can explain a scientific phenomena, but that will be more the goal of a classical science "rules". And in my opinion citizen science has more to do with..[..] some kind of social change or social issue [...]explaining purely a scientific phenomena', for me it's not really visible for Citizen Science. But in some cases, [...] for example 'theoretical physics'. I know there were some projects about it, [...] having that [...]impact*. (DE10)

Resumée for the competence "Explaining scientific phenomena and predicting changes"

- For older students more important than for the 7th and 8th grade (DE6)
- The most unimportant competence for students
- for teachers considered as more important

Knowledge of the strengths and limits of science and technology

Ratings: Students 4 Teachers: 4

The competence "knowledge of the strengths and limits of science and technology" is rated as well for students as for teachers as important (both 4).

First, E11 considers knowledge of the strengths and limits of science and technology because "*that also includes where science comes from, what can it still do and what cannot. I would also prove strengths and powers* "(DE11). E2 also highlights the knowledge "*about the strengths and limits of science and technology [....]I also want to say a 5 then to be able to better assess the "risks and benefits*". (DE2) E6 agres and says: "*So awareness of risks, benefits of science. Yes, I think that's important."*(DE6), but also states about the teachers: "*I would say that of course they go in with more prior knowledge than the students.*" (DE6)

Moreover, E4 tells: *“I think it's very important that you know a little bit. Where are my options and where does it end? So that you separate yourself a bit and say “I have come this far” and that would have to be examined again now, that has always been the subject of every scientific work. That people say that this is my part and that it could go on in this or that direction. I also think that you or the students can definitely assess what and what. What other advantages does that have now, for science, for society? And where is the risk if you think ahead wrongly now? Yes, I think that's important. Definitely for students and for the teachers, I think they should definitely take that with them”*. (DE4).

Moreover, it is also important to discuss the possibilities: *“that you can simply say that this is possible or that you can do it. Or you can do that with this data and not. Same with teachers* (DE5).

Through a practical project it is possible to “really experience “*this when you are so close to such a practical project ”*(DE9). Moreover, it also depends on “*what have you been doing as a teacher before? So when I think of a couple of colleagues in physics and bio, they have just done a lot in their studies and with the students afterwards. I'm never quite sure whether this really still offers them the insane increase in knowledge.*” (DE9)

Resumée for the competence “Knowledge of the strengths and limits of science and technology”

- Knowledge related topic could be splitted into groups (DE3)
- Teachers may have a bigger prior knowledge (DE6)
- Possible to experience through a practical project (DE9)

Resumée:

Citizen Science competencies of students:

13 of the 14 competencies were considered as important (>=4). The competencies “*self-efficacy”,* “*data skills*” reached 4.5 points and the skills “*scientific inquiry skills*” and “*basic digital knowledge*” were considered as very important (the interviewees “*strongly agreed*” with 5/ 5). Only about 1 competence the experts were not sure: “*explaining scientific phenomena and predicting changes*”. Expert 5 stated: *“I can see it will be more demanding somehow. Difficult. So I would rather say because I am going down to a 2 and probably also with the teachers. So that's no longer our claim* " (DE5). And expert 3 was “*not sure about it*”.

Table 1 : Overview of the rated competencies (for teachers) by teachers

Competence	**Value (Median)**
Interest in science and the environment	4,25
Self-efficacy	4,75
motivation	4,25
Knowledge of the nature of science	4
Data	4,75
Scientific inquiry skills	5
Responsible citizenship	4
Basic digital knowledge	5
Social competence	4,5
Economic, moral and ethical aspects of science	4
Troubleshooting	4
Knowledge of scientific concepts	4
Explaining scientific phenomena and predicting changes	3
Knowledge of the strengths and limits of science and technology	4

Citizen Science competencies of teachers:

10 of the 14 competencies were considered as important (4), “knowledge of the nature of science”, “Motivation” and “responsible citizenship” as very important (5) and the competency “troubleshooting / problem solving” as unsure (3).

Table 2 Overview of the rated competencies (for teachers) by teachers

Competence	**Value (Median)**
Interest in science and the environment	4

Self-efficacy	4
motivation	5
Knowledge of the nature of science	4,5
Data	4
Scientific inquiry skills	4
Responsible citizenship	5
Basic digital knowledge	4
Social competence	4
Economic, moral and ethical aspects of science	4
Troubleshooting	3,25
Knowledge of scientific concepts	4
Explaining scientific phenomena and predicting changes	4
Knowledge of the strengths and limits of science and technology	4

Additional identified competencies:

- Economic, moral and ethical aspects of science (important)
    - commits to responsible personal and civic behavior after weighing the possible consequences of alternative options.
- Problem solving (important)
    - Use scientific and technological information to solve problems,
    - Problem solving through the use of quantitative and statistical skills
- Knowledge of scientific concepts (important)
    - Knowledge of domain-specific scientific concepts
- Explaining scientific phenomena and predicting changes (neither agree or disagree)
- Knowledge of the strengths and limits of science and technology (important)
    - Result of human labor, awareness of the risks and benefits of science
- Understanding the logic of science (not rated as it was new mentioned)
- Critical reflection (not rated as it was new mentioned)

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9. Barriers and Interventions

What are the main barriers for incorporating CS in schools = Do you have ideas how to overcome those?

Barriers	Interventions
"*curriculum* *: Lack of flexibility,difficult to integrate*"(DE Nr.1) *"With the core curricula and the centralization of degrees, it has tended to become more and more difficult to have freedom at all where one can do such projects." (*DE 5) "*curriculum is rigid*" (DE 7) "*Citizen* ***Science is not in curricular:*** *volunteer for teacher.This is the first and most important barrier.****" (DE 3)*** Curriculum (DE 6) "missing room for curriculum adaption"	"*Need a* ***Good argumentation****"(*DE Nr.1) *"that means you need* ***concrete projects that are listed as model projects in a list,*** *where exactly it says, which competencies are there that can be learned and these in turn have to fit the curriculum"*(DE Nr.1) "I*f you do a project like XY afterwards - you learn XX competencies and that fits into a topic block in a curriculum, where these competencies also play a role." (DE Nr.1)* "*And the* ***compulsory elective****, which I just mentioned, Natural Science, is just an area where you still have these freedoms," (DE 5)* *"But actually, as already described,* ***there are supplementary lesson areas****, there are also* ***differentiation areas that don't have a totally fixed curriculum a****nd, of course, there are also additional offers such as* ***AG/ working-group*** *offers," (DE 7)* ***Need motivated teachers.*** *And you only get schools, which have got very motivated teachers. [...] "*(DE 3) "The curriculum, depending on how tightly it is knit. I think you could cut back at one point or another, so that there is time for such things."(DE 6) **integrate into school internal curriculum. (Always in class/year) (DE 9)** "Firmly integrate into the school's internal curriculum ... Year 7, always do a Citizen Science project in the February to March time slot when we cover topic XY."(DE 9)

presence of the topic (DE 1) *citizen science **concept isn't already common.***"(DE 3)	Conduct project days (DE 1) *""I would find project days very useful. But of course difficult in Corona times. The teachers naturally want to find exciting projects. And if you have something exciting and you put it in the project day, for example, then you might be more open to doing something outside of it. (DExpert: in No. 1)"* "*There are **many initiatives to make this concept present to the society.***" (DE 3) "*If it is public investment, we are very worried what comes to society. That you have the aim that you bring sth. to society and that the society brings sth to science*." (DE 3)
high occupancy / workload for teachers (DE 1) + (DE 2) *"[...] but then it is still more work than 08/15 teaching". (DE 2)* *"The intensification of work, as we have it everywhere in our society, does not stop at schools" (DE 5)*	Make the connection clear between citizen science projects and the possible achievable competencies (DE 2) "*Teachers shouldn't have to invest to much of time. **Try to make things easy for the volunteer.***"(DE 3)
establish the CS-projects long-term (DE 2)	*"If you want to establish this firmly, then you have to make binding agreements: Cooperation agreement" (DE 2)*
finances / sponsoring, citizen science projects can be expensive (as the stratosphere balloon) (DE 2) Funding and funding - lack of funding (DE 5) Continuity: Topic 'Financing' (DE 7)	*"It would be nice if **you could integrate it into the lessons**, where you could regularly fly a tethered balloon, why not? We could also support the geography department. " (DE 2)*

time aspect (DE Nr.2) *"And of course there is a time aspect. We teachers always get the same money, no matter what we do, whether we are involved in a study group or not." (DE 2)* **Burden on teachers**: "*Well, and that means it has tended to be more difficult to find colleagues at all. We got the* topic of inclusion in 2015") (DE 5) Time factor (DE 7)	*"Definitely. If there are academic staff who could support with manpower, regularly, if there are agreements for repetitive teaching concepts that fit well into the lessons, then that's a great way to do it." (DE Nr.2)*
Motivation of teachers (DE 5) *"I mean, it ultimately stands and falls with the teachers who carry out the projects with the students*." (DE 5)	
Direction / Location of Schools (DE 7) *"Of course, **it always depends a bit on the location of the pupils, so in a school** in Bonn it is certainly **not as difficult as with a school that is located somewhere in the countryside,** where of course, for such a cooperation, **you would always have to accept distances that** you can't exactly make with public transport." (DE Nr.7)*	
Contacts in schools, personal relationships (DE Nr.8) " *It will only work **if you have contacts in schools. You basically either need contacts for the ticket or you somehow make** them through the competitor, but it takes very personal relationships to be the next barrier.* " (DE 8) "Finding the **right partner is the biggest barrier**. If advocacy comes from within the college, it is much easier to carry out such a project." (DE No. 4)	Linking science and schools (DE Nr.8) "Establish contact" (DE No. 4)

linguistically → same language level scientific language is not understandable (DE8) *“So the **linguistic is always a barrier, so a researcher.** So you have to **meet on the same language level, that is, the scientific language is not understandable for schoolchildren**, so that it is these skills of the researchers to break it down* “ (DE8)	Language has to be simplified → one level linguistic adaptation and communication - addressing (DE 8)
Long project duration - motivating students over the long term (DE8) *“Logic of time is different*”(DE8) “*Another barrier is that scientific projects **can take a very long time**. Keeping the schools, that is, keeping students happy with projects for so long, is just very difficult”* (DE Nr.8)	Get on board at an early stage to deal with the time aspect. (DE8)
Preparation and Materialis (DE3)	“*Teachers shouldn't have to invest to much of time. **Try to make things easy for the volunteer.***”(DE3)
Interest in the college (DE6) *"Yes, otherwise. There is always the question. Yes, how great is the interest among the staff? To what extent does someone feel called? To do something like that with their students."* (DE6)	*Direct advertising for such projects more specifically to the teachers* (DE6) *"... specific ... advertising ... should be done."* (DE6) *"... Schools ... quickly learn about such offers directly, be notified by clubs or something."* (DE6) *"... or ... times gets a circular email."* (DE6)

Time/time frame for implementation (DE9) "I think time is always a factor, especially for projects of any kind. Is think that's always the problem, that you have to create time windows to do something like that. It's just very time intensive." I would see that as the biggest barrier at the moment."(DE9) "Of course, that also needs people to carry it out."(DE9) **staff** who carry out the project(DE9)	**Project week/s** (DE9) "... relatively difficult, or then other subjects would have to be cut again or **project weeks** would have to be introduced."(DE9) **project weeks** (DE9)
Communication in the school (school management & staff) "You then have to **coordinate really well** with the school management, with the subject colleagues, perhaps also generally with the other colleagues. So communication in the school and planning across several organs of the school is already necessary."(DE9)	**integrate into school internal curriculum. (Always in class/year)** "Firmly integrated into the school's internal curriculum ... Year 7, always do a Citizen Science project in the February to March time slot when we cover topic XY."(DE9)

Resumée:

The following barriers were identified through the interviews:

- rigid curriculum (DE 1,5,7,3,6)
- presence of the topic (DE 1,3)
- high workload / occupancy of teachers (DE 1,2,5)
- establish the projects long-term (DE 2)
- lack of finances / sponsoring (DE 2,5,7)
- time aspect (of teachers) (DE 2,5,7)
- Motivation of teachers (DE 5)
- Location of schools (DE 7)
- Establish contact to schools / finding the "right partner"(DE 4,8)

- linguistic barrier (DE 8)
- Long term duration of projects (motivating the students long term) (DE 8)
- (Missing) interest among the staff(DE 6)
- Timeframe for conducting CS-projects (DE 9)
- Coordination needed with school management (DE 8)

Interventions:

The following interventions were identified through the interviews:

- Intervention against the barrier “rigid curriculum” (DE 1,5,7,3,6)
    - good argumentation needed / concrete project list with fitting competencies (which competencies can be learned in the CS project and how does it fit to curricula) (DE 1)
    - compulsory elective / differentiation areas- still freedom (DE 5,7)
    - use the supplementary lesson areas
    - use the option of AG / working-groups offers (DE 7)
    - need motivated teachers (DE 3)
    - shorten the curriculum (DE 6)
    - integrate CS into internal curriculum (DE9)
- Interventions against the barrier “presence of the topic” (DE 1,3)
    - conduct project days (DE 1)
    - use initiatives to bring this topic to society (DE 3)
    - bring sth to society(DE3)
- Intervention against the barrier “high occupancy for teachers”(DE 1,2,5)
    - Make the connection clear between citizen science projects and the possible achievable competencies (DE 2)
    - Make things easy for the volunteers / teachers (DE 3)
- Intervention against the barrier “establish the projects long term
    - Make binding agreements: “cooperation agreements” (DE 2)
- Intervention against lack of finances / sponsoring (DE 2,5,7)
    - Integration into the lessons (DE 2)
- Intervention against time aspect (of teachers) (DE 2,5,7)
    - Academic staff who could support with manpower (DE 2)
- Intervention against Motivation of teachers (DE 5)
    - /
- Intervention against Location of schools (DE 7)
    - /
- Intervention against Establish contact to schools / finding the “right partner”(DE 4,8)
    - Linking science and schools, establish contact (DE 4,8)
- Intervention against linguistic barrier (DE 8)
    - Language has to be simplified → one level linguistic adaptation and communication - addressing (DE 8)
- Intervention against Long term duration of projects (motivating the students long term) (DE 8)

    - Get on board at an early stage to deal with the time aspect (DE 8)
- Intervention against (Missing) interest among the staff (DE 6)
    - Direct advertising to the teachers (DE 6)
    - Notification through clubs / circular emails (DE 6)
- Intervention against Timeframe for conducting CS-projects (DE 9)
    - Use project weeks (DE 9)
- Intervention against Coordination needed with school management (DE 8)

Explaination of country-specific terms:

Project days: At schools can be conducted project days or excursions. How many projects are available, depends on the grades and the school.

Differentiation area / elective subjects: “In the compulsory elective classes of grades 9 and 10 at the Gymnasium with a nine-year course of education and of grades 8 and 9 at the Gymnasium with an eight-year course of education, the school offers at least one third foreign language and the subject computer science or a subject combination with computer science. In addition, it may offer all other subjects or subject combinations provided for in the Education and Examination Regulations for Secondary Level I (APO-SI) and the Gymnasiale Oberstufe (APO-GOSt).” (Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen 2021)

Project courses and technical papers (Facharbeit) in upper school:

“*Project courses* *are generally part of the school's curriculum with regard to the individual support of the pupils. The school management decides on the extent and the concrete design of the offer of project courses after consultation in the school conference.*” (Schulministerium NRW 2021)

“Project courses consists of two consecutive half-year courses” (Schulministerium NRW 2021)

“The Facharbeit (technical paper) is a comprehensive written assignment that must be written independently. The aim of the subject-specific paper is to write an exemplary scientific paper”(Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen)

“*By taking a project course, the obligation to write a subject-specific paper in a subject is waived. In this case, the obligation to take written examinations in the chosen subjects remains. A pupil may also write a subject paper in addition to taking a project course; however, there is no entitlement to do so*.” (Schulministerium NRW 2021)

Supplementary hours: “*Supplementary lessons are primarily used to intensify the individual promotion of competences in German, mathematics, foreign languages or in the natural sciences, especially if a repeat class or a change of school type can be avoided. In addition, schools can use supplementary hours for profile building and other school-based offers. Of the supplementary lessons provided for in the timetable, eight lessons are not compulsory for all pupils at the Gymnasium with a nine-year course of education, and five lessons at the Gymnasium with an eight-year course of education. The school conference decides on a concept for the use of the supplementary lessons on the proposal of the*

headmaster or headmistress." (Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen 2021)

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10. Needs

i) Do you think that CS could be a helpful practice / tool to be used in grades 5-9 in science subjects?

Experts 1,2,4,5,6,9 see CS as helpful practice to be used at school. Expert 1 highlights that he or she "*is an absolute friend of the fact that you take on a project and ultimately look at it from different departments*.". Furthermore, for conducting CS-projects Expert 1 says "Hybrid is of course also a compromise." but also comes to the following preference order: " *Presence first, then hybrid and then online.* "(DExpert: in No. 1). Expert 2, 5,7 would "*like to do these projects*" and requests "*please get in touch with us*" (DE 5). Expert 1 states that there should be "academic staff who could support with manpower, regularly" and also " *agreements for repetitive teaching concepts that fit well into the lessons*". Finally she compromises: "*then that's a great way to do it*." (DE 1)

Other experts say that CS-projects should "*not only*" be in "*science classes, also art teachers, math and language*"(DE 3)."*With art teachers it does also work, because they were working with visualization tool*s" (DE 3).

Furthermore, "*...such a totally practical work, is always profitable, no matter in which subject and no matter in which grade.*"(DE 9). DE 9 appends: ""*...students don't just learn something because they are supposed to learn it, but that they also realize why they are learning it.*[...] *I would see that as a totally helpful tool, precisely because we are always trying to address different channels in the students and to do justice to different learning types.*" (DE 9)

Expert 8 would not limit CS projects to certain "*target or to these age groups*". The argumentation is that "*it all depends on the projects and on the design*".(DE 8)

ii) In which subjects would you see most potential?

The most potential is seen in STEM-subjects: *"natural sciences, biology, chemistry, physics*,"(DE 6) and also other subjects as "*possibly geography. Social theory, depending on what we call the subjects*." (DE 6).

Expert 1 sees the most potential in "*Geography, physics, math* " and expert 2 "*could imagine that in the field of geography or mathematics*" and "*would limit it to the natural science for now*" assuming that "*it's mainly physics, maybe a bit of biology*" and in "*chemistry [..] they rarely have connections like tha*t".

More mentions of STEM-subjects:

- *"Geography, physics, math"(DE 1)*

- *“biology, physics, math, chemistry”(DE 3)*
- *"...physics and computer science (DE No. 4)*
- *"...in the natural sciences, i.e. in biology. I can imagine that super well.”(DE 9)*
- *"In geography, I can also imagine it super well, if you somehow do a trial."(DE 9)*
- *"In geology, it lends itself to that."(DE 9)*
- *"...physics ... you could certainly also integrate it, ...there is simply a lot of experimentation."(DE 9)*

Expert 9 highlights: "*This experimental work is also totally present in physics and also in chemistry lessons.*".

Furthermore, Expert 7 could well imagine that “*Especially in the natural sciences: chemistry, physics, biology, where they simply don't have the conditions at school to try out all kinds of things that could be tried out in such a research question.*" (DE 7) and also “*in computer science*”.

Moreover, Expert 3 would not limit it to STEm-subjects and states: *“It depends on the project. Because some projects focus that the citizens collecting data.* [...]“*It can be in all disciplines. You need a team of scientists who are trained with scientific question and methods.”* (DE 3).”*Even if it has long been said that Citizen Science primarily relates to the natural sciences, it is now clear to everyone that there are also humanities and social science projects*.” (DE 8).

Resumée:

The most potential is seen in the following subjects:

- STEM subjects
    - natural sciences
    - biology
    - chemistry
    - physics
    - mathematics
    - computer science
    - geology
- NON-STEM subjects
    - geography
    - social theory / social sciences
    - arts
    - sports
- Other answers
    - all disciplines

- depends on the project

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iii) What do the pupils need?

According to Expert no. 1 "*The students should also be able to use their own cell phones more, especially to record measurements. Why should this be made so taboo.You could bring in more*". The students also need "end devices"(DE 1).

Furthermore, the students need "*smart devices, explanation videos and tablets*" (DE 3).

iii) What do the schools and educators need?

There are IT-infrastructure needs, such as "WLAN, end devices", because "WiFi is a problem in many school" (DE Nr 1). There is obviously a lock of IT-infrastructure. At the school of expert No. 5 there are only"*actually 16Mbit for the whole school*"(DE 5).

Other needs are academic support as the teachers and students "need project ideas" and "academic staff to support us from the university" (DE 2). Additionally to that, " *a bit of concrete suggestions (for projects), which I don't have at hand.*" would be helpful(DE 9). Furthermore, is needed "*clear and good instructions for interesting topics, clear and good instructions. In this case, it should also be interesting that you somehow have the opportunity to talk to the researcher and yourself or to see a laboratory*"(DE 8). Furthermore, "i*t depends very, very much on the instructions, it has to be very clear on what I am doing. How long does it take? And it must not be 10-page descriptions, but short and crisp*" (DE 8).

Additionally to that "*Probably material of what is a scientific method, what implies science and so on. And also apps to pick up data from nature. And also accessing data in excel-forms."* would be helpful. Another idea is to *"provide videos and tutorials to explain some concepts. And also some fun materials as caps and stickers. Some schools are quite poor in tablets and the university provided tablets*" (DE 3).

Resumée of the needs

- Hardware/ Software/ IT infrastructure
- Project ideas
- staff support from university
- material and explanation videos

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iii) Which project would you like to conduct?

There are several projects which the experts would like to conduct, as for example "*in the field of environment*" (DE 6), or "... *somehow with a European or international thought. Maybe projects to clean up the environment. Both in Germany and in Spain, for example*" (DE 6). Expert 2 and 11 were excited about the tethered balloon [...]"*when you plan and build the thing together and put measuring sensors in it and send it up like that and then evaluate the data afterwards. That would certainly be a good project in that direction. And I would be happy if we could work together on that, of course.*" (DE 2) and both would like to conduct such a project. Furthermore, Expert 5 would like to conduct a project with "*measuring boxes and take local measurements in the district*".

Additionally, Expert 8 thinks "*a lot of scientific projects are suitable for primary schools.*", as for example in "*social sciences*" and Secondary level 1 is very, very well suited for this.

Moreover, Expert 8 also likes the projects which is called "*German in Austria*" and tells: "*So there you can create and design dictionaries online and that's the way it is, you can play it through all school levels, but it may also be more interesting for older people*.". Another project is "*nutritious Middle Ages where you simply transcribed the cooking recipes from the Middle Ages and tried to cook. That was a project for older students*."(DE 8)

All in all expert 8 sums up: "*So it depends on each project itself. So in principle you can use any topic, if it makes it exciting and if you as a researcher also have the opportunity to use this data from Citizen Scientists for the project, because not every research design that can be incorporated into Citizen Science is suitable. But otherwise there are opportunities in all directions*." It is also possible to "*involve students even in highly medical projects*" (DE 8).

Expert 5 would like to conduct "*tree planting actions, for example. [...] I've seen young people set out and tried out the goal*." (DE 5) or a "*Hands on projects, I kind of say. And then of course you could see that you were dealing with forest management or with raw materials and renewable raw materials. Or with the subjects of "CO2 reduction" or "Oxygen production". I could imagine that, for example*" (DE5).

Further, Expert 11 could imagine projects in the "*field of water, biology or marine biology. If you have the chance to go on excursions towards the sea and the Wadden Sea again, that would also be something that I would definitely like to do for my students. So all about water, geology*"(DE11).

Resumée of the project desires

- Stratosphere Balloon
- Environmental projects (biology, water, geology, Co2 Reduction, tree-planting)

- Hands-on projects
- any projects are possible also in social sciences (or the language project “German in Austria)

2.4

Country results: Greece

Summary interview

1. Interviewees' background data

In Greece there has been relatively fair representation regarding gender (male (6/10); female (4/10)), representation of educational levels (Primary & secondary education level) and teacher levels (teachers and head teachers with the majority having more than 12 years of experience). Regarding interviewees' level of education 9/10 have MSc studies and 3/10 PhD.

2. School background data

Regarding schools there is a fair good representation since the interviewees are employed in public as well private schools, experimental ones (2/10), in urban as well as rural areas of Greece and there is a variety of school sizes ranging from 150-1500 students.

Description of the results from the interviews about citizen science

1. Experience with CS-projects

a. Personal Experience in CS projects

Expert EL1 is aware of the term and has participated in activities such as part of a workshops organized in the context of European projects. EL2 Was active in some past CS projects: e.g., Avso project variable stars, to measure the luminism of stars. EL4 first heard about CS projects from Scientix CPD courses and during my involvement in the OSOS program No practical experience. EL5 had attended Workshops, a seminar, some theoretical discussions; News, magazines, campaigns from NASA. EL7 has conducted with students various projects concerning science and how to spread their application knowledge to society. EL8 works towards implementing a CS project regrading biodiversity.EL9 and EL10 working in a private school allowing more flexibility; they have participated in CS projects with their students. EL3 EL4 and EL6 have no practical experience within their school (only personal).

b. Example citizen science project

Expert EL1 mentions activities such as Galaxy Zoo and other projects in the Zooniverse, as part of a workshop organized by the REINFORCE project.
EL2 has experience in past Avso project variable stars, to measure the luminism of stars.
EL4 “first heard about CS projects from Scientix CPD courses and during my involvement in the OSOS program; however, have no practical experience”. EL5 has attended Workshops, campaigns from NASA, taken pictures of clouds.
EL7 mentions “have conducted with my student’s various projects concerning science and how to spread their application knowledge to society”.
EL8 mentions projects regrading preservation and spread seeds of traditional vegetable varieties.
EL9 and EL10 mention deploying CS as a method to implicate students to the project BigO (https://bigoprogram.eu/).

c. Experience with citizen science at schools

EL7 has “conducted with my student’s various projects concerning science and how to spread their application knowledge to society. Best projects were about earthquakes, electromagnetic radiation and CERN”.

EL8 already implements a CS project having to do with seeds preservation and furthermore is in the process of creating a Space Museum in the school where they will have STEAM workshops for students, teachers and families of the school and other Schools. “We already have a Planetarium - Geodesic Dome made by students for students. Cs projects could be implemented in our Space Museum”.

EL9 and EL10 mention deploying CS as a method to implicate students to the project BigO (https://bigoprogram.eu/). *“The goal of this project was to gather data about their meals and their physical activity exploring the correlation between these and other socioeconomical factors with obesity. Students were using smartwatches to record their physical activity and using smartphones and tablets for capturing pictures of their meals”.*

Interviewees 1, 2, 3, 5 have some kind of previous personal CS experience with CS, however had no experience with citizen science projects in schools.

Resumée: Some interviewees have got some experience with CS-projects with their participation in teacher trainings and involvement in European projects being the starting point. Interviewees 1, 2, 3, 5 have some kind of previous personal CS experience, they can describe main characteristics of a good CS project although have not experienced CS in schools and would be really *happy to conduct such projects.*

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2. CS curriculum at schools

All experts agree that there is no curriculum for citizen science.

EL8 also mentions that “the national curriculum for schools and the curriculum for the education of Muslim students in minority schools in Thrace include references to CS but do not actually support CS”.

a. Possible ways for implementing citizen science

ii. STEM-subjects

All interviewees mention that in STEM-subjects, citizen science projects implementation, as for example “***biology, physics, computer science****, [...] mathematics”.*

iii. non-STEM / various subjects

Expert 6 mentions it is also possible to integrate CS-projects in non-STEM subjects.

More specifically, EL8 mentions CS projects could be implemented in all the subjects and by all the teachers. It could be implemented in the subjects of Maths, Physics, Astronomy, Environmental Sciences (Environmental Sustainability Education), ICT, STE(A)M, Social & Political Education of Citizens (S. & P.E.of C), Language, History, Local History, Oral History, Geography, Physical Education, Religion, foreign Languages (English, German and French) and Arts. “My favorite way to implement a CS project would be by combining interdisciplinary teaching and inquiry-based learning with the Big Ideas of Science. It would also find it interesting if it would include engineering”.

EL9 and 10 also mention ***physical educational*** *classes.*

iv. other options (competitions, extracurricular places of learning)

EL1 mentions “Some hours per week for free topics / experimental work and after school activities”.

For Expert No. 9 competitions are a useful tool for implementing citizen science projects (they have been used in the context of BiGo project). And “we have our own Department of Research and Development for educational programs, which bring CS projects to class”. On top, Citizen Science is implemented in extracurricular sessions in after school students’ clubs.

Resumée: There is no curriculum for Citizen Science in Greece and all schools need to follow the national guidelines. The relevant projects are done on a voluntary basis mainly through the participation of the school in a European program. Nevertheless, most of the experts see possible implementations mostly in STEM-subjects, but not only. Primary schools allow for more flexibility versus the secondary ones where there is more pressure for covering topics. Furthermore, in three cases the flexibility that an experimental or private school offers in CS implementation is mentioned.

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3. Data science in the curriculum

a. Are there data science concepts in the curriculum?

Are there data science concepts (e.g., data acquisition, analysis, interpretation, ethics) in the curriculum?

Some experts were not sure since they are working with younger ages (e.g., EL1). EL04 mentions “Not in a formal way. There is a corresponding section in Maths and ICT curriculum for elementary data analysis (in general). It could fit interdisciplinary in sciences, Maths and ICT curriculum and be applied on other subject fields such as social sciences”. EL6 mentions “Unfortunately, no. We have only statistic topics in mathematics in B secondary and B high school but we study only basic concepts. Students are unable to understand data science concepts. In my extra curriculum activities, I try to include real data for environmental or labor market for analysis and make conclusions”. The rest of the interviewees’ answers are in line.

b. Concepts in STEM-subjects

Several experts see data science concepts in STEM-subjects (EL 1,4,6,7,8).

c. Concepts in non STEM-subjects

Some of the experts also see data science concepts in non-STEM subjects such as technology (EL02), social sciences (EL03), multidisciplinary courses (EL04), Geography, Environmental Sciences (EL08).

d. Concepts in project courses and other answers

Furthermore, EL09 mentions "*In private schools data acquisition or analysis and interpretation are more often as a teaching method, but ethics is not usually included".*

e. Where could the data science competencies fit?

*EL08 mentions "*They could fit in all subjects. A text about concepts of science and modern physics, Nobel prize winners could be included in the subject of language and become an activity for creative writing (poetry, storytelling, song writing) and expressing with art. Data science could be included in Geography and S. & P.E.of C. combined with Sustainable Development Goals".

Resumée: Data science competences can be found in different subjects (STEM and non-STEM); however, they are not introduced formally in the curriculum and only in Maths/statistics in the secondary schools.

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4. Support for teachers

a. How are teachers supported when introducing new topics / subjects?

EL01 mentions "Difficult question and it really depends on each school. In public schools, often colleagues do not support new ideas, or are lacking resources to implement new things. (e.g., no computers, infrastructures)".

EL2,9 and 10 mention that their school is very supportive; being a private one.

EL05 mentions “Not a supportive environment; it’s totally based on teachers’ motivation; Active teachers can find ways, but no support from schools; but teachers have the flexibility to do it, as long as curriculum goals are reached and as long as students and parents are happy”.

EL06 mentions “No our curriculum, especially in high school is strict. We cannot include new topics, but we receive guidelines by ministry of education in the starting of school year that we have to follow them. Any extra action or pilot research need license”.

EL07 mentions “Teachers don’t have any support when they introduce new topics”.

EL08 mentions “It is up to the teacher to introduce new topics and when doing this they are usually alone and have no support”.

b. Adaption of the curriculum possible?

EL01 mentions “as a rule of thumb: experimental schools are more open to new approaches than the “normal” public schools”.

EL02 mentions “The curriculum is quite rigid, and it is difficult to introduce CS actions, in the normal curriculum; Afternoon clubs and possibly Technology lessons 2nd 3rd grade of secondary school could be an opportunity”.

EL07 mentions that “teachers can’t freely adapt the curriculum if they want to do anything outside curriculum, they have to do it extra time” (afternoon clubs).

EL08 mentions “Teachers can adapt the curriculum if it ensures that the topic-concept is integrated in the subject/s and fits the learning aims and objectives. In my experience it takes time, effort and the added value of an implemented and successful project to get the support and collaboration of the Headmaster/Headmistress of the school, the colleagues and the parents”.

c. Is there education, monetary support or support groups?[2]

EL07 mentions “There aren’t any support groups, it’s up to the teachers how they will support their projects”.

EL08 mentions “A teacher can find support in likeminded groups, networks and communities locally, nationally and globally. After the Pandemic many groups of teachers were formed in social networks about remote teaching and learning…I am a SCIENTIX ambassador, eTwinner, EU Code Leading teacher, and an #EdChatEU facilitator. I enjoy participating in EUN MOOCS, ESIA Summer Schools. I am a lifelong learner by choice….” Specifically, regarding barriers “A barrier for most of my colleagues to find the educational support they need/seek is proficient knowledge of English and digital literacy”.

Resumée:

In general, the curriculum is quite rigid and difficult to adapt especially in secondary level schools. Some possible adaptations of the curriculum are given through multidisciplinary projects. The availability of teachers’ support when introducing new topics/subjects depends on each school. As a rule of thumb: experimental and private schools are very supportive and open to new approaches. Also, often in public schools there is a lack of resources to implement new things (e.g., no computers, infrastructures). Since it’s difficult in the normal curriculum, after-school students clubs could be a good opportunity to introduce CS actions.

7.CS skills

Please see the list of competences below. Which are the most relevant / useful skills for pupils and teachers taking part in CS projects?

Do you see additional skills that can profit from CS?

Competency	**For Pupils (which grade?) (Could provide a range of importance from 1-10)**	**For Teachers**

Interest in Science & the Environment Interest in pursuing science and environmental topics, and issues.	7	10
Self-efficacy The extent to which a learner has confidence in his or her ability to participate in (citizen) science	8	8
Motivation Motivation to pursue science and environmental goals such as STEM careers and citizen science project activities.	8	9
Knowledge of the nature of science; understanding of the scientific process and how science is conducted by researchers	8	10
Data Understanding how to gather, analyze, interpret and critically discuss data Understanding how to handle data securely and ethically.	9	10

Skills of Science Inquiry Procedural skills such as asking questions; designing studies; handling data; experimenting; argumentation; synthesis;	10	10
Responsible Citizenship Behavior change towards becoming a responsible citizen (e.g. towards environmental or sustainability issues)	10	10
Basic skills technology use; digital literacy	9	9
Social skills Collaboration Communication Critical thinking Reflection	10	10

Below follow the qualitative answers provided: (EL02, 03, 05 & EL08).

Competency	**Skills For Pupils** (which grade? - provide a range of importance from 1-10)	**Skills For Teachers**
Interest in Science & the Environment Interest in pursuing science and environmental topics, and issues.	All grades Change their attitude towards science Brings them closer	Most relevant /useful

	to the topic, Brings down barrier Probably yes, if someone gets involved, he will probably become interested in topic Probably yes, 10-12 years old students Totally agree that students could benefit from becoming part of science Critical thinking, Emotional intelligence, Research skills, Most relevant /useful For all the grades	Also, important and interesting It helps teachers if students are more interested
Self-efficacy The extent to which a learner has confidence in his or her ability to participate in (citizen) science	It will generate motivation and interest and help them understand that it is not “rocket” science. Totally agree By getting involved in an active way,	Most relevant /useful Maybe they would, but again, it’s more helping students, could cause extra work for them Also, for adults true But again, it’s more

	that what students want, extra motivation I do believe it, Science activities are mandatory, so these approaches could be helpful Stress management Most relevant /useful For all the grades	helping students, could cause extra work for them Leadership, Empowerment
Motivation Motivation to pursue science and environmental goals such as STEM careers and citizen science project activities.	It can give them a sense purpose Could be a motiving to choose stem emphasis and possibly career Not an examen, no competition, no fear of failing test Problem solving, teamwork For many students, it could be a great motivation. Some will not care either way	Not sure about adults / teachers But the more you are involved, the more likely you would be motivated Most relevant /useful

Knowledge of the nature of science; understanding of the scientific process and how science is conducted by researchers	Definitely Learning by being an active part, Depends on how much the contribution / work. It is important to give them time and space to understand the whole process. If you give them just a task to collect “simple” data, but then they would skip or not be aware of the other parts of the scientific process. Students need to learn about the big idea, make sure that students understand what happens to their work / data collection. Put it in context and how it helps scientists. Linking to scientists, personal interaction could be really helpful Research skills, communication skills	Also true for adults, to become involved in the whole scientific inquiry cycle, Also, they can learn more about “how science works”. Social aspects of science, Important of science communication, Theories being accepted by other scientists Subject to criticism, learn how to deal with it. Resilience. Usually only understand sth when you are part of the research. Most relevant /useful

Data Understanding how to gather, analyze, interpret and critically discuss data Understanding how to handle data securely and ethically.	Definitely Learn the value of data and data collection Creativity, time management	Most relevant /useful
Skills of Science Inquiry Procedural skills such as asking questions; designing studies; handling data; experimenting; argumentation; synthesis;	Definitely Mindfulness, Mental agility Most relevant /useful For all the grades	Most relevant /useful
Responsible Citizenship Behavior change towards becoming a responsible citizen (e.g. towards environmental or sustainability issues)	If you do a project that would deal with e.g., environment, and you realize the pollution in your neighborhood that could lead an increased sense of RRI, and you will manage for them to have a better understanding. Also: clean see, beaches, etc. plastic, garbage Maybe yes, If the process of science had an outcome that	Most relevant /useful

	would be useful and important to the whole society e.g., CO2 measurement, publish data, provide solutions, good practice, link this with practical consequences, not just theory Decision making, 9 Trust reliability, Most relevant /useful For all the grades	
Basic skills technology use; digital literacy	Definitely, IT, News reading sources, Smartphone use, beyond social media Probably yes, Depends on freedom of teaching process. How free can the citizen science actions be? Is it structured exercise? Can you students do the research that is asked of them? Not impossible for primary students	Most relevant /useful

	Probably yes, Technology skills, computer skills Most relevant /useful For all the grades	
Social skills Collaboration Communication Critical thinking Reflection	Yes, definitely. It's part of the scientific process. Communication with scientists can promote reflection! Yes, could greatly contribute, give them the sense that they are not "alone" in this endeavor. Resilience skills	Collaboration Most relevant /useful
Additional:	Possible international cooperation Civil engagement The aforementioned skills are the most relevant and useful skills. From my experience many of those skills are	All the aforementioned skills are the most relevant and useful skills for teachers that will inspire their students, motivate them and help them develop their skills.

	absent, underdeveloped or in lethargy. The implementation of such projects awakens these skills and develops them. The earlier we start the better.	
	I would also add self-regulated learning to self-efficacy.	During the Open Classroom Conference (6 – 8/11/2020) I heard in presentations from OSOS teachers that during the implementations of SNAC - OSOS projects they developed and improved their skills (basics) due to the implementation of the project and the interaction with the students who were experts in basics skills.
	I would add empathy, resilience, making connections and creativity to the social skills.	I would add interdisciplinary teaching in skills of science inquiry.

9. Barriers and Interventions

What are the main barriers for incorporating CS in schools = Do you have ideas how to overcome those?

Barrier	**Intervention**
Infrastructure, lack of tools	More money
School culture	Workshops for school leaders
Colleagues	Incentives / recognition
New term, not familiar with CS	Training workshops
Fear of data sharing (parents)	Workshops / material
Curriculum	Linking with curriculum
Time	
Generate curiosity in students	Needs to be captivating
Competition of other attention of students (out of school)	
Changing attitudes of individuals	
Fit to curriculum (	Fit to curriculum
Teachers' mind-set; not interested in new things	Fit to curriculum… well organized, additional incentives, "cookie" at the end. Make it easier for them
Authorization of ministry for public schools	
Infrastructure in public schools	
Must not have cost for children	
Language has to be in Greek!!!	
Lack of pre-service training	University courses
Lack of continuous training	Formal CPD courses
To be provided by the curriculum common lessons and preparation hours for teachers of different specialties	Common projects hours for teachers of different specialties

Isolated school. Lack of connection with society	Connection of the school with the society and all the involved stakeholders
No teachers training	Organization of MOOCs
Need educational visits that are so easy to organize them	
Time limitations	Need to adapt it to the curriculum
School equipment	More money to schools and education
Teachers' lack of knowledge for modern science	Teacher seminars and workshops
Permission of the Ministry of Education	Participating in ERASMUS+ projects
Permission of the Directorate of Education	Open Schools to society
Permission and support of the School and its Headmaster/Headmistress	Initiating partnerships and collaborations
Lack time for cs projects	Transforming schools into Labs that will contribute to society and cs projects
Insufficient knowledge of SC projects on the part of teachers	School entrepreneurship
Lack of confidence in implementing a SC project.	Strong Leadership and vision for the school
Absence of appropriate resources and materials.	Institutional support
Insufficient institutional leadership	Meetings with the school community about the school
Lack of funding	Getting funded from relevant to the CS project institutions
Pressing socio economic problems of students that leads to incomplete school attendance and school dropout (in our school)	
The Pandemic and the lockdown created many restrictions in consideration with	

field trips, scientists visiting schools etc.	

10. Needs

Do you think that CS could be a helpful practice / tool to be used in grades 5-9 in science subjects?

EL01 mentions that there is great potential in CS for schools and sets as possible issue for further investigation Connection with CS with AI?

EL05 In my opinion this subject could be better taught at ages over 10.

EL06 Yes, I think that as earlier student get familiar with scientific methodologies in real phenomena as better could take motivations for learning science and development skills.

EL07 CS could definitely be helpful practice in all grades and specially to younger students.

EL08 mentions “As a Headmistress of the 9th Primary School of Komotini I face 2 challenges which are the following:

1. Change the monosemantic story of my school which is underappreciated in the minds of the local community despite its stable and experienced human resource power and the spacious infrastructure.
2. Tackling incomplete school attendance and drop out of students of vulnerable social groups living in marginalized areas of the city.

I believe that a CS project would definitely benefit our school. It can be integrated in every subject and adapted to the needs of the students. It could be integrated in workshops with the students and their families extra curricularly”.

EL09 mentions “It is difficult for these grades to understand firstly what science is and then data acquisition, analysis, interpretation; so, it will be better not to practice it in low grades”.

EL10 No, it would be very difficult

In which subjects would you see most potential?

EL06 Subjects: in primary education geography /environment

In kindergarten the Greek curriculum is free for implementation CS projects, there are not specific topics.

(EL09) Physics, mathematics, Physical education and nutrition and social studies

(EL10) Mathematics and Social studies

What do the schools and educators need?

EL01 mentions workshops, training, as well as Definition of basic scientific concept

EL02 mentions:

- Instant support! Pick up a telephone, zoom, etc. messenger!
- Workshops, training
- Should be easy to implement.
- Practical
- It could help to work with local stakeholders, will provide extra visibility, appearances, to establish local cooperation

EL03 mentions

- Specific suggestions, variety of possible projects
- Guidelines, instruction
- Contact with scientists,
- Equipment

EL04 mentions that obstacles to teacher training, child-friendly material and the opening of the school to society must be overcome.

EL05
Need to learn about the concept of citizens science

- The concept of science might be difficult
- Some teacher depending on topic might need extra explanation about the science topic.
- Balance everyday practice vs. scientific quality of the results?!
- Are teachers really able to implement scientific inquiry? Teachers might need support to learn about the nature of science,
- Quality assurance of data
- Guidelines, instruction
- Contact with scientists,

EL06 mentions that teachers need training for intergrade CS projects.

EL07 mentions Schools need new curriculums and more financial support, teachers need seminars

EL08 mentions:

- to be inspired and motivated
- be introduced to it and guided
- To know that they will be supported during the project
- Positive school climate
- understand its value for their students and the whole school community
- workshops
- to discuss the timeline and procedure of implementation.
- to integrate in the subjects of their class and adapt it to the needs of their students
- have appropriate learning resources and materials.
- institutional support
- funding
- time

EL09 mentions they need to learn how to write attractive scenarios and what is Citizen Science Research

What would the students need?

EL01 mentions that students need to explanations about the importance and the reasons why they should get involved, make it relevant to their personal lives & how their involvement would help science and their own learning.

EL02 mentions that materials need to be in Greek!

- Many children copy paste a lot, so if they need to create their own data set, create original.

EL03 mentions

- Instructions,
- Contact with scientists.
- More time to do the lessons.
- Equipment

EL05 mentions

- Helpful if they could be in contact with real scientists, would help with motivation
- Could ask questions about every aspect of the project
- Being able to communicate with the real scientist.
- Explain the basic concepts better

EL08 mentions

- inspiring and motivated teachers
- support from the school community
- projects that give meaning to the knowledge offered in school
- express themselves orally, written, creatively
- inspiring role models
- get in touch with professionals
- interesting and up to date learning materials
- Fill up pre and post surveys
- Work with rubrics
- Be guided and have feedback
- to develop all the aforementioned CS skills
- field trips
- broaden their horizons by using for example telescopes
- network with students of other schools in other countries
- IBL interdisciplinarity, learn to make connections, the Big Ideas of Science
- Labs and workshops with hands on activities and experiments
- to contribute to science and SDG
- present their work to the community
- learn to write a scientific article, make references
- have a conference for students
- learn in a democratic school culture
- learn about the democratic culture of science for example CERN, its mission and its ethics.

(EL09) They need time, resources, community interest and scholar benefits

EL10 “Resources, Skills, and benefits”

- How this will be linked to daily life.

School flexibility, time, motivation, to be out of the class (EL10).

2.5 Country results: Italy

Description of the results from the interviews about citizen science

1. Experience with CS-projects

a. Personal Experience in CS projects

The expert No. 4 had direct experiences of CS in schools through the Environmental Education Center of the Municipality of Bitonto where for 5 years he took care of various projects including those of water and energy saving and sustainable mobility for differentiated collection. The expert asserts in fact : "*My experience of CS in schools is through the Environmental Education Center of the Municipality of Bitonto, within which we have taken care of for 5 years*" (IT Nr. 4). However it seems that the concept of CS is not clear in all its meanings, and it's interpreted semantically close to a more general "Environmental Education".

Expert No. 5 reports that he did not participate directly in CS projects: "*Being a teacher of literary subjects, during my years of teaching I have not had any experience of CS projects to follow or propose."* (IT Nr. 5). Even if the expert considers the CS closer to scientific topics, attempt to join together humanities and scientific studies on the "umbrella topic of CS" are pointed out: "*to participate to projects proposed to promote the dissemination of scientific research, the reduction of the discrepancy between humanistic and scientific culture with a wide involvement of children on the paths that the academy has proposed year after year*" (IT Nr. 5). But he did research in the scientific field and participated in some PON (National Operational Program) in the same area. He also reports that the school he works for has joined projects proposed by the "Accademia Vitale Giordano" for the reduction of the discrepancy between humanistic and scientific culture, with extensive involvement of students in the proposed projects.

Expert No. 10 contributed to the "Participatory Action Research" in the slums of Kibera and Korogocho, Nairobi, Kenya, consisting of a shared data collection with resident citizens, and to the "Participatory Action Research" in the Breglumasi district, Tiranam, also consisting of a census and shared data collection with the with the participation of residents of the neighborhood.

Other experts report no previous experience in CS projects both inside and outside schools projects.

b. Citizen Science Project description

The topic is not well known by the interviewed experts. The statement *"I have heard of Citizen Science, I know what it is but I cannot fully describe a project since I do not have direct knowledge of it" (*IT *Nr.3)* by the expert No. 3, shows that when the concept is known, its effective implementation is still not focused.

Expert No. 4 has actively participated in education projects on water and energy saving, sustainable mobility and separate waste collection, but does not specify its implementation and does not describe the experience properly.

Expert No. 10 states that a Citizen Science project should combine both methodological and technological skills to be defined as a good CS project: "*A good CS project should combine methodological and technological skills". (*IT *Nr. 10)*

c. Experienced Citizen Science in schools

There are no effective examples of CS projects in schools.

The expert No. 5 worked as an high-level project manager at a municipal scale, by providing "*the planning of the territorial training offer plan that the municipality of Bitonto proposed to schools of all levels"* (IT Nr. 5); in this context the school in which she works has distinguished itself for the project "Scuola Riciclona", on subjects of ecology, environment and recycling.

Expert No. 6 reports to have a "*not proper*" (IT Nr.6) indirect experience in CS based on its sons' activities in school. The statement "*A biomedical curriculum within which there is a exercises-based portion of activities"* (IT Nr.6) suggests that CS projects are perceived to be strictly linked with laboratorial activities.

Resumée: Few interviewees claim to have some experience with CS-projects (4,5,10). Actually, their experience could not be classified strictly as CS-projects. The majority of the interviewees haven't got any experience at all.

2. CS curriculum at schools

Almost all of the interviewed experts state that there is no mandatory school curriculum for Citizen Science. There are sporadic experiences led at teachers' discretion. In particular, Expert no. 7 points out that civic education is present in the school curricula in a structured way and it could be considered an "Italian" version of Citizen Science because it takes partially into account CS-related topics.

Expert no. 5 says "*There is a generalized inclination in promoting scientific knowledge, a certain culture of attention towards the research approach and data collection.* [...] *There are no specific project plans that have become structural part of the curricula.* [...] *also because the topic is not well known*".

"*Many of the initiatives in similar projects are currently mainly extra-curricular"* (IT Nr. 5).

a. Possible ways for implementing citizen science

"Some flexibility in the implementation of projects and programs is possible thanks to school autonomy" (IT Nr. 3)

ii. STEM-subjects

Almost all of the interviewed experts consider STEM or scientific subjects such as **biology**, **environmental education**, **physics**, **technology**, **mathematics** as the natural framework for CS projects. Also speaking about different education grades, *"It would be interesting to see CS also included in the various curricula offered by the University"* (IT Nr. 2)

According to the Expert No. 1 that states that "*The disciplines with a technical core are the closest.* [...] *These subjects should be the most stimulating for students. A methodological approach such as CS can really increase student results*".

iii. non-STEM / various subjects

The Expert No. 3 asserts that it is possible to integrate CS projects also in humanistic subjects such as citizenship, history, geography, art.

The experts No. 4, 6, 7 and 10, moreover, see a perfect fit also in **environmental and social-based subjects**, such as "*the study of the cycle of waste and innovative materials, how to reuse them and in which fields of application*" (IT Nr. 7), in **civic education**, in **environmental education**, in **citizenship** and **legality**.

iv . other options (competitions, extracurricular places of learning)

"*Citizen Science deals with projects such that ordinary citizens* [...] *can contribute to scientific research. For this reason I think it can be used in any area of the training course*." (IT Nr. 9)

Resumée: There is no official or mandatory curriculum for Citizen Science in Italy. close to CS approaches can be found in STEM and scientific subjects: they are mainly conducted through specific proposed projects and independently from school curricula.The Civic Education can be seen as an italian teaching close to CS topics, focused on citizen aspects. The main implementation field is found in STEM subjects (for example mathematics, physics, technology, natural and environmental sciences) with a possible extension in more humanistic non-STEM subjects such as geography, history, art, citizenship and legality. In particular, Expert Nr. 2 considers a greater cooperation between schools and universities interesting, with the possibility of carrying out experiences of this type even in university courses.

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3. Data science in the curriculum

a. Are there data science concepts in the curriculum?

Data science topics seem not to be formally present in standard curricula in secondary schools.

Expert No. 1 and No. 2 focuses the answer on different school grades. With "*fifth year of secondary schools, in the discipline of mathematics, deals with statistics*" (IT Nr. 1) it's highlighted by Expert No. 1 that statistics studies are addressed during the fifth year of secondary schools, during mathematics lessons. Therefore, the acquisition and processing of data is addressed but not applied to a specific argument.

Expert No. 2 states that data science is widely used in university pathways, especially in electrical engineering, information engineering, computer science, and automation studies. When speaking about 5-9 grade, he states that "*I do not think it is possible that these topics are addressed in paths that are not university given the complexity*" (IT Nr. 2).

Expert No. 3 and No. 6 argue that there could be some kind of non-formal approach to this topic in 5-9 grade schools: *"non-explicit way"* (IE Nr. 3) and "*Not in a structured way"* (IT Nr. 6) denote that notions of data science are present in a non-explicit way in the curriculum of different subjects.

While Expert No. 5 asserts that "*No, there are none, except that there are particular choices of teachers who particularly care for these aspects*" (IT Nr. 5), the other experts can't find this topics in standard school curricula.

b. In which subjects?

The expert No. 1 confirms that these topics are covered in mathematics. The experts Nr. 3 and 6 confirm and extend the answer to science.

Expert No. 5 states that there is a clear need to process data especially in scientific disciplines such as natural sciences, chemistry, physics, mechanics and electronics. This, however, is a choice of the specific teacher.

Expert No. 4 confirms what was said previously: mathematics is the most relevant subject to data processing. But he also highlights how Mathematics data analysis is a different concept from data science.

c. If not, where would they fit?

Expert No. 1 states that data science would be useful for all those socio-health subjects, such as human sciences, psychology, pedagogy, psychometry. He also said that it would be useful, at any level of education, to introduce useful concepts to develop computational thinking.

Experts No. 2-4-6-10 said that data science concepts should be taught in all scientific and technological subjects and more generally, according to expert No. 9, in all those subjects based on practical experience.

Expert No. 3 reports that social sciences use population behavioral data for statistical analysis, both for synchronic comparisons and for diachronic development models. Finally, expert Nr. 4 states that in the institute where he teaches, the departments of technology and mathematics are merged precisely because the topics covered are similar and therefore the approaches can be integrated.

Resumée: Provided that Data Science Curriculum doesn't seem to be present in the Italian school system grade 5-9, with the exception of pure statistical mathematics, most of the interviewees would see their placement in all STEM subjects but also in the humanities, where a collection and data analysis could support research.

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4. Support for teachers

a. How are teachers supported when introducing new topics / subjects?

As for the Expert No. 4 "*Teachers are not directly supported in introducing new topics and / or new subjects*" and this concept is shared by all the interviewed.

"*Each discipline has a total annual number of hours; the biggest percentage is established at national level while the remaining can be managed independently at school level. Institutions can decide both to compensate between subjects or to insert new topics / subjects.* [...] *The choice must be deliberated by the teaching staff*". (IT Nr.1)

Of fundamental importance is the teachers' continuous training activity, which could foster the introduction of new themes in school teaching.

As Expert No. 3 points out: "*Teachers are generally left alone to experiment with new methods and new topics. When training courses are well structured, teachers are also followed in the experimentation phase in the classroom and in collecting feedback and improving the approach in learning dynamics; most of the time training courses are not so performant. Well-structured training courses are then mandatory to make the teacher feel more confident in adapting their teaching program to new teaching challenges*". On the basis of what the Expert No. 7 also affirms: "*There are courses available on a ministerial platform called Sophia. These courses credits us in such a way that we are always encouraged to follow and document ourselves. They are not mandatory, but they are diversified and classified according to objectives and subjects*".

b. Adaption of the curriculum possible?

The answer of Expert No. 1 is straight to the point on the topic: "*There are no longer prescriptive plans, but ministerial guidelines according to each educational address. There are learning objectives that pupils must achieve, but the methodology is up to teachers that are free to embed new topics in their work plan*". This flexibility in school curricula "customization" is confirmed by the totality of the interviewees; they all speak of a "*unitary ministerial framework within which each school organizes its own curriculum*" and "*teachers are free to organize their own plans according to the time-varying needs which*" (IT Nr. 8 and IT Nr. 9).

In particular, Expert No. 5 underlines the concept of "***Scholastic avant-gardes***", or "*experiments launched at ministerial level, recognized experimental paths that provide for rewards for those who join; they are currently in free form and are a didactic approach which should favor an innovative model of involvement and experimentation*".

c. Is there education, monetary support or support groups?

Teaching staff's training is partly supported by annual funds, made available by the Regions or by the European Community, as emerges from the interviews Nr. 1, 3, 7 and 8. In particular, "*the main support comes from the EU, with PON projects or Institute Funds for specific projects*", such as the "*terminal grades, or 2th grade, 5th grade and 8th grade recovery activities*" (IT Nr. 8). There are therefore no particular support groups; there are platforms that support training (Sophia platform already mentioned above) as underlined by Expert No. 7, or tutoring groups to support teachers during training experiences, as can be seen from the Expert No. 4.

d. Is the education ongoing?

The totality of the interviewees affirms that the training is not continuous and it is stricly individual; it can be active or not depending on the plans. In particular, no training "*strictly related to CS*" is ongoing. (IT Nr. 7)

Resumée: In general, the curriculum is customizable by teachers. This, however, does not mean that the teachers proceed in complete autonomy. A unitary ministerial framework that states the guidelines for the plan development is always outlined; each school can then adapt it according to the educational direction. Therefore, teachers can propose new activities or new subjects to the teaching council, develop projects and introduce "innovative teaching" courses. At ministerial level, there are platforms that support teachers' training with structured courses and that issue credits that encourage teachers to research and update themselves; these courses are not mandatory.

On the basis of specific projects proposed by schools, regional and / or European funding is provided to support the educational activity of the institutes through training and practical experiences.

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5. Citizen Science Skills

1 = strongly disagree, 5 = neither agree nor reject, 10 = totally agree

a. Interest in Science and Environment

Average Ratings are: Students 8.2 | | Teachers 8.3

Expert No. 1 states that students' interest in science and the environment is a necessary skill especially for first-year high school students. Furthermore, he says that scientific method and environmental issues should be of interest to all school curricula. He also states that teachers, in addition to having a strong interest in science and the environment, they must have a high level of competence to be able to teach certain topics.

Expert No. 2 underlines how for students a high awareness of an issue can be an incentive to the success of the related experience. On the other hand, from a teacher point of view, personal interest is obviously a good way to involve students in the learning process.

Expert No. 3 reports that interest in science and environment may not be strictly necessary, especially for disciplines not related to that educational sphere and, instead, it is more important for teachers who represent a guide for students.

Expert No. 4 affirms interest for the environment, on the student side, is sufficiently important. Teachers' side speaking, on the other hand, interest comes after the scientific component.

While most experts agree that interest is important for both students and teachers, expert No. 6 argues that competencies are also important for teachers while expert No. 7 affirms that, in order to convey interest for a particular subject, the teacher should be the first to be interested.

Resumée for the competence "Interest in Science Environment":

- They are very important to almost all respondents
- They can offer an incentive for students and teachers to participate
- They are not a substitute for teacher preparation

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b. Self-efficacy

Average Ratings are: Students 8.3 | | Teachers 8.0

Expert No. 1 reports that self-efficacy, in general, can be considered a typical transversal competence, that concerns multiple disciplines. It's an important topic at school, along with emotional skills. Apart from science, it is developed with exercise, probably more important than the previous one. Same thing can be said for teachers too.

According to experts No. 2 and 6, self-efficacy is linked to the character of each student, consequently some may have more than others. While, for the first expert, it is a fundamental component also for teachers, the second stresses how this is underestimated for teachers.

Expert No. 3 states that self-efficacy is linked to a more motivational approach for both students and teachers, but that it is slightly more important in teachers because they are guides for students.

For expert No. 4 self-efficacy is crucial for young people along with self-awareness, and for teachers it is important for the success of positive experiences. Finally, for the No. 8 expert this is not as important as the interest in science and the environment, but it is still an important feature for students, as a transversal soft-skill.

Resumée for the competence "Self-efficacy":

- Is considered a typical transversal competence that concerns multiple disciplines
- Is related to the character of individual and it's as important for students than for teachers
- Could be less relevant than the previous skill

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c. Motivation

Average Ratings are: Students 7.4 | | Teachers 7.4

According to expert No. 1, experiences can have value not only for orientation, therefore determining a direction for a possible future study path, but they can be central to the "vertical curriculum" issue which not only concerns the school but, also, other educational institutions. The same argues that experiences can have value in helping students' orientation.

Expert No. 2 states that the motivational aspect is not always central but depends, like self-efficacy, on the character of the individual. It is certainly a way of dealing with a problem from a more "mature" point of view. He also argues that a motivated teacher is certainly better performing than one who does his job only out of duty.

On the contrary, expert No. 7 states that motivation is derived. It is therefore stimulated by the first two skills, almost automatically. Motivation also arises from the stimuli due to doing something different from the usual routine, an act that is already stimulating in itself. According to expert No. 7, the same thing can also be said for teachers.

Finally, according to the expert No. 8, motivation is important for pupils but depends mainly on the ability of teachers to stimulate it or not in their students. He also reiterates that not all teachers are capable of transmitting and stimulating motivation in their students.

Resumée for the competence "Motivation":

- The rate is lower than the previous skills, both for students and teachers
- Could be dependent from the character of the individual, like the self-efficacy
- Can be derived, it arises from the stimuli of doing something new
- It depends from the teacher's skill of stimulate it in students

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d. Knowledge of the nature of science

Average Ratings are: Students 6.9 | | Teachers 7.1

Expert No. 2 states that knowledge of the nature of science is less important for students than other aspects, especially since the structuring of experiences is not students' responsibility but of teachers, who must certainly be more aware of the reasons some operations are planned in a certain way and, therefore, of a scientific process logic.

For expert No.4, meta-knowledge, or knowledge of knowledge, can be a valid support in motivating the choice of certain experiences such as, in this case, the experiments of Citizen Science. While for other experts it is not so crucial as knowledge can always be increased.

Resumée for the competence "Knowledge of the nature of science":

- Less important than other skills
- The rate is lower than the previous skills, both for students and teachers
- It's derived

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e. Data

Average Ratings are: Students 6.6 | | Teachers 7.1

If, according to expert No.1, data skills are "*considered important for the transverse nature of the analysis and the understanding of data*" (IT Nr. 1) with regards to students, he continues by stating that "*when ti comes to teachers, a proper use of data is fundamental, also in relation to the students evaluation process. The evaluation must be transparent with a verbal assessment associated with a score. Teachers are always required to continuously process data to monitor students' progress. A teacher who deals with data, in his own way, is involuntarily led to transfer it to all areas of work* "(IT Nr. 1).

For expert No.2, "*an awareness, although basic, of the nature of a data and of the importance of clear management, can be advantageous. More than anything else, a critical issue about when you are in positive or negative conditions for a right acquisition* "(IT No. 2). Furthermore, he says

that “*For the experiments to be successful, teachers must be aware of the limitations and deficiency of the students*” (IT No. 2).

If for expert No. 3 Data Skills "May not be required extreme specificity" for Students, No. 4 states that "It may not be the focus of the experiments, also because they may not be directly used or processed by the students" (IT No. 4-3).

Resumée for the “Data Competency”:

- Important to analyze, understand and manage data
- May be less important for student than for teacher who must process data

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f. Scientific Inquiry

Average Ratings are: Students 8.0 | | Teachers 8.3

According to expert No. 1 the evaluation of science inquiry, as a CS skill, is very high because *"it’s linked to the fact that children already approach starting from elementary school, obviously in a more or less complex way depending on the level of education. But the approach of "question" and curiosity is always used in the Italian school system*" (IT No. 1).

For expert No.6, the science inquiry "*It’s a competence included within the school program, with practical applications and synthesis of the data collected and analyzed*" (IT 6), and is considered "*more important than the data. Because in schools it is more important to produce things than to understand the result obtained. School is a passage, it does not have such a long-term structure that allows you to metabolize. In short, it is important to do things rather than analyze them*” (IT No.6).

Finally, for expert No. 8, science inquiry is complied by "*Teachers of scientific disciplines also through practical laboratory activities"*. (IT No.8)

Resumée for the competence “Scientific Inquiry”:

- They are already present in different STEM subject starting from the first school grades
- More important than data
- As important as Self-efficiency

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g. Responsible Citizenship

Average Ratings are: Students 9.2 | | Teachers 9.1

Expert No 1 states that since "*Social Studies has been reintroduced into the Italian school system, it is clear that responsible citizenship is an important competence in the regulatory framework*". While expert No. 2 underlines how responsible citizenship is "*close to the motivational concept, which can also be declined as "citizenship"*" (IT No. 2).

According to other interviewees, responsible citizenship "*Can help to teach the role in society*" (IE No. 3), is "*Related to motivation and awareness of the role of the citizen in society*" (IT No. 3). In addition, it is highlighted by the expert No. 4 that "*In learning processes, very often, an awareness that frames this process can be successful*" and that "*The same applies for teachers, perhaps to an even greater extent*" (IT No. 4).

Resumée for the competence "Responsible Citizenship":

- The higher rated skill, seems the most important for teachers and students
- It can teach the role of individuals in society
- It's important for teacher to act like a guide for pupils

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h. Basics Skills

Average Ratings are: Students 7.8 | | Teachers 9.1

According to interviewee No. 2 "*The generic acquisition of skills is always central. Thus, it can be an opportunity to fill gaps even in basic skills*" for students, while for teachers "*It can be an opportunity to focus on a strong structuring of basic skills*" (IT No.2).

Experts No. 3 and 4 consider Basics Skills to be "*a learning opportunity itself*" and "*necessary as a basic tool of inquiry*" for students (IT No. 3 - 4). Again expert No.4 argues that it is "*hard to believe that it can be demanded only from students and not teachers*".

Expert No. 7 does not consider them important because "*fortunately we are not in a situation of digital backwardness*" while he states that for teachers "*perhaps a little in-depth auto analysis is needed for them compared to students*" (IT No 7).

Finally, expert No. 8 underlines the importance of basic skills for "s*tudents of all school grades, especially up to eighth grade, as an evaluation criterion*" (IT No. 8).

Resumée for the competence "Basics Skills":

- It’s mostly taken for granted
- It’s always advisable to acquire a basic knowledge

I. Social Skills

Average Ratings are: Students 8.9 | | Teachers 8.5

On the student side, interviewee No. 1 argues that Social Skills play a fundamental role as "*Probably linked to the fact that I consider school a place for socialization, as soft-skill*" (IE No.1).

Expert No. 2 states that being Citizen Science projects "*activities that take place in groups, the ability to know how to relate*" assumes a central role, but he highlights that on the teaching side they could be "*Less important for teachers*" (IT No .2).

Expert No. 4 takes the opposite view and reports "*They are fundamental for teachers regardless of CS projects*" and agrees with colleagues for the student side, asserting "*The innovative teaching techniques claim that the ability to work in groups is fundamental*" (IT No.4). In addition, expert No. 3 defines Social Skills as "*First steps in interfacing with different environments*" (IT No.3.

Resumée for the competence “Social Skills”:

- One of the most important “soft-skill”
- Crucial for group activities

L. Additional Skills

Expert No.1 suggests an additional skill useful for CS projects, that is the ability of "Learning to Learn" asserting that "Meta-learning, or learning to learn, is a key competence of European citizenship supported by the bodies of the European Union" (IT No.1). In support of this thesis, the espert No. 7 argues that this ability "is part of our studies to become teachers and for updating", furthermore it states that "I think it is also important for professors" (IT No. 7).

Finally, the interviewee No4 suggests that there should be a "*friendly, “child-focused" and "H-focused" management of urban spaces, not only squares and green areas but roads and access to public places from offices to places of culture would be appropriate*” (IT No. 4).

Resumée

Citizen Science competencies of students:

Table 3 : Overview of the rated competencies (for students) by teachers

Competence	Value (Median)
Interest in science and the environment	8.2
Self-efficacy	8.3
Motivation	7.4
Knowledge of the nature of science	6.9
Data	6.6
Scientific Inquiry	8.0
Responsible citizenship	9.2
Basic digital knowledge	7.8
Social	8.9

Citizen Science competencies of teachers:

10 of the 14 competencies were considered as important (4), “knowledge of the nature of science”, “Motivation” and “responsible citizenship” as very important (5) and the competency “troubleshooting / problem solving” as unsure (3).

Table 4: Overview of the rated competencies (for teachers) by teachers

Competence	Value (Median)
Interest in science and the environment	8.3
Self-efficacy	8.0
Motivation	7.4
Knowledge of the nature of science	7.1
Data	7.1
Scientific inquiry	8.3

Responsible citizenship	9.1
Basic digital knowledge	9.1
Social	8.5

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9. Barriers and Interventions

What are the main barriers for incorporating CS in schools = Do you have ideas how to overcome those?

BARRIER	**INTERVENTION**
Lack of information and promotion "Even if the CS is not so much developed, teachers should be aware of it" (IE Nr. 1) **Poor attitude to cooperation** *"Lack of networking capabilities among schools to generate a virtuous exchange of good practices and collaboration for shared projects implementation "(IE Nr. 5)*	**More information for teachers and among teachers** **Networking** *"To favor non-competitive networking among schools for experience exchange and motivational approach fostering"* (IE Nr. 5)
Lack of specific training "*Lack of a preliminary training for teachers*" (IE Nr. 1 + 8) **Lack of competences and interest for research**(IE Nr. 3 + 4 + 10)	**Teachers' training** "*Specific training courses on specific topics, notions and skills would be necessary [...]. Most of the time teachers feel "alone" in their work and so difficulties show up. Call for interdepartmental team building could be useful*" (IE Nr. 2) "Training courses supporting the effectiveness of such actions for teachers; also benefits in terms of active involvement and critical

	thought evolution should be highlighted" (IE Nr. 3) **Mandatory educational updating** *"A new school reformation that update didactic plans, teaching courses and also school timetables* [...] *A mandatory training on new discipline"* (IE Nr. 8) **FabLab direct support as environment of innovative learning** *"Workshop and guided tours in Fablabs should be integrated into curricula"* (IE Nr. 4)
Lack of Resources (IE Nr. 1, 2, 3, 6, 7, 10)	**Synergy with academic and universitary research** *"A deeper synergy with universities could be imagined since the topic is so vast and interesting: generally universities are involved in "students' future orientation". Networking activities with universities could give an initial push."* (IE Nr. 1) *"One may think to structure vertical competent offices, acting on different educational grades, to look for national and european funds."* (IE Nr. 2) *"Out-of-curricula good structured courses, held with experts allowing teachers and pupils proper time and materials to perform a valid educational activity"* (IE Nr. 3) *"To organize round tables with university, schools and politic acting as stakeholder of these interactions."* (IE Nr. 6) **Specific funds for project development**
Lack of active involvement (IE Nr. 2)	**Creation of opportunities for discussion and involvement of citizens**

	Improved involvement in projects "*Projects with real outcomes, caring for motivational and citizenship aspects*" could be important" (IE Nr. 2) *"Involvement of political stakeholder in permanent assemblies or forums"* (IE Nr. 4) *"Networking between schools and associations, city quarters, initiatives such as "open schools" hosting open laboratories for analysis of daily usual activity with scientific approach."* (IE Nr. 5)
Lack of flexibility in updating school curricula (IE Nr. 6, 8, 9, 10) *"Poor flexibility in older teachers"* (IE Nr. 6) *"Poor flexibility and difficulties in integration and updatiing of older teachers" [...] "Many older teachers near to retirement with poor attitude to updating"* (IE Nr. 8) **Poor flexibility in institutional updating** (IE Nr. 7) **Poor motivational push in teachers** (IE Nr. 5)	**Creation of continuous updating opportunities** *"Possibility to insert compulsory professional training credits also for teachers, create specialized training and updating opportunities"*(IE Nr. 6) *"Necessity of creating external learning groups, different from standard school classes"* (IE Nr. 7) **Different teachers staff recruitment** *"Not our usual kind of competition "* (IE Nr. 8) **Thinking opportunities for teachers** Teachers should have more occasion to reflect "*to get better motivation, discover, investigate, re-think the main sense of their role, improve themselves*" (IE Nr. 5)
Lack of a needs global picture (IE Nr. 2) **Lack of data** (IE Nr. 6)	**Mapping of needs** *"Different teachers must highlight their own needs to work on"* (IE Nr. 2) **Sharing and data collecting opportunities creation** *"Sharing activities organized at a annual frequency during which a particular field for data collecting is defined and during which*

	roles of the activity are defined and in which is possible to discuss about results" (IE Nr. 6)
Lack of Adequate spaces (IE Nr. 5) School are often bad equipped regarding spaces for specific projects (such as laboratories)	**Actions on school buildings** An appropriate institutional scheduling for "school buildings (e.g. "*Creation of external open spaces where to perform laboratory activities*") (IE Nr. 5)

Resumée:

Barriers:

The following barriers were identified through the interviews:

- Lack of information and promotion (IT 1)
- Poor attitude to cooperation (IT 5)
- Lack of specific training (IT 1, 8)
- Lack of competences and interest for research (IT 2, 3, 4, 10)
- Lack of Resources (IT 1, 2, 3, 6, 7, 10)
- Lack of active involvement (IT 2)
- Lack of flexibility in updating school curricula (IT 6, 7, 8, 9, 10)
- Poor motivational push in teachers (IT 5)
- Lack of data (IT 2, 6)
- Lack of Adequate spaces (IT 5)

Interventions:

The following interventions were identified through the interviews:

- Intervention against the barriers "lack of information and promotion" and "low attitude to collaboration (IT 1, 5)
    - Increased information among and for teachers (IT 1)
    - School networking (IT 5)
- Interventions against the barrier "lack of specific training for teachers" (IT 1, 8)
    - Training courses
    - New school reform for mandatory disciplinary update
- Intervention against the barrier "lack of competencies and interesting in scientific research"(IT 2, 3, 4, 10)
    - Updating courses on specific topics, content and skills

    - Interdepartmental university teams
    - Active support of fablabs as innovative learning environments
- Intervention against the barrier “lack of resources”
    - Synergy with the world of academia and research
    - Specific offices responsible for the acquisition of funds
    - Structured training courses and extracurricular projects
    - Workshop between universities, schools and politics

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10. Needs

a. Do you think that CS could be a helpful practice / tool to be used in grades 5-9 in science subjects?

All respondents said yes. Expert No. 2 adds: "I believe that CS is not only useful for grades 5-9, but can be a useful tool also for various university courses, such as engineering and architecture departments" (IE No.2).

b. In which subjects would you see most potential?

Expert No. 1 states that the subjects in which he finds CS methodologies most useful are "Without any doubt in the scientific and specific subjects: scientific, because they represent the investigated field; specific because they could be useful for the school. Nevertheless, they could find application in disciplines of general education. Once known, CS is a really interesting topic” (IE No.1).

Expert No. 2 agrees with the previous colleague and adds "I would see the potential especially in the subjects for master's degrees of university courses. CS could help the student to mature his own professional mindset by helping him to apply his knowledge in projects whose objectives would have a strong social impact ”(IE No. 2).

Expert No. 5 argues that he sees potential for CS methodology "Certainly in scientific subjects such as natural sciences, geography, mathematics, chemistry, physics, technology, mechanics, mechatronics, computer science, astrophysics. But also subjects such as archeology could have great potential for development. Geology, sciences supporting historical research, sociology, psychology. Not to underestimate those areas closest to daily life, for example the

waste cycle, ecology, knowledge of food and the human body, nutrition, biology, flora and fauna, territory and knowledge of its essential elements. " (IE No. 5)

Other subjects mentioned are:

Mathematics (IE No. 6-7-8), Biology (IE No. 3-6-10), Technology (IE No. 3-4-6-8-9), Physics (IE No. 3-6), Earth Sciences (IE No.3-6-8-9-10), Citizenship and Legality (IE No. 3-4-6), Environmental Education (IE No. 6-10), Geo-history (IE No.3) , Sociology (IE No. 3), Geography (IE No.9-10)

Resumée:

The most potential is seen in the following subjects:

- STEM subjects:
    - natural sciences
    - Earth science
    - biology
    - chemistry
    - physics
    - mathematics
    - physics
    - technology
    - computer science
    - geology
    - mechanic and mechatronics
    - astrophysics
- NON-STEM subjects:
    - geography
    - social theory / social sciences
    - arts
    - archeology
    - history
    - sociology
- Other answers
    - citizenship and legality
    - environmental education
    - ecology and waste cycle
    - human body

- education of food and nutrition

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c. What do the schools and educators need?

Most of the interviewees agree on the need for skilled training for teachers, particularly also with "*tools and guides for operational activities*" (IE Nr. 4) or "*new training plans oriented in this direction*" (IE Nr. 5). Training that can also come from companies and consultants beyond the school world, as Expert No. 6 points out: "*It would be important to create a more direct link between schools, universities and scientific research with the world of work and business.* [...] *to generate with students skills that are immediately usable in future practice*".

In particular, Expert No. 1 also emphasizes the importance of information before training, "*through informative workshops [...] we start with information and then confront the promoters of the initiatives*".

Expert No. 2 also brings out the need for a basic organized structure, with competent offices to which to turn to support projects or activities and to raise funds for their development. "*The university would need a network of coordination and cooperation with all the other realities involved (Companies in the area, schools, public administrations)*".

"*Rediscovering teachers' motivation*" (IE No. 5), a very important aspect is therefore the motivational drive and suitable inputs to increase awareness of their role as educators. "*Schools and educators would need more virtuous examples to make use of that can fire up in them the desire to get involved and create something innovative, suitable spaces to carry out co-working activities, dynamic and engaging staff*". (IE No. 3). Of the same opinion are Experts No. 5 and 8 who agree on the opportunity to have appropriate laboratories, facilities and tools for project development. "*Available spaces and facilities, wealth of tools, resources for instrumental equipment suited to the development of projects. [...] Exchanges and examples of good practices and twinning work*" (IE No. 5). Added to this is the need for the right funding, as is clear from IE No. 2, 8, 9 and 10.

d. What would the students need?

"*Students would need technological and economic resources. Public and private must open their doors to students during their university projects. Students must be seen as a fundamental resource to catalyze progress not only technological and economic, but above all social. They*

must be able to study and be able to respond to the needs of the local area". (IE No. 2). Of the same opinion are Expert No. 10 and Expert No. 5 who, in particular, emphasizes the need for an educational offer closer to the students to make them protagonists of experiential paths: "*Starting from the needs and interests of the students to motivate them in the educational path, make them actors and curious to lead exciting projects*." (IE No. 5).
In fact, almost all interviewees agree that providing students with hands-on experiences and workshop activities is a starting point to encourage learning. (IE No. 1, 4, 7, 8, 9).

An important aspect for students is also the role of the teacher (IE No. 3, 8, 10), Expert No. 3 in fact states that "*students need motivated teachers and companies",* as does Expert No. 8: *"the teacher is the motivational lever*".

Finally, Expert No. 6 points out the importance of listening and sharing "*for example, through questionnaires of teaching satisfaction or opportunities to share the teaching process and curricula*".

Resumée of the needs

- Hardware/ Software/ IT infrastructure
- staff support from university
- Networking and sharing
- material and resources
- Specific trainings
- Coworking spaces
- listen and share
- Dynamic input
- Hands-on projects
- Funds dedicated to project development
- updated training plans

2.6 Country results: Lithuania

Description of the results from the interviews about citizen science

Interview transcripts (in Lithuanian) can be found in this document:
https://docs.google.com/document/d/1nZqd3tVf3c_XIuL-V7yguPV7KN8F8VY3nevbZeZrWVw/edit

1. **Experience with CS-projects**

a. Opinion about CS-projects / Experience

Citizen Science is a rarely encountered topic in the Lithuanian educational system. There are some initiatives of individual institutions and educators. But the national-level strategic documents do not mention CS or any related activities. More focus is given to STEAM education and its integration into educational programmes. Such context makes it difficult to research the opinion and experience of Citizen Science. Nevertheless, some teachers are conducting experiments and collecting data with students but are not defining it as Citizen Science.

b. Examples citizen science project

Some projects could be positioned as CS projects in media science. During Vilnius Lights' Festival different schools made installations and analysed numbers of visitors that came to see them.

Couple examples of activities similar to CS were mentioned during the interviews

- The most detailed was the analysis of participation with lighting installations at Vilnius Lights' Festival. "*And one example from the subject of the media - I could remember - we had purposefully done the statistical analysis - I had forgotten. Somehow I changed my mind. And I remembered. We participated in the Vilnius Lights' festival last year. In January and with the students, we did a school lighting installation in the courtyard. [because of installations] visitors had to enter the yard. People there could try different sensations, sensory media were created. And different students I asked to be at a certain place and count how many people can experience the installations during 10 minutes. Since this is an international event and the numbers of people are very high, we cannot constantly monitor the process that has been showing the installations for 3 days. Occasionally we measured the number of people entering every 10 minutes and the students kept those statistics. Well, here they are so directly. We add to the collection whether or not those numbers are generalizations by that quantity.*" (LT4). Although the

analysis was not the focus of this activity, still it allows to position this project as CS in media science.
- In addition, research of their family trees through professional point of view was a regular activity in school (LT4, LT6)

c. Experience with citizen science at schools

Majority of the interviewees state they do not have experience with citizen science at school. The only exception was the teacher, relating CS to the subject she teaches: *"Officially no. We don't have such terminology, but I think it's close to methodology. Personally I teach business from 5th grade. In part of the course students produce real products (so I think it's very close to CS)"* (LT3)

Resumée: Majority of interviewees could not relate any of their activities to CS. Although they are interested they doubt that researchers would see interaction with schoolchildren as useful, as well as they see lack of motivation on students' side, while teachers themselves would like to be involved.

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2. CS curriculum at schools

Although contemporary understanding about CS and STEAM suggests that CS activities are natural components of school curriculum, the majority of interviewees do not see it as such. This is because such activities are not considered mandatory in the national educational system (LT2: *"The Kaunas University of Technology has a FabLab laboratory, which is used to diversify students' research activities. There is also a mobile laboratory and a student technical creation center in Vilnius, which also create conditions for students' research activities, but they focus on more motivated students. This is not compulsory under the national concept of education"*).

However, some interview participants see ways of integrating CS into curricula. Mostly through integration between scientific and social sciences school curricula: "*We use integrated lesson models between different subjects: chemistry and business, and etc. As I mentioned before, I think some schools have some integrated subjects not just on paper*" (LT3). Interviewees see possibilities in scientific activities in different subjects, however, they more see possibilities of that in natural sciences curricula (eg., LT5, LT6).

According to all interviewed participants CS projects are difficult to implement in Lithuanian schools. Interview participants listed few possible reasons for that:

- Limited knowledge of what Citizen Science is and how to conduct experiments, research or data collection activities together with students > "*I don't have CS experience*" (e.g. LT1, LT2, LT3). High positioning of science and lack of imagination about what can

schoolchildren do, shapes this understanding about CS: "*Could activities with schools be interesting for researchers?*" (LT4);

- Limited time resources to conduct innovative activities such as Citizen Science (LT4, LT5) due to bureaucratic requirements of the system and workload of the teachers;
- Limited motivation to use innovative teaching methods (LT7: "It depends on the teacher's own enthusiasm. And then it is possible to ignite others with this desire and aspiration"; R28: "It depends on the teacher what topic they want to take, as far as it relates to their subject, how much they want to do, how not ");
- Mistrust of their level of scientific literacy (LT7, LT1);
- Lack of motivation of students to participate in extracurricular activities (LT7);
- Costs of implementation (LT1: "*I think we need to get more access to more diverse materials and sources of knowledge. The sources of good quality nowadays are fragmented and very expensive. This makes it more difficult to integrate different subjects, use an interdisciplinary approach, and make lesson content more relevant. Speaking from the standpoint of Social Studies, it would be great to have access to many movies, TV series, documentaries, etc. Moreover, it would be great to have programs, apps that could help us easily and use as little time as possible to cut movie scenes and modify videos in other useful ways"*);
- Already 'crowded' curricula (LT2: "*The content of the national program is very crowded, the teacher has to go to a different topic every lesson, because otherwise the program will not complete in a year. There is no possibility to apply it freely. The curricula of all subjects are crowded, students learn a lot of subjects, and there is almost no time for mastering and deepening.*")

Resumée: Citizen Science is considered an extracurricular activity in Lithuanian educational system. However STEAM approach is existing, although interviewees do not match both and rather see possibilities in implementation of CS in their subjects, but technical and financial support is needed.

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3. Data science in the curriculum

All interview participants see data acquisition, analysis, interpretation and ethics as essential and possible in each subject. Exception – curricula in the humanities field. In this field teachers do not see such possibilities (LT8). All interviewees mentioned data ethics in their discussion. However collected data was rather statistical, not disclosing personal data, so was not mentioned as a key issue (LT4). Media curricula taught at school focus on media creation, but data acquisition, analysis and interpretation is not seen as easily integrated due to lack of students' motivation (LT7).

Most frequently it is just stated that in school projects students have to collect, analyse and interpret data. Organized data science usually is not part of curricula. "*In our school we have*

project hour 1/per week and 5 long term projects (each lasting 6 weeks) . These projects include at least 3 subjects. Students have to find the problem, make research, analyse the data, and interpret results)" (LT3).

Data science is touched on topics about private data and data analytics (LT1: "*We used to discuss ways in which social media or data analytics changed the nature of politics and police work. We discussed the perils of someone having a monopoly in personal data. We draw historical analogies between the contemporary data related problems and authoritarian regimes in the past (History class). Theory of Knowledge (ToK) offers an optional theme 'Technology and Knowledge' where similar topics are discussed. The implications such as fake news, post-truth age are also covered in ToK. So roughly speaking the subjects in which we cover these topics are: ethics, history, and ToK").*

Resumée: Data science competences can be integrated in the majority of subjects, there are no official, national requirements to do that. Hence, the motivation to do so is limited.

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4. Support for teachers

In discussion on how teachers could be assisted in introducing Citizen Science activities in their subjects' curricula, few possible support tools were mentioned:

- Teachers do not know where or how they could get help: (LT8: *"…not very easy to get some help. Somehow we have a teacher to do everything here. Find that material yourself. Develop methodological tools for analysis. There is no such thing. For the time being, most of the weekend has to be prepared by him*"). Especially with the introduction of new study contents (LT4: "*it is up to the teacher, the teacher to come up with. Well, yet to discover who will approve, approve, whether there is any possibility that someone helps*");
- New topics are not even associated as possible to search for help (LT4: "*The counseling line might be the Ministry of Education or something else. It is this primarily looking for perhaps the closest people in the circle one knows. <…> Maybe a methodological group. If there is such a thing");*
- Usually help in the process is associated with interaction with other teachers (LT3: "*At first teachers of all subjects have to communicate with each other, it is not enough just to teach the subject program.*")

The availability of resources is only one part of the problem. In most cases, the educators do not try to search for help and work within inner circles at school (LT6: "*It's hard to prepare right away. Are we absolute pioneers? And I think if you already communicate with Donatas, you really know a lot - he told me everything. I started the social media thing myself from the fact that I came up with topics for myself. I chose which topics are, in my opinion, for me personally*

first the ones I want to teach and we are still with the kids. The first week we met, we put together the topics I suggested because the topic of social media and overall is very big. Here we chose what we wanted to do first, and then I personally supported both English, American, and universities. There are a few things on social media, namely that content and we then tried to adapt to school basically what we were doing. It was a complete absolute experiment").

Resumée:

New subjects are difficult to introduce. It may not be made by the teacher him/her-self. If a school decides to make a new profile – in one of the analyzed cases the school became the first media school in Lithuania – it is really difficult. School has made methodological materials, prepared everything, and then found evaluators. Teachers had to prepare everything by themselves. Due to a good connection to VilniusTECH, teachers had support and help from university.

2.7 Analysis

Key findings (across countries - use these three questions)

How can the integration of CS can be **facilitated**? **Recommendations** regarding integration about citizen science

- Project courses (DE4)
- Advanced course subjects (DE2)
- Integration in STEM-subjects (DE1,DE5, DE6, DE9, IT1 to 10, LT1 to 8, EL1, EL2)
- Integration in non-STEM /various subjects (DE3, DE5, DE6, DE8, IT3, IT7, LT4, LT8, EL1)
- Extracurricular places of learning (DE7, IT3, EL1, EL2)
- Youth competitions (DE4)
- Use the special column in curricula for integrating CS (DE7)
- Integrate CS projects in higher grades than 5-9 (IT2, IT7)
- Implement CS in school curriculum (IT 1 to 10)
- Form (Train) Teachers with courses and workshops about CS (IT1, IT2, IT3, IT6, IT7, IT10)
- Curriculum should be freely adaptable with unscheduled experiences (IT2, IT3, IT4)
- Allocates funds for CS (IT2, IT7, IT10, LT4, LT7)
- Allocate spaces, structures and tools dedicated to CS projects (IT5, IT7, IT10, LT3-7)
- Organize awareness raising activities (trainings, seminars) for the teachers to learn about Citizen Science (LT7)

Which CS-projects are already conducted at school?

- Conduction of projects which are closely related to citizen science (DE1,2,4,7)
    - Hydric power plant project (DE2)
    - Jugend forscht - competition in Germany
- Plastic pirates (DE5, DE11)
- Measuring box and stratosphere balloon (DE1)
- Preservation and spread seeds of traditional vegetable varieties (EL8)
- Deploying CS as a method to implicate students in BigO project (https://bigoprogram.eu/) (EL9 & EL10)

How is the experience with Citizen Science?

- Some experience with citizen science projects (DE3, DE8, DE5)
- Teachers who already have got conducted projects closely related to citizen science projects (DE1, DE2, DE4, IT5, IT10)
- Interest in conducting a citizen science project (DE2, DE5, DE7)
- No experience in citizen science projects (DE6, DE9, IT1 to 4 and 6 to 9, LT 1 to 7)
- Some personal experience with CS but not in the school context (EL1, EL2, EL4, EL5).
- Preservation and spread seeds of traditional vegetable varieties (EL8)
- Deploying CS as a method to implicate students in BigO project (https://bigoprogram.eu/) (EL9 & EL10)

Curricula (CS and data science - 1 or two sentences per country if CS / DS is established at schools)

Curricula CS (integrated yes/no)

- There is no curricula for CS actually (DE1,DE3,DE5,DE6,DE7,DE8,DE9, IT4, IT6, IT7, IT 8, IT9, LT 1 to 7, EL1 to EL10)
- Not sure (DE3, IT1, IT2, IT3, IT10, EL1)
- There is a generic invitation to promote the scientific knowledge, data collection, ad generic research approach (IT5)

Curricula CS (where could it be integrated and added to some other subjects (e.g. non-STEM subjects which are not related)

- University Curriculum (IT2)
- non-STEM subjects (IT3, IT4)

Curricula data science (integrated yes/no)

- Not sure about it (DE1, IT10, EL1)
- There are data science concepts in STEM-subjects (DE2,DE3,DE5, DE8,DE9, IT1, IT2,)
- Concepts in non-STEM-subjects like history (DE9, DE2)
- Concepts in project courses and competitions and technical orientated schools (DE4, DE7, DE8, IT3, IT6)
- No (IT4, IT5, IT7, IT8, IT9), No (LT1 to 7)
- There are some concepts in Maths, Statistics (EL2, EL3, EL4, EL6)

- No (EL1, EL9, EL10)

Curricula data science (where could it be integrated and added to some other subjects (e.g. non-STEM subjects which are not related)

- Different possibilities (DE1)
- Geography and physics (DE1)
- Mathematics / computer science classes(DE2, DE8)
- Social Health, Human Sciences and Psychology (IT1, IT3)
- In STEM as well as non-STEM subjects (EL1 to EL10)

Summary of requirements

Support for teachers

- Not sure if the teachers get support (DE3, LT4, LT7, IT6, IT8, IT9, IT10)
- Support for teachers depends on the school (DE4, EL1)
- Teachers help each others (DE9, LT3)
- Support through educational days (DE1, IT3)
- School autonomy (Autonomia Scolastica) provides that teachers can freely introduce new topics, which facilitates their choices (IT1, IT2, IT3)
- Online courses platforms (eg. S.O.F.I.A.) (IT7)
- No support (IT4, IT5)

Possible adaption of the curriculum

- Not much leeway / very limited(DE1,6, 9, LT2)
- Small numbers of supplementary hours which makes the adaption possible (DE 7)
- Depends on the school (DE5)
- Matter of interpretation how it is done at school and depends on the teachers (DE8, LT4)
- Within the differentiation areas and the electives there is more flexibility (DE4)
- Curriculums can be freely adapted within guidelines set by MIUR (ministry of education) (IT1, IT2, IT5, IT6, IT7, IT8, IT9)
- Not sure (IT3, IT10)
- Experimental and private schools provide more room for adaptation (EL1, EL9, EL10)
- Primary level allows more flexibility than secondary level courses

Education, monetary support or other groups

- Not known (DE1, DE6, LT4, LT7, IT6, IT9, IT10)
- Certificate courses (DE2)
- Training programmes for the changeover to G9 (DE2)
- For new topics are provided educational materials (DE9)
- Financial support from the school booster’s club (DE7)
- Raise third-party funds (DE7)
- School-budget (DE5)
- Personal bonus for training courses and materials (IT1, IT2, IT4, IT5, IT8)
- No education, monetary support or support groups (IT3, IT7)

Summary of competencies (use this structure)

The following Citizen Science competencies were ranked as very important (5) (9-10 IT) for students:

- Self-efficacy (DE)
- Data competency (DE)
- Basic digital knowledge (DE, LT)
- Scientific inquiry skills (DE)
- Responsible Citizenship (IT)
- Motivation (LT)

The following Citizen Science competencies were ranked as important (4) (7-8 IT) for students:

- Interest in science and the environment (DE, IT)
- Motivation (DE, IT)
- Knowledge of the nature of science (DE)
- Responsible citizenship (DE)
- Social competence (DE, IT, LT)
- Economic, moral and ethical aspects of science (DE)
- Troubleshooting (DE, LT)
- Knowledge of scientific concepts (DE)
- Knowledge of the strengths and limits of science and technology (DE, LT)
- Self-efficacy (IT)
- Scientific inquiry skills (IT)
- Basics Skills (IT)

The following Citizen Science competencies were ranked as neutral (neither agree or reject)(3) (5-6 IT) for students:

- Explaining scientific phenomena and predicting changes (DE, LT)
- Knowledge of the nature of science (IT, LT)
- Data competency (IT, LT)
- Knowledge of scientific concepts (LT)
- Scientific inquiry skills (LT)
- Responsible citizenship (LT)
- Interest in science and the environment (LT)

The following Citizen Science competencies were ranked as very important (5) (9-10 IT) for teachers:

- Motivation (DE, LT)
- Knowledge of the nature of science (DE, LT)
- Responsible citizenship (DE, IT)
- Basics Skills (IT)
- Interest in science and environment (LT)
- Knowledge of scientific concepts (LT)

- Basic digital knowledge (LT)
- Scientific inquiry skills (LT)

The following Citizen Science competencies were ranked as important (4) (7-8 IT) for students:

- Interest in science and the environment (DE, IT)
- Self-efficacy (DE, IT)
- Data competency (DE, IT)
- Scientific inquiry skills (DE, IT)
- Basic digital knowledge (DE, LT)
- Social competence (DE, IT, LT)
- Economic, moral and ethical aspects of science (DE)
- Knowledge of scientific concepts (DE, LT)
- Explaining scientific phenomena and predicting changes (DE, LT)
- Knowledge of the strengths and limits of science and technology (DE, LT)
- Motivation (IT)
- Knowledge of the nature of science (IT)
- Data (LT)
- Troubleshooting (LT)

The following Citizen Science competencies were ranked as neutral (neither agree or reject)(3) (5-6 IT) for teachers:

- Troubleshooting (DE)
- Self-efficacy (LT)
- Responsible citizenship (LT)
- Economic, moral and ethical aspects of science (LT)

Summary of barriers and interventions (use this structure)

Also mark with barriers are mentioned in the literature and which not

The following **barriers** were identified through the interviews:

- Rigid curriculum (DE1,DE5,DE7, DE3, DE6, LT1, LT3, LT6)
- Presence of the topic (DE1,DE3)
- High workload / occupancy of teachers (DE1,DE2,DE5, L1-L7)
- Establish the projects long-term (DE2)
- Lack of finances / sponsoring (DE2,DE5,DE7, IT6, IT8, IT10, LT2, LT3, LT4)
- Time aspect (of teachers) (DE2,DE5,DE7, LT1, LT2, LT3, LT7)
- Motivation of teachers (DE5, IT2, IT5, IT6, LT2, LT3, LT4)
- Location of schools (DE7)
- Establish contact to schools / finding the “right partner”(DE4, DE8, IT5)
- Linguistic barrier (DE8)
- Long term duration of projects (motivating the students long term) (DE8)
- (Missing) interest among the staff (DE6)
- Timeframe for conducting CS-projects (DE9)

- Coordination needed with school management (DE8)
- Lack of information about CS (IT1, IT2, LT2, LT1-7)
- Lack of resources (IT1, IT2, IT3, IT7, LT7)
- Missing requirements (IT2)
- Missing interest in Scientific Projects (IT3, IT4)
- Teachers' competencies (IT3, IT8, IT10, LT4, LT5)
- Lack of data sharing (IT6)
- Bureaucratic and institutional complexities (IT7, LT3, LT4, LT5)

Interventions:

The following interventions were identified through the interviews:

- Intervention against the barrier "rigid curriculum" (DE1,DE5,DE7,DE3,DE6)
  - good argumentation needed / concrete project list with fitting competencies (which competencies can be learned in the CS project and how does it fit to curricula) (DE1)
  - compulsory elective / differentiation areas- still freedom (DE5,DE7)
  - use the supplementary lesson areas (DE)
  - use the option of AG / working-groups offers (DE7)
  - need motivated teachers (DE3)
  - shorten the curriculum (DE6)
  - integrate CS into internal curriculum (E9)
- Interventions against the barrier "presence of the topic" (DE1, DE3)
  - conduct project days (DE1)
  - use initiatives to bring this topic to society (DE3)
  - bring sth to society (E3)
- Intervention against the barrier "high occupancy for teachers"(DE1,DE2,DE5)
  - Make the connection clear between citizen science projects and the possible achievable competencies (DE2)
  - Make things easy for the volunteers / teachers (DE3, LT3, LT5)
- Intervention against the barrier "establish the projects long term
  - Make binding agreements: "cooperation agreements" (DE 2)
- Intervention against lack of finances / sponsoring (DE2, DE5, DE7, IT6, IT8, IT10)
  - Integration into the lessons (DE2)
  - Organize round-table meeting with schools and politics to catch interest on the subject (IT6)
  - School system reform to update lessons, schedules and curriculums (IT8)
- Intervention against time aspect (of teachers) (DE2,DE5,DE7)
  - Academic staff who could support with manpower (DE2)
- Intervention against Motivation of teachers (DE5, IT2, IT5, IT6)
  - /
  - Work on projects with concrete objectives, to push motivation (IT2)
  - Gap year for teachers to refresh motivation, attention to the subjects, sense of the profession (IT5)
  - Mandatory training credits also for teachers (IT6)
- Intervention against Location of schools (DE7)
  - /

- Intervention against Establish contact to schools / finding the “right partner”(DE4,8, IT5)
    - Linking science and schools, establish contact (DE4, DE8, IT5)
- Intervention against linguistic barrier (DE8)
    - Language has to be simplified → one level linguistic adaptation and communication - addressing (DENr. 8)
- Intervention against Long term duration of projects (motivating the students long-term) (DE8)
    - Get on board at an early stage to deal with the time aspect. (DE8)
- Intervention against (Missing) interest among the staff(DE6)
    - Direct advertising to the teachers (DE6)
    - Notification through clubs / circular emails (DE6)
- Intervention against Timeframe for conducting CS-projects (DE9)
    - Use project weeks (DE9)
- Intervention against Coordination needed with school management (DE8)
    - /
- Intervention against “Lack of informations about CS” (IT1, IT2)
    - Refresher training courses for teachers that provide informations on the specific topic (IT1, IT2, IT3)
- Intervention against “Lack of resources” (IT1, IT2, IT3)
    - Create a network between schools to collaborate and share informations (IT1)
    - Create relevant offices in education, European tenders, funds acquisition (IT2)
    - Extracurricular projects taught by external expert, providing information and materials required to develop educational paths (IT3)
- Intervention against “Missing requirements” (IT2)
    - Interested parties should express how many and which requirements are missing (IT2)
- Intervention against “Missing interest in Scientific Projects” (IT3, IT4)
    - Guided tours of Fablabs integrated in Shool’s Curriculums (IT4)
- Intervention against “Teachers’ competencies” (IT3, IT8, IT10)
    - Training courses (IT3)
    - New ways to recruit teachers (IT8)
- Intervention against “Lack of data sharing” (IT6)
    - Annual meeting to share data on a particular field, to analyze and comment them during round-tables (IT6)
- Intervention against “Bureaucratic and institutional complexities (IT7)
    - Facilitate procedures for teachers to facilitate the insertions of new lessons (IT7)
- Intervention against lack of training “Teachers training and support is requested by EL experts. More specifically:
        - Workshops for school leaders/Training workshops/material
        - University courses, Formal CPD courses Organization of MOOCs
        - Make CS easier for teachers/students
    - The need of opening up the schools/Intervention against time limitations was mentioned:
        - Common projects hours for teachers of different specialties
        - Connection of the school with the society and all the involved stakeholders; Open Schools to society; Initiating partnerships and collaborations; Transforming schools into Labs that will contribute to

society and CS projects; Meetings with the school community about the school
    - Intervention against lack of vision/motivation:
        - Strong Leadership and vision for the school
    - Intervention against lack of resources:
        - Participating in ERASMUS+ projects
        - Getting funded from relevant to the CS project institutions

Summary of needs / teacher support (same structure of barriers and interventions)

- Hardware/ software/ IT infrastructure (DE1, DE5, IT5)
- Project ideas (DE2)
- Staff support from university (DE2)
- Material and explanation videos and good instructions (DE3,8, LT1-7, IT1, IT4, IT7, IT8, IT9, IT10)
- Funds dedicated to education (IT2, IT5, IT9, IT10)
- Improve network between Schools, public administration and private enterprises (IT2, IT6)
- Spaces dedicated to co-working (IT3, IT5, IT8)

- Incentives / recognition (EL)
- Institutional support (to teachers) (EL)

Country specific aspects

Germany:

In Germany exist the following country-specific aspects:

- Different types at school
    - Secondary school (Hauptschule)
    - Secondary school (Realschule
    - Comprehensive school (Gesamtschule)
    - Grammar school (Gymnasium)
- Project days at grammar schools
    - At schools can be conducted project days or excursions. How many projects are available, depends on the grades and the school. (DE1)
- Differentiation area / elective subjects
    - “In the compulsory elective classes of grades 9 and 10 at the Gymnasium with a nine-year course of education and of grades 8 and 9 at the Gymnasium with an eight-year course of education, the school offers at least one third foreign language and the subject computer science or a subject combination with computer science. In addition, it may offer all other subjects or subject combinations provided for in the Education and Examination Regulations for Secondary Level I (APO-SI) and the

Gymnasiale Oberstufe (upper school).” (Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen 2021)

- Project courses and technical paper(“Facharbeiten”) in Q1(grammar / upper school)
    - “Project courses consists of two consecutive half-year courses”
    - “The Facharbeit (technical paper) is a comprehensive written assignment that must be written independently. The aim of the subject-specific paper is to write an exemplary scientific paper” (Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen 2021)
- Supplementary hours (grammar school) (DE7)
    - *Supplementary lessons are primarily used to intensify the individual promotion of competences in German, mathematics, foreign languages or in the natural sciences, especially if a repeat class or a change of school type can be avoided. In addition, schools can use supplementary hours for profile building and other school-based offers. Of the supplementary lessons provided for in the timetable, eight lessons are not compulsory for all pupils at the Gymnasium with a nine-year course of education, and five lessons at the Gymnasium with an eight-year course of education. The school conference decides on a concept for the use of the supplementary lessons on the proposal of the headmaster or headmistress*.” (Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen 2021)

Italy

In Italy exist the following country-specific aspects:

- In Italy, citizen science has not yet spread as an educational practice in schools
- School autonomy allows teachers to integrate citizen science projects into school curricula
- Lack of funding for teacher training and an overly complex bureaucratic system

Lithuania:

- Different types of schools (primary, secondary and high-school)
- Private schools (especially in main cities) are more open to collaborations and introduction of innovative teaching methods
- Lack of funding and a lot of bureaucracy

Greece:

- CS is not integrated in the curriculum; data science concepts are not formally integrated in the curriculum too (aspects in secondary schools)
- Private and experimental schools allow more room for flexibility and are more open to collaborations and introduction of innovative teaching methods
- Lack of funding and teachers’ support

3 Implications and Recommendations

The provided competency list composed from scientific literacy, citizen science and data literacy is a good starting point for developing citizen science learning scenarios as most of the competencies were ranked as important and as very important.
Additionally identified competencies were “understanding the logic of science” and “critical reflection” (DE). These competencies will be added to the competency map.
The central role of technology runs parallel to data science competencies issues. Teachers consider digital knowledge more important for themselves than for pupils (IT). This aspect seems important because it can identify the “computational thinking” as a key-competence instead of the mere proper usage of technology, that can be considered as functional skill acquirable also in older age.

- **Barriers / interventions**

The interventions differ among the countries as there are different opportunities in the countries. Furthermore, the **following principles / implications** for CS-projects can be defined:

- **Make things easy** for the participating teachers by preparing the lessons and learning scenarios well to draw a clear connection between the achievable citizen science competencies and the competencies of the curriculum (DE, LT).
- **Make binding agreements:** Make binding agreements between the university and the schools so that a citizen science course can be established long-term (DE).
- **Use initiatives** to bring citizen science to the society (DE)
- **Use the compulsory electives, supplementary lessons areas** and a concrete project list with fitting competencies (DE)
- **Establish contac**t: Approach to link schools with science and to establish contact (DE / IT)
- **Use simple language**: Adaption of the linguistic level. Use simple language (DE)
- **Get in touch with the teachers,** do advertising and use circular emails (DE, LT)
- **Use project weeks and project days** doing citizen science projects (DE)
- **Shorten or adapt the curriculum** (DE)
- **Not only computers or smartphones:** provide project documentation and design projects and scenarios that can be performed also without computers or smartphones (IT).
- **Involve public institutions:** inviting public institutions to support and sponsor CS knowledge and to organize informative open-days activities for schools and citizens (IT).
- **Lead Activities:** a bigger “institutional-transversal” group (with Universities in leading position) can help to program long-term projects (IT).
- Prepare **introductory material to CS** in the national language as not too many teachers have a working knowledge of the concept and processes involved (LT, EL).
- **Workshops for school leaders & Training workshops & supporting materials:** are mentioned in several occasions (EL01, EL03, EL04 EL06, EL07,
- **Linking with the curriculum** is also mentioned since CS in not existing in the curriculum (EL02, EL08)

- **Incentives / recognition** are also mentioned (EL01, EL08) and that **CS needs to be captivating/generate curiosity in students.**

Furthermore, interventions against the barriers “location of schools” and motivation of teachers should be further researched and defined as no proposition of the teachers was provided for these barriers (DE).

- **Support needs**

The following implications for the support needs can be defined:

- **Academic staff:** Support the schools by providing academic staff who can support with manpower (DE, LT)
- **Material**: Explanation videos, well-prepared materials and good and easy instructions (DE)
- **Project ideas:** Provide project ideas (DE, LT)
- **IT infrastructure**: Provide hardware, software and WIFI
- **Preliminary Information**: Informative Workshops (IT)
- **Specific trainings:** for teachers (IT, LT)
- **High level involvement**: teachers motivation must be driven from institutional and administrative involvement (IT)
- **Funding**: specific funds (such as National Operativ Programs - PON) can increase activities quality (IT).
- **Trainings (or any other support) in how to motivate students** to participate in innovative activities (LT).

● Workshops for school leaders & Training workshops & supporting materials: are mentioned in several occasions (EL01, EL03, EL04 EL06, EL07,
● Linking with the curriculum is also mentioned since CS in not existing in the curriculum (EL02, EL08)

- **Recommendations for the pilots**

Implications of the design of the learning scenarios:

- Develop learning scenarios which can be conducted within a project day (DE)
- Write down the competencies of the learning scenarios on the sheet and try to find connections to the curricula subjects (DE)
- Make things easy and formulate them simple (DE, LT)
- Use citizen science, data literacy and scientific literacy competencies for the learning scenarios as most of the presented competencies were ranked as important or very important (DE)
- Provide simple and plain materials for learning scenarios. Materials that don’t imply the usage of computers or smartphone should also be provided and used (IT)
- Create Learning Scenarios that are linked to each other, make possible to build on pre-acquired competencies (IT)
- Prepare materials in national language (LT)

- Prepare training materials for teachers on how to conduct the projects (could be in easily shareable video format (LT)
- Organize trainings and prepare CPD resources (EL)
- Provide incentives & recognition so as to stimulate teachers (EL)

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Annex 1 Analysis Planning - Interview Guideline

The following interview guideline was used in each country. The guideline was translated to do the interviews in the local languages.

Interview design
Expert interview, semi-structured

Participants (10 per country, academic experts and school teachers / curriculum designers)

Note: Introduce the key concepts before the interviews. Parts of the presentation of the kick-off meeting can be re-used to introduce the project idea.

The interviewees should agree that the interview is recorded. The interview is anonymized on request.

1. Interviewee background data
Name/Role
Age
Level of education, year of graduation, years of teaching

2. School background data
Country, city:
Level:
Student age
school size

3. CS experience
What is your personal experience in CS projects? Can you describe a good CS project? Have you experienced CS in schools?

4. CS in curriculum
Is there a school, regional or national level curriculum for Citizen Science? How is it implemented? Is it compulsory? In which topics of the curriculum could you see CS kills to fit/to be learned?

5. Data science in the curriculum
Are there data science concepts (e.g. data acquisition, analysis, interpretation, ethics) in the curriculum? In which subjects? If not, where would they fit?

6. Support for the teachers

How are teachers been supported when introducing new topics / subjects? Can they freely adapt the curriculum? Is there education, monetary support or support groups? Is the education ongoing?

7. CS skills

What are useful skills for pupils and teachers (based on https://www.citizenscience.org/wp-content/uploads/2018/11/USERS-GUIDE_linked.pdf)? Do you see additional skills?

Competency	**Pupils, which grade?**	**Teachers**
Interest in Science & the Environment Interest in pursuing science and environmental topics, and issues.		
Self-efficacy The extent to which a learner has confidence in his or her ability to participate in (citizen) science		
Motivation Motivation to pursue science and environmental goals such as STEM careers and citizen science project activities.		
Knowledge of the nature of science; understanding of the scientific process and how science is conducted by researchers		
Data Understanding how to gather, analyze, interpret and critically discuss data Understanding how to handle data securely and ethically.		
Skills of Science Inquiry		

Procedural skills such as asking questions; designing studies; handling data; experimenting; argumentation; synthesis;		
Responsible Citizenship Behavior change towards becoming a responsible citizen (e.g. towards environmental or sustainability issues)		
Basic skills technology use; digital literacy		
Social skills Collaboration Communication Critical thinking Reflection		
Additional:		
Additional		

9. Barriers and Interventions

What are the main barriers for incorporating CS in schools = Do you have ideas how to overcome those?

Barrier	Intervention

In case that the interviewee has no idea, typical barriers can be discussed:

- Curriculum barriers: Lack of flexibility, hard to integrate
- Lack of resources (time, budget)
- Lack of skills (of teachers)
- Lack of interest in scientific projects
- Lack of active involvement
- CS is not a school issue, universities should take care of it
- Lack of interest in research / science
- Lack of benefits (e.g. certification)
- Lack of community interest

10. Needs

Do you think that CS could be a helpful practice / tool to be used in grades 5-9 in science subjects?

In which subjects would you see most potential?

What do the schools and educators need?

What would the students need?