DIGITAL ACTION AT HIGHER EDUCATION INSTITUTIONS AS A CATALYST FOR SOCIAL CHANGE IN THE COVID-19 CRISIS

Methodological guidelines for the design, implementation and assessment of Digital Action

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Abstract:	**This report aims to create the conditions for the co-creation of Digital Action between citizens, HE staff and students. It is intended as the basis for a set of methodological guidelines for the design, implementation and assessment of digital activities by High Education Institutions. All the information is based on existing guidelines and insights on the barriers and drivers of Digital Action.**
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List of Abbreviations

The following table presents the acronyms used in the deliverable in alphabetical order.

Abbreviations	Description
CS	**Citizen Science**
DA	**Digital action**
HEI	**Higher education institution**
ToC	**Theory of Change**

Executive Summary

This report intends to foster the co-creation of Digital Action involving citizens, higher education faculty, and students. The report is designed to serve as the foundation for a set of methodological guidelines for the design, execution, and evaluation of Digital Action involving Higher Education Institutions. The study is divided into four sections:

1. Primary definitions of Digital Action.
2. Recommendations for designing different types of Digital Action projects and activities that address social change.
3. Repositories of Tools, Guidelines and Platforms for Digital Action.
4. Evaluation and metrics. The data used in this report is derived from existing guidelines, insights into barriers and drivers of Digital Action collected from the stakeholders participating in roundtables organized by HEIDI project, as well as relevant scientific literature and published reports.

Introduction

The Project '*Digital Action at HEIs as a catalyst for social change in the COVID-19 crisis*' (HEIDI) is an Erasmus+ two year project, which aspires to reposition Higher Education Institutions (HEIs) with respect to society, and enable them to become co-creators of solutions to problems that surface in crisis situations (e.g. the COVID-19 pandemic).

The main objective is to upskill Higher Education (HE) staff and students towards more resilience, adaptation to change and agility that could enable HEIs to work together with citizens to shape better societies. The main actions examined are three forms of Digital Action (DA): Maker culture, Citizen Science, and Hacktivism.

This deliverable responds to the specific objective of creating the conditions for co-creation of Digital Action between citizens and HE staff and students (O2). It sets the basis and presents the methodological guidelines for the design, implementation and assessment of a set of Digital Action activities which are carried in HEIDI (i.e. in O2A3). In other words, the guidelines aim to inform the co-creation process of ten Digital Action activities developed by HEIDI's Consortium partners, involving HEIs and communities, but they are further intended to be used by any HEI actor considering to implement Digital Action projects with communities.

This report does not make any claim that the guidelines, descriptions, and processes discussed herein are an "one-size-fits-all solution" for any type of Digital Action. Instead, the intention is to serve as a resource of information for HEIs or partnerships that intend to design, implement, and evaluate Digital Action which responds to community needs.

Section 1 presents a general definition of the main types of Digital Action as used within the HEIDI Project.

Section 2 presents the general guidelines to design Digital Action; specifically guidelines for Citizen Science projects, hackathons and Maker Movement activities. The guidelines presented herein are based on existing guidelines from recognized organizations in the relevant fields, scientific literature, and the previously published HEIDI report about the barriers and drivers of Digital Action as experienced by different stakeholders who were engaged in HEIDI roundtable discussions (McNamara et al, 2022).

Section 3 contains a series of tool repositories, materials, and documents that will help anyone who wants to dive deeper in the design and implementation of specific DA activities.

Finally, Section 4 includes the impact assessment framework, a methodology to set the indicators and measure the impact of HEIDI's Digital Action activities. The selection of indicators depends on the impact statement, organization's decisions, the type of DA, and the context in which it is executed.

1. Definitions

1.1. Citizen Science Projects

Citizen Science is a growing global movement that encourages people who do not have a formal scientific training to participate in scientific research (Wehn et al., 2020). Anyone with the right tools and interest in a project can contribute their time and skills to make a scientific contribution either through top-down or bottom-up Citizen Science initiatives. Among many formal definitions, we highlight one with an inclusive view of Citizen Science that follows the White Paper on Citizen Science, which defines it as: "*general public engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort or surrounding knowledge or with their tools and resources*" (European Commission, 2014).

Citizen Science has been around for a long time. It has existed since the 18th century - long before the professionalization of science. Nevertheless, the increased levels of literacy, a set of digital technologies as well as a commitment of a growing number of scientists to better sustain public engagement in knowledge co-creation processes resulted in a growing interest in Citizen Science. In recent years, Citizen Science has become more popular, with hundreds of projects trying to adhere to the Open Science policy framework. The topics of Citizen Science projects are extremely diverse. Projects using participatory biology research, ecology and environmental monitoring, projects in digital humanities and in the health sciences are just some examples of the disciplines that currently implement Citizen Science methodologies (European Commission, 2022).

The variety of Citizen Science projects is reflected not only in the topics discussed, but also in the methods used, the duration of the projects, the number and types of people involved, the range of activities, the levels of documentation, and the levels of success achieved (Sanz et al., 2021). Citizen Science projects differ on the purpose, motivation and method. Some are intended for educational or community involvement, others are designed to scientifically analyze phenomena or to influence legislation and decision-making. Thus Citizen Science Projects are not limited to one scientific purpose or level of involvement of participants (EPA et al., 2019).

Currently, *big data* and new digital technologies are an opportunity for citizen scientists to collect even more data and make new discoveries. While having fun and learning about science, participants tend to build new capabilities and obtain a better understanding of the scientific process. When Citizen Science is properly planned and executed, it can help scientists learn more about the world around them, make people more aware of their surroundings, and let people, who share the same interests and passions, learn from each other (Tweddle et al., 2012). To best achieve these diverse goals, it is essential to take into account the principles and guidelines based on lessons learned in past projects or general past experience about the design and implementation of Citizen Science projects.

1.2. Hackathons

A hackathon is usually a short, intensive event, during which participants join teams and work together to accomplish a project. The projects are typically built in 24 to 48-hour sessions (although they can be longer), and often held on university campuses, maker spaces or public venues. Although hackathons were originally designed for software engineers, they are now being attended by people from a variety of backgrounds with only basic knowledge of software development.

When attempting to solve urgent corporate and societal concerns, a hackathon is an effective method for stimulating long-term innovation. In a hackathon, participants work together to construct prototypes and solutions to a specific problem or attempt to invent something completely new. Furthermore, hackathons are used to leverage policies and use them as an effective way to value R&I (Research and Innovation) through citizen co-creation (European Commission, 2022). A common goal of hackathons is to include as many people as possible in the creation of new technologies and foster an environment for informal learning.

The use of hackathons is becoming more popular and they can be a powerful tool to study, network, and create projects that can affect social change (Fowler, 2016). However, there remains room for improvement, as hackathons have been criticized for their lack of inclusion of a diverse range of participants and the rarity of applicable long-term solutions (Falk et al., 2021).

1.3. Maker Movement

An emerging trend known as the Maker Movement or Maker Culture has risen in the previous decades. There are many theories about its origins, but scholars believe that it may be traced back to the 1970s' counterculture, when personal computers and new technology were considered as an opportunity for social emancipation and free leisure (Lindtner et al., 2014). The maker movement is not new, and an argument can be made that it has always existed in various forms "as long as people have been producing things and require locations to work with tools and equipment" (Burke, 2015).

The Maker Movement is a growing field that has a lot of different perspectives, interpretations, and definitions. For example, in the MAKE-IT project[1] (2016–2017), the definition of the Maker Movement was based on the overlap between four main fields of work: digital fabrication, community awareness platform, crafts & do-It-yourself (DIY) and creative industries (Millard et al., 2018). Some of the elements of the maker movement, such as a focus on hobbies, arts and craft organizations, courses, practical education, and scientific fairs, have been present in other types of communal spaces, such as libraries and community centers (Rosa et al., 2017). Maker Movement

[1] MAKE-IT Project: is a Horizon2020 European research project focused on how the role of Collective Awareness Platforms (CAPS) enables the growth and governance of the Maker movement. LINK

has a strong DIY approach, mostly applied to developing personal fabrication technologies, like 3D printing and laser cutting.

A Maker Movement may take place in a variety of spaces, including HEIs but also community centers, *Fablabs*, and private and association spaces. The importance of physical "Makerspaces" may also come from their role in transforming and empowering a local community by focusing on and fostering individuals' unique skills and abilities (Rosa et al., 2017). This document uses the term *Makerspace* as a general term to refer to all spaces used by Maker initiatives.

Since the Maker Movement is a global phenomenon, it is important to avoid narratives that lead to inadequate practices. One way to ensure that is that the ambitions and inspirations are crowdsourced and co-constructed.

1.4. Features of Digital Action

Table 1 presents some features that can help to differentiate between the three types of Digital Action. These represent a typical example of each type of Digital Action, but we acknowledge that there can be many variations, e.g. a Hackathon that lasts several months or a Citizen Science project that runs for a single day.

Table 1. Examples of Basic features of Digital Actions

Feature	Citizen Science project	Hackathon	Maker Movement
Products	Written Publications Policies recommendation Communication Datasets Open repositories Digital platforms Training Materials	Documentation Product innovation Social innovation Digital Products Code Databases Open repositories Training Materials	Documentation Product innovation Digital products Code Open repositories Collection of tools Events Training
Learning	Behavior Awareness Data collection Science Concepts Data Storytelling Research Process Defining research objectives Producing research Outputs	Coding and hacking Design thinking Ideation Prototyping Pitching	Coding and hacking Ideation & Prototyping Use of tools & equipment Awareness DIY skills and methodology
Spaces	Online or Offline	Digital / Hybrid	Digital / Makerspaces
Organizational model	Led by scientists Led by communities (formally	Lead by one organization or partnership	Local hubs & Networking with others makerspaces

	or informally organized) Led by organization (e.g. an NGO) or partnership Led by individuals		
Funding needs	Team Data collection tools and activities Digital platforms and technology (e.g. phones for data collection) Communication strategy Writing publications Volunteer incentives (if necessary)	Team Mentors Prizes Logistics (Food, electrical appliances, T-shirts…) Communication strategy	Team Tools & material Equipment Makerspace Digital platform Administrative expenses
Participants	Anyone can be a volunteer; e.g.: Community members Researchers Teachers Third sector Government Industry Children	Community members Researchers Students Entrepreneurs Companies Third sector Government Industry	Makers community Researchers Students Teachers Entrepreneurs Companies Third sector Government Industry

2. Guidelines for Digital Action

From the previous section it should be clear that the types of Digital Action in HEIDI (i.e. Citizen Science, Hackathons and Maker Movement) are quite generic and therefore, it would be impossible to compile a very comprehensive set of guidelines that cover every aspect of each type of Digital Action as it should be performed taking into account the characteristics of the specific context that it is being implemented, the purpose that it serves and the aims it tries to achieve. However, several sets of guidelines for the design and management of the three types of Digital Action are already available, with differing focus on specific topics or disciplines.

Although Digital Action projects become increasingly sophisticated and complex, it is evident that there is more to focus on in the project design than simply data collection. A key element for all types of Digital Action and their success is to build new and flexible mechanisms for engaging

participants, and to keep open the possibility of serendipitous discovery by participants (Trouille et al., 2019)

The HEIDI project seeks to create collaborative frameworks between HEIs, organizations in the voluntary-sector and civil society; to upskill HEI staff and students not only in technical skills but also to be more resilient, responsive and adaptable to change; and to situate HEIs in a central role in ongoing debates about social change as co-creators of solutions to problems that surface with the pandemic. Thus, the guidelines presented in this report not only cover technical and logistical aspects for the development of Digital Action but also include guidelines for community building (to ensure a collaborative framework) and for the design of an impact strategy (to ensure actions are responsive to change and enable co-creation of solutions to community problems).

In this report we present the common guidelines that can apply to all three types of Digital Action and a set of guidelines specific to each Digital Action, as well as further guidelines for community building.

2.1. Common Guidelines for Digital Action

We start by presenting a general scheme to show a broad overview of co-creation in Digital Action. One possible way of structuring and describing the process of Digital Action implementation is to start with the identification and gathering of the resources and team, followed by problem framing and actual design of the Digital Action activity. The activity is then executed - be it a Citizen Science project, a Hackathon, or a Maker Movement event - followed by collection of results and evaluation of outcomes. Finally, the impact and learnings are evaluated, which then should feed back, creating an iterative process to arrive at better Digital Action in the future. Community building is an essential activity that occurs during all the process. We proceed to present detailed guidelines for all of these different stages as shown in Figure 1.

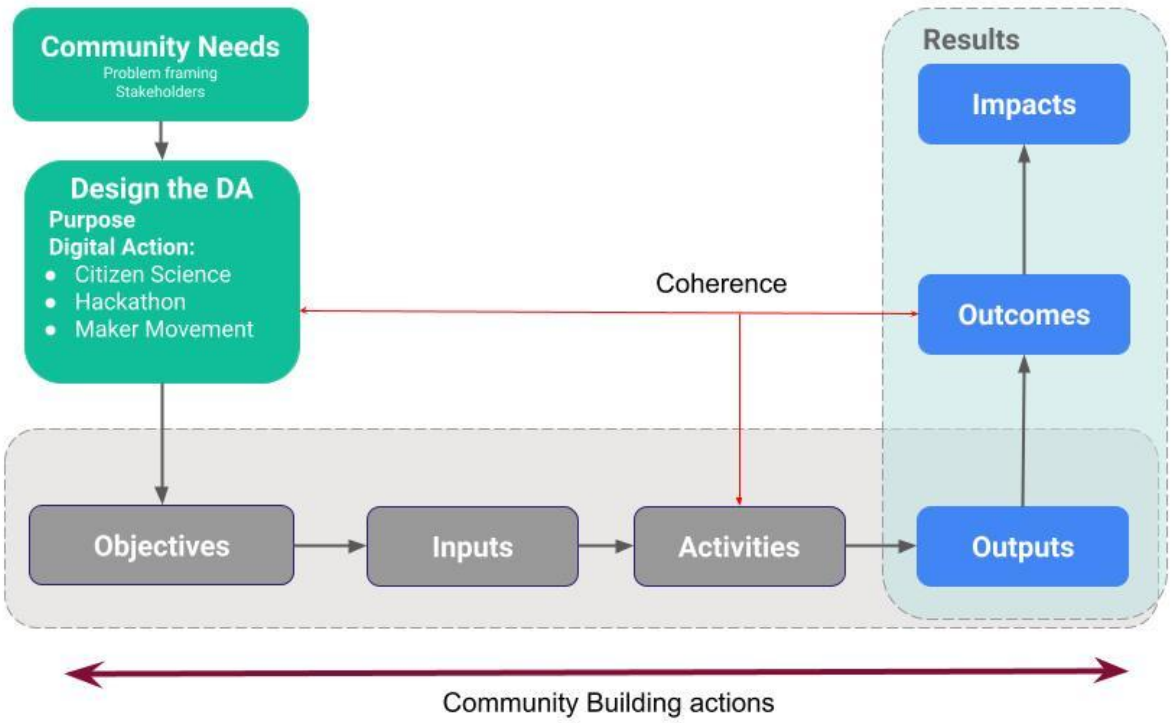


Figure 1. Main stages in the design, implementation and evaluation of Digital Action. Figure Inspired by (Wehn, et al., 2017).

2.1.1. Defining the Role of HEI and Resources

Defining the role of the HEI and the purpose of the Digital Action. It is important to think about what the HEI offers in the implementation of a Digital Action for responding to community needs or impacts. Based on the resources available in a HEI - and complementing this information with an understanding of who is involved - it is possible to define the role of the HEI, their resources to address a problem and possible stakeholders to be involved. Specific resources HEIs should contribute to in order to guarantee the successful participation of an organization in Digital Action - as stated by the HEIDI consortium partners in the IO1 deliverable report - include financing, access to digital infrastructure, and digital skills (McNamara et al., 2022), see Box 1.

Box 1. Example of resources that define the role of a HEI in terms of addressing a problem though Digital Action

- Skills
- Experience
- Network
- Funds
- Recognition
- Scaling ability
- Digital and other infrastructure

2.1.2. Problem framing - What do we want to solve?

Having a clear "Problem Framing" process is key for setting up clear goals and objectives. It is essential in order to: develop more effective activities and methods; acquire background knowledge to support the decision-making in the project; learn about people's realities; understand the needs and ambitions of those who will be directly impacted; and identify the stakeholders involved and the resources available or needed to support the project (McNamara et al., 2022).

During this stage, the organizations should have a clear idea of what research or action will be done, and it is similarly important to define the goals which the stakeholders involved want to achieve. This could be done through roundtables or general discussion with all the stakeholders.

Identifying the problem. The definition of the problem to address frames the entire process of a Digital Action. It is the essential first step and it needs to be as narrowly and concretely defined as possible. For example, you should focus on the elements of a wider problem, or think about a particular community or place. Problems can be identified by the HEIs but may also be identified by the stakeholders themselves, who then approach a HEI to obtain help and support in solving them. In both cases, asking questions is an effective way to identify and frame the problem. Some examples of such questions are presented in Box 2.

Box 2. Key Questions for Problem Framing

- Who is affected by the problem?
- Who is particularly vulnerable?
- What are the consequences?
- What are the causes of the problem?
- What are the barriers?
- What are the opportunities to address these barriers?

Identify the needs of the community affected by the problem. After identifying who is affected, it is important to identify the needs of the community in order to connect the Digital Action objectives with the motivations and needs of the community - especially for those cases in which the problem is identified and defined by the communities themselves. A deeper understanding is needed to all other community aspects which will further drive and successfully materialise a Digital Action project. Specifically, HEI representatives need to identify potential participants, have a comprehensive understanding of who is (or should be) involved, and define the approaches to build with (not *for*) them, in order to ensure their participation.

Digital Action may involve users from different educational backgrounds with various digital skills, so they should necessarily be based on genuine requirements and motivations and tailored to the context in which they can be implemented. An important first step in creating effective Digital Action is to have a thorough understanding of the intended audience, especially when participants come from completely different socio-cultural contexts, and occasionally without any formal education qualifications and without literacy skills, which makes them very different from the average Digital Action participant in the Western world (UNESCO, 2018). Identification of needs is not easy because the stakeholders involved in the Digital Action may come from entirely different worlds, both literally and symbolically. Designing for low-skilled or illiterate users necessitates a greater focus on developing empathy for their unique set of challenges. Also, when getting to know the stakeholders, it is important to define the objective factors - such as age, location, level of education or daily activities - and subjective factors - such as knowledge, attitudes and behaviors, etc. For example, for a target community of young people at risk of becoming NEET (not in education, employment or training), it is important to know their academic performance, their expectation, the interest in future career options, or their previous behavior and attendance (NPC, n.d) in order to design a Digital Action that is coherent with the target community and ensuring their participation. Box 3 presents questions that can help identify the community and its needs.

Box 3. Key Questions that help to identify who is involved

- Who (and who else) is involved in addressing the problem?
- What is missing? What are the gaps?
- What are their particular needs and how are they currently being met, or not?
- What is the demographic?
- What are their education and literacy levels?
- What is technology usage and digital competence?

2.1.3. Designing the Impact Strategy - What are the desired impacts?

Defining the desired impact should be considered at the earliest stages of project planning to directly lead to the establishment of an impact strategy for the Digital Action. Currently, the two most accepted and widespread frameworks to design and document the impact of an intervention are the Theory of Change[2] and the Five Dimensions of Impact[3] by the Impact Management Project. However, there are other frameworks to measure impact with differing approaches, which help organizations, businesses, governments, and the voluntary sector to account the impact of their actions and investments. In this report, we mainly focus on the Theory of Change for the reasons listed below.

Using Theory of Change (ToC) can help design activities and goals that generate impact in their communities (Rogers, 2014). ToC is a useful tool to consider causality and contribution analysis, and it invites the stakeholders into the process (Funnell & Rogers, 2011). It can be used for strategic planning in order to identify existing conditions (in terms of needs and opportunities), as well as how to go from an initial situation to an expected situation. In this way, it is necessary in order to set realistic goals, formulate responsibilities and have a clear understanding of how to develop the activities.

People and groups use ToC to plan how they will make changes, evaluate success, and communicate with people who will be affected by the changes they are making. Over the last decade, it has become more and more popular. It is now used by charities, social enterprises, the public sector, and even some mainstream businesses.

A ToC is normally represented as a map or a journey, linking the activities of a programme, intervention, or organization to the short-term, medium-term, and long-term outcomes experienced by stakeholders. The ToC is a living framework that should be changed as the work or context changes. A Theory of Change for Digital Action should be established when planning an impact evaluation and drafting the terms of reference. Once established, every impact evaluation should be based on the Theory of Change.

ToC has a fundamental role not only for achieving and monitoring impact, but also for evaluation purposes. It safeguards the intervention from making unintentional mistakes, and allows defining the metrics of results and delivering tangible outputs (Dembek et al., 2017)

More broadly, the ToC can be used for multiple purposes, the four main ones being:

- **Design**. The ToC is a practical tool that aids in mapping the process, the changes and effect expected (outcomes) .

[2] Theory of Change. Link
[3] Five Impact Dimensions. Link

- **Monitoring and evaluation**. It is possible to keep track of progress and outcomes by referring back to the ToC. This enables organizations to evaluate the activities and role driving change (Van Stolk et al., 2011)
- **Communication**. ToC helps internal and external partners to communicate the process chosen, and share a common language and understanding. Also, it is key for the engagement and participation of the stakeholders.
- **Knowledge**. Using a ToC can assist people to better understand the activities and purpose of the intervention.

The basic process to define the ToC can be organized in the following steps:

Step1. Identify the problem that the Digital Action is trying to solve

Step2. Identify the goal and specific sub-goals

Step3. Map the desired outcomes. The outcomes in this case are the changes expected from the Digital Action activity. This will help develop a more detailed map of the change process, including the many processes involved in achieving each specific goal. It is important to map the short, intermediate, and long-term outcomes. After defining the outcomes, organize them in the sequential order they need to occur. Take into consideration that some outcomes are independent and others are related. The changes can be mapped at different levels (individual, familiar, community, policy, etc.)

Step4. Identify the activities and outputs. Consider which activities and outputs will help achieve the goals of the intervention. Think creatively about which outputs could be the most effective and the time in which to deliver them. To define the outputs, collaborate with other stakeholders and participants. Make sure there is coherence between inputs, outputs, activities, and outcomes.

Step5. Define the indicators to measure the achievement. Establish indicators for each of its components described above. This step will be more explained in section 3 of this document.
Additional resources about the Theory of Change are listed in Table 3.

An example from the implementation of a logic model and a ToC in the context of citizen science is demonstrated by Skarlatidou and Haklay (2021) which discusses the use of such a framework for the EU coordination and support action Doing It Together Science.

2.1.4. Deciding between types of Digital Action

When choosing the type of Digital Action to design for (e.g., Citizen Science project, Hackathon, or Maker project) the following elements can help decide which one is the most appropriate taking into consideration the community, context and resources available:

- **Let your audience dictate your design.** You should define the most suitable Digital Action based on the desired participants and the community whose problems the Action seeks to answer. Digital Action for HEIs create new pathways for good research practices and reach different sectors of society (McNamara et al., 2022). There is not a single Digital Action that fits all audiences and thinking about the contributions, capacities, limitations and dynamics of a particular group will provide elements to improve the design and implementation.

- **Build a team.** A successful Digital Action involves a well-organized team. Even hackathons, which are typically short events (48 hours), may need months of preparation and a follow-up process. Some of the organizing team's specific roles and responsibilities include:

    - Relation-building with stakeholders (participants, partners, sponsors, contractors)
    - Management of events/spaces (methodology, user/participant guide, pitching event, team building, mentor checkpoints, progress reports, seminars and workshops, final presentations, technology, logistics, trainings)
    - Marketing and communication strategy (website, social media management, media relations)
    - Follow-up (project continuance, networking, new prospects, acceleration, governmental and corporate interactions)
    - Data collection, data analysis and data practices
    - Digital platforms and solutions (design, management, allowing for serendipity)

- **Define the Scale.** For technical staff in HEIs, the scale of the Digital Action is based on how Digital Action at local level may be replicated at a national or global scale. However, more research is always required in order to determine the value of such expansion (McNamara et al., 2022). Developing Digital Action at global scale may include some challenges, such as textual and digital literacy, technological access, concerns around the digital divide and so on. To address this, having interactions with the local organizations that work with the communities of interest and designing with them the adoption of a Digital Action could ensure a more effective upscaling of the project.

- **Consider technology requirements.** The design of a Digital Action needs to take into account textual and digital literacy, other skills, technological access and affordability for participants - especially those of more vulnerable populations, who have fewer opportunities and who are located in regions or countries with limited digital infrastructure (McNamara et al., 2022). Project teams should consider the availability and usability of current technologies and tools in order to handle technological and infrastructure concerns (Chari et al., 2019). Closing the digital gap in order to achieve equality of participation requires both upskilling of individuals.

- **Harness opportunities for collective serendipity in digital spaces.** The use of online environments can bring flexibility (e.g. asynchronous learning) to better suit participants'

individual schedules (McNamara et al., 2022). Nevertheless, online sessions are challenging due to a lack of face-to-face interactions with the participants, making it necessary to create opportunities for collective serendipity. One way to do that is by implementing specific learning tools and methods to support online learning and introduce techniques and practices to increase engagement, such as using collaborative tools and technologies that are easily accessible by all - and especially the targeted audience- and engaging participants though some casual, non-project related discussion to make them feel comfortable and allow them to engage in the conversation.

- **Identify and report potential risks.** Risk assessments must be carried out in order to examine potential barriers that prevent individuals from participating and obstacles for the development of Digital Action. Identifying the risk might help reduce the social marginalization experienced by the participants.

2.2. Citizen Science Projects Specific Guidelines

Community Citizen Science projects can face various obstacles during implementation. Some of the most common include being able to scale up activities, balancing the roles of professionals and volunteers, recruit and retain participants, face competition and duplication within the field, clearly communicating the project's mission and objectives, and securing necessary project resources (Chari et al., 2019).

The following guidelines are specifically designed to ensure good practices for Citizen Science projects responding to community needs.

2.2.1. Principles of Citizen Science

One way to identify and shape a Digital Action as a Citizen Science project, is by following the ten principles of Citizen Science (ECSA (European Citizen Science Association), 2015) developed by the European Citizen Science Association and presented in Box 4 below.

Box 4. Ten principles of Citizen Science (after ECSA (European Citizen Science Association), 2015)

1. Citizen Science projects actively involve citizens in scientific endeavors that generate 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 scientific outcome. For example by 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 through that, 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

Source: ECSA (European Citizen Science Association). 2015. Ten Principles of Citizen Science. Berlin. http://doi.org/10.17605/OSF.IO/XPR2N

2.2.2. Complexity of the protocol

There is an expected trade-off between the amount of people that are enrolled in a Citizen Science project and the complexity of the protocol (Tweddle et al., 2012). It is important to promote participation to include many individuals, obtain basic data (e.g. a wildlife observation) and simplify the protocols for data collection. However, if a complicated procedure or a massive data collection is required, one might want to consider a smaller group of individuals who can adhere to a complex protocol more efficiently. For any protocol used in a Citizen Science project, ensure that participants are adequately supported and the methodology is well tested (Tweddle et al., 2012).

2.2.3. Ensuring data quality

The validity of data gathered through Citizen Science projects might occasionally be questioned, although there is evidence in the literature that Citizen Science data can be of the same quality as data collected by professionals, given of course that several elements along the process are taken into account. Towards this purpose a Quality Assurance Plan might be used to reflect and take necessary precautions and steps to ensure high data quality (EPA et al., 2019). The data quality assurance and data quality control need to be defined by the project's coordination person/team.

To develop the quality assurance and documentation, the organization should take into account the project's objective and data use. Also, the purpose of the project defines the process and actions in the quality assurance planning. There is a difference in the quality assurance of the data collection for legal and policy action and data collection for public understanding.

To establish the appropriate degree of quality control and documentation, the U.S. Environmental Protection Agency (EPA) categorizes Citizen Science projects by purpose to help organizations decide the actions necessary to achieve quality assurance and documentation standards (EPA *et al.*, 2019) as shown in Table 2 below.

Table 2. Level of detail of quality assurance and documentation for different project purposes. The deeper the hue, the more meticulous the quality assurance process (Source: EPA et al., 2019)

Categories of Data use	Intended Project Purpose	Quantitative	Qualitative	Level of Detail
Increasing public understanding	Community engagement			
	Education			
Scientific studies and research	Phenomen indicators			
	Studies and research			

Legal/Policy action	Regulatory decisions			

Specific issues that are particularly significant and valuable in the context of Citizen Science, and should be considered and addressed in the data quality plan, includes: Management description, sampling design/collection, sample handling & custody, sample analysis, quality controls, data interpretation (Emmett Environmental Law & Policy Clinic, 2019).

2.2.4. Sampling/Data Collection

One should assist Citizen Science groups through training, collaboration, and the creation or provision of standard operating procedures. When relevant, consider establishing programs for citizen scientists, such as certification or training, as well as standard operating procedures. Using these tools, Citizen Science volunteers may be evaluated (or self-evaluated) in their capacity to gather and analyze samples while maintaining high standards of data quality.

Discuss the logistics of sample storage and the conditions for ownership transfer. In order to help citizen scientists and promote participation, consider lending or renting out special equipment. Citizen scientists should be educated on the correct usage and calibration of their equipment.

2.2.5. Data Documentation and Review

In order to ensure adequate data documentation, it is necessary to collaborate closely with citizen scientists to design the data quality strategy and to understand the needs of the users of the information. When evaluating the data in order to verify and authenticate it it helps to answer the following questions (EPA, 2021):

- Was the proper information gathered? When and where was it collected and what was the collection method?
- Is the data useful? Do the datasets meet quality standards?
- What problems did you have with quality control? Outliers: what are the plans for them?
- Is it necessary to collect more measures in order to inform decision-making?

Use data gathered by citizen scientists to help you evaluate the findings and plan your next moves. Data analyst teams may benefit from a combination of local knowledge and scientific skill. Assist in determining the most effective methods to provide information depending on the expected audience. Ask how the information can be made available and useful to all stakeholders involved.

2.2.6. Long Term Engagement

Citizen Science projects depend on the engagement of the participants, independently of the benefits they may provide for the scientists who wish to develop experiments with wider coverage. Engagement is not easy to build in the long term because the majority of participants in a project never return, affecting initiatives that require recurring involvement, such as several observations of a single site (Sauermann & Franzoni, 2015).

A study analyzed individuals' participation patterns in Citizen Science projects on Zooniverse throughout the first 180 days following launch, found that 60 percent of participants came once and never returned; in the worst cases, 83 percent never returned, and the top 10% of contributors are responsible for 80% of total classifications in the Citizen Science projects. Then, projects have become more reliant on their most dedicated users and the majority of the participants lose motivation along the way (Sauermann & Franzoni, 2015).

For the design of the Citizen Science project, the long term engagement strategy needs to be considered, if possible co-designed with the participants, and verified during the process. Researchers should determine ways to motivate participants during all the stages of the project.

Research has shown that people's participation in online Citizen Science is related with the design of the platforms, where different design methods are needed depending on the type of community and individual involvement profiles of citizens (Aristeidou et al., 2017). For example, the usability of the platform might be improved to identify and support individuals; e.g. ensure easy access and provide mentoring for newcomers.

Taking into account that there is a distinction between patterns of behavior observed in online communities (Ren & Kraut, 2014) and that the design considerations based on the behavior cannot be one-size-fits-all, the moderation and design of digital platforms need to be more personalized based on the behavior of participants. Skeptical behavior by reluctant visitors should be explored further as the foundation for strengthening the community's support system. Some of the recommendations are that the design should attempt to improve software usability by involving usability specialists or by maintaining ongoing feedback, as this is one of the key reasons why people leave (Aristeidou et al., 2017), and the emphasis on the topic is irrelevant, since connecting with what's matter to prospective volunteers will determine their motivation (Pocock et al., 2014; Skarlatidou et al., 2019).

2.3. Hackathons/Datathons Specific Guidelines

Academic, peer-reviewed literature is scarce on hackathons despite several guides and reporting from specific Hackathon events being available online. Only a few papers have been published, and the majority of them are summaries of individual hackathons (Kos, 2019; Stoltzfus et al.,

2017). In Box 5 below we present a list of guidelines to help design and implement effective Hackathons:

2.3.1. Principles in hackathons/datathons for being impactful

Box 5. Principles for Impact hackathons

- Motivate and empower individuals to move ideas forward.
- In order for participants to come up with ideas that can have a real impact, they should be given sufficient information on the subject matter. In most cases, this is accomplished with the help of industry experts who serve as mentors.
- Interactions among the members of a team can lead to long-term commercial ties.
- Facilitates follow up with the teams that show potential to go from "ideation" to product development and the foundation of a new business.
- Consider social causes as themes
- Consider the larger cause – Think beyond the event
- Include networking as a goal

Source: https://www.fastcompany.com/90301054/the-subtle-sexism-of-hackathons
https://futuredistributed.org/stories/5-ways-get-real-world-impact-from-a-hackathon/

2.3.2. Steps to design and implement a hackathon

A number of steps need to be followed before a hackathon can be carried out:

- **Define the purpose.** Consider the aim of your digital hackathon as you begin to prepare your event. Discuss the purpose of your event with the members of your planning committee. The hackathon decision-making will be guided by this. People who want to host a hackathon often struggle to come up with a clear goal for the event (Major League Hacking, 2021). There are a variety of reasons to hold a hackathon, everything from empowering a local community to designing a new technology. Knowing exactly what the desired outcome is makes it easier to figure out how to achieve it.

- **Clearly express the problem.** Are you seeking to tackle a specific problem or take advantage of a specific opportunity via innovation? Either way, the problem should be clearly defined and shared with potential participants.

- **Define the theme.** It is necessary to define the issue to tackle and define a general theme. This determines who participates and how, and helps motivate the participants to take part in the event. Do not restrict yourself to subjects that only lead to products or technology. Social issues throughout the world can benefit from new approaches too.

- **Share background.** Give to the participants as much background and insight about the problem as possible, including stakeholders involved, past solutions or attempts, and risks.

- **Time Planning**. To effectively prepare an event, you'll need anywhere from four to eight weeks, depending on its scope. Establish milestones in your timeline and adhere to them.

- **Learning sessions during the hackathon**. Establish with the stakeholders the knowledge needed to develop the solutions, digital and non-digital (e.g. design thinking, ideation, pitching). Also, there are hackathons that allow the participants to lead the conferences during the event, modifying the topics and agenda in a DIY variation, such as the *Unconferences* (McCann, 2014)

- **Rest period.** Allow for adequate rest periods between tasks. Having some fun activities or a tasty meal can keep people motivated and ensure a successful outcome. Such breaks can serve as milestones for participants.

- **Deployment procedures**. A key statistic for determining the success of a hackathon is the number of working projects resulting from the event. That their projects will be implemented and accessible to the public is a motivating aspect for teams.

- **Analyze concepts.** Analyze concepts for their originality, viability, ease of implementation, scalability, and economic worth.

- **Prizes and awards.** A prize or an opportunity should be decided upon: Prizes (reward points, gift vouchers, and incubation processes) are always helpful in fostering an innovation-driven culture in the workplace.

- **Wrap-up.** After the hackathon, show the world what you have accomplished. Publicize your work using photos and videos on your website, in a blog post featuring the winners, or in the media.

- **Actions to extend beyond the event.** For a hackathon to make a difference, the solution is not created during the short event. Encourage people to comprehend the problem and the opportunities. Some recommended actions with the winning teams are to introduce them to persons and organizations who might benefit from the solutions, so they may learn about

the challenges directly and incubate the idea. Also, raising public awareness, e.g. media attention for those projects could make sure that the audience and champions will extend well beyond the event.

2.3.3. Inclusive hackathons

- To have an inclusive hackathon it is necessary to consider the people to whom the Digital Action needs to respond to and invite them to the process. To have different groups (technologists and non-technologists) is necessary to create an atmosphere that would allow both "groups" to feel part of the hackathon, while also allowing individuals who do not identify as “hackers” feel at ease in a location where their tech expertise is not required. Consider interactivity, learning opportunities and diversification of projects.

- People should be able to walk in, figure out what's going on, and quickly find a way to get involved (whatever their threshold for involvement).

- Everyone should be able to play, build, or do something else with one or more of the tech-related projects that are there, even if they do not have a laptop.

- Set a schedule that fits the needs of as many people as possible, with the possibility to interact offline and online options. Also, people should not be stuck inside all the time, they should be able to stay and leave whenever they want. For example, some hackathons do not use night hours so people can return home during the event, giving the opportunity for people with families to participate.

- Pre-events or Workshops are especially useful for new participants. It is a way to bring together diverse stakeholders and receive input on who is still missing to promote the forthcoming social hackathon. Also, it helps to assess and motivate participants and reduce the “impostor syndrome”, giving the participants confidence, and to explain the hackathon's rules and approach.

- Make the event better gender responsive. Encourage Pronoun Usage, create affinity groups, provide hackers with safe spaces to ask questions and access support. To support gender-focused hackathons and clubs, focus more on what the HEI can give to them and less on what these groups can give you.

- Diversify the Hackathon Organizing Team, bring others perspectives from the early stages of planning the hackathon.

2.4. Maker Movement Specific Guidelines

As there is a great variety of makerspaces and the HEIDI project is focused on Digital Action, the following guidelines are focused on makerspaces that enable digital fabrication or use digital tools and platforms.

2.4.1. The Maker Movement Manifesto

In 2013, Mark Hatch, one of the leaders of the Maker Movement at that time, published the Manifesto of Maker Movement based on years of experience and stories from the Maker culture. He also recommended that readers can make the manifesto their own by modifying it and incorporating their own ideas into it.

Box 6. The Maker Movement Manifesto - Short version

- **MAKE.** Making is fundamental to what it means to be human. We must make, create, and express ourselves to feel whole. There is something unique about making physical things. These things are like little pieces of us and seem to embody portions of our souls.
- **SHARE.** Sharing what you have made and what you know about making with others is the method by which a maker's feeling of wholeness is achieved. You cannot make and not share.
- **GIVE.** There are few things more selfless and satisfying than giving away something you have made. The act of making puts a small piece of you in the object. Giving that to someone else is like giving someone a small piece of yourself. Such things are often the most cherished items we possess.
- **LEARN.** You must learn to make. You must always seek to learn more about your making. You may become a journeyman or master craftsman, but you will still learn, want to learn, and push yourself to learn new techniques, materials, and processes. Building a lifelong learning path ensures a rich and rewarding life and, importantly, enables one to share.
- **TOOL UP.** You must have access to the right tools for the project at hand. Invest in and develop local access to the tools you need to do the making you want to do. The tools of making have never been cheaper, easier to use, or more powerful.
- **PLAY.** Be playful with what you are making, and you will be surprised, excited, and proud of what you discover.

- **PARTICIPATE.** Join the Maker Movement and reach out to those around you who are discovering the joy of making. Hold seminars, parties, events, maker days, fairs, expos, classes, and dinners with and for the other makers in your community.
- **SUPPORT.** This is a movement, and it requires emotional, intellectual, financial, political, and institutional support. The best hope for improving the world is us, and we are responsible for making a better future.
- **CHANGE.** Embrace the change that will naturally occur as you go through your maker journey. Since making is fundamental to what it means to be human, you will become a more complete version of you as you make.

Source: (Hatch, 2013)

2.4.2. Elements for Digital Action in Makerspaces

Open source. The term "open source" indicates a source code that could be used by anybody, could be modified from its original design, and can be redistributed freely (Wikipedia, 2022). The open source philosophy encourages users to make their creations available to other Makers so that they may all learn from each other. Then, using equipment and designs, open source gives the possibility to be modified and used for more people (Johns, 2019).

Accessibility. It includes accessible tools, material and technology, and accessible spaces. It is important that Makerspaces are physically accessible, close to public transportation and parkings, which make it easier for users to travel to the lab and carry supplies for their projects.

Business model. The maintenance of Makerspaces is difficult after the initial financing has ran out. From the beginning of the process of setting up a Makerspace, or any Digital Action in the Makerspace, it is a must to keep a long-term vision in mind. Identify long-term stakeholders and business associates. Makerspaces networks have a wide variety of models to choose from. Building the model for running a Makerspace requires careful consideration of the local stakeholders, their needs and their interests. Also, it needs to consider that there are a variety of ways to get support, personal and social networks, funding sources and technological support from other makerspaces or stakeholders.

Equipment. Buying and assembling the equipment “by yourself” is the lowest price pathway. However, that means having an expert to install, debug, and teach the staff. Fab Foundation published a standard kit that aims to make it easier and more appealing for anyone to design and build items that can be shared to users worldwide. The intention of shared designs, machine settings, and suggestions is to make it possible to replicate products from any location on the planet (Johns, 2019). However, the equipment options do not be constrained to the pre-packaged

kit. Acquiring more equipment, being unable to obtain the whole equipment kit, or using different methods and tools when tackling a problem is acceptable and it is necessary to become a more versatile Makerspace, allowing sustainable practices (Smith & Light, 2017). Also, one way to access equipment is establishing working relationships with companies who produce equipment, it can help to lend equipment or arrange for long-term leases.

Staff and roles. The makespace involves a variety of staff members on a variety of contracts and participation. One of the most important roles is that of the manager, but also individuals with expertise on the equipment and Makers that are related with Maker networks and people who can assist administrative tasks and logistics, such as inventories or cleaning. Additionally, when considering the impact of the Makerspace and its sustainability it is necessary to include people to handle its communication strategy, do community-building and perform an impact evaluation and a business development model (Johns, 2019).

Communication. Publicity and marketing is a way to engage stakeholders, communities at different levels and other media that can help to spread the word about the makerspace and the impact. Makerspaces can benefit from using social media platforms like Twitter, LinkedIn, Facebook, and Instagram to motivate people to talk about the Makerspace, publish their creations, services, and workshops. Also, include in the marketing strategy the relation with the networks of other education institutions, local businesses and equipment manufacturers. However, for sharing, people need to be empowered to share, then it is a must to learn, think, and convey what should be communicated and to whom (Lotz et al., 2019). A proven strategy is "storymaking" that combines code and narrative, making and storytelling (Bull et al., 2017). To develop this strategy it is necessary to teach engineering with literacy skills and the use of non-exclusive language.

User experience. Users can experience the makerspace through time spent in it, experience with equipment and the support available, as well as collaboration processes and workshops. The experiences and facilities depend on the business model that allows or frames an experience. For example, deciding to open on weekends or after-work is a great user experience for people who work during weekdays, but it means having staff available at the weekends. Some makerspaces have an environment that fosters cooperation among the makers.

Collaborative Learning. A Makerspace's role is to not only teach people how to make, but also how to share their creations, so as to ensure that everyone's voice may be heard in the community. Leading collaborative learning is a pathway to achieve individual learning, boost the creation and innovation for new businesses, and build strong relationships with the users (Oswald & Zhao, 2021). Also, what is learned and the content of workshops can be tailored and co-created with the makers community, as it helps strengthen the community feel.

Intellectual Property. Can be protected and sold by the inventor, but should be freely available for usage and learning

2.4.3. Inclusive Makerspaces

Makers from underserved communities. Makerspaces that are inclusive towards marginalized and underrepresented communities can, through co-design and co-creation process, empower these communities tremendously in multiple ways, for example, by giving people the opportunity to engage in STEM education in a less formal environment (Lotz et al., 2019). However, co-design with such communities may have its own challenges. For example, makers in developing countries may prefer traditional approaches and can see innovation as inefficient and risky (Lotz et al., 2019). The positive meaning of the connotation of failure that is used in European Maker Movements may not have the same meaning for makers in unprivileged communities (Lotz et al., 2019).

Gender equality. Women are underrepresented in both the usage and leadership of maker efforts (Millard et al., 2018). Male participation in Makerspaces is higher than female participation. Also, the Makerspace design, language use, attitudes and the absence of female role models, particularly in leadership roles, reflect a male-dominated Maker culture (Sarpong et al., 2020). The local Maker community in France, for example, is approximately 70-30% in favor of men (Maric, 2018). The disparity in the maker culture could be linked with underrepresented women in STEM areas, as a result of the socio-cultural implications and gender stereotypes that are prevalent in early schooling (Maric, 2018).

Younger generations bringing cultural change to Makerspaces and breaking gender preconceptions have the ability to increase gender equality in the Maker Movement. To achieve sustainable development, the inclusion of women is a must. The World Economic Forum claims more has to be done to close the gender gap while also ensuring that the next generation has the necessary skills to take part in and contribute to the growth of their country's economy (World Economic Forum, 2021).

To reduce the gender gap while preparing for the next generation for challenges the California Community College Makerspaces and other communities have proposed the following guidelines (Dayton, 2017):

- Use proper language and communicate the same objectives for girls and boys, but also accept diverse ways to achieve progress.
- Broaden the meaning of making. Using multidisciplinary education that bridges STEM with the arts and craft design. This helps to break stereotypes of women being more related with arts and men to tech.
- Allow for a variety of solutions and processes. *I.e.* People can set their own goals and introduce the making environment in a fun and welcoming way.
- Promote “making for good”, such as solving societal issues, creating initiatives that are meaningful for individuals and communities or tackling a challenge of gendered preconceptions.

- Build Maker communities through social interaction, Makerspaces that are open to everyone, that are friendly and promote cooperation rather than competition between the Maker groups.
- Provide mentoring by identifying potential Makers as mentors to support others.

Finally, it is important to create awareness about this topic in the Maker space and communities. An adaptation of the Bechdel Test, the gender assessment for media studies (Launius & Hassel, 2015) was made to assess the role of the females in the maker spaces with the objective of reducing the gender gap (Eckhardt et al., 2021). The following four questions may be used to increase gender balance and improve inclusiveness:

1. What percentage of your members identify as male, female or non-binary?
2. Do all three groups make things?
3. Do all groups initiate and lead their own projects?
4. Is there a female or non-binary Makerspace manager in your Makerspace?

2.4.4. Impact from Makerspaces

Sustainability. The distance between "making" and social and sustainable innovation is still rather large. Technical competence and playful experimentation are crucial for creativity, but these factors are often overlooked when it comes to making. Sustainable social and environmental improvements, on the other hand, need deeper relationships with communities that have been working for years or decades to address issues like poverty, environmental protection, and elder care (Millard et al., 2018).

In addition, Makerspaces are facing the pressure to foster entrepreneurship and new businesses more than social impact (Smith & Light, 2017). This can lead to unsustainable behavior from the mass customization or overconsumption (Smith & Light, 2015). One case is the creation of "throwaway" items - called in the Maker culture "crapjects" or “pongos” - that are impossible to reuse or recycle (Oxley, 2015). For example, 3D printing without a sustainable plan can lead to increased consumerism, plastic waste, and a dumbing-down of design (Holman, 2014).

Community Empowerment. Community empowerment can be expanded into impact actions - bringing the concept of active involvement beyond an object being manufactured - to transform conditions of the users or community. Community-based Makerspaces have the ability to empower vulnerable communities, mostly by providing access to informal education and the labor market, and also give opportunities for entrepreneurship (Lotz et al., 2019).

The process of empowering marginalized groups can not be started and then left to proceed on its own. A recommendation to Makerscapes working with people from developing countries is to analyze and adjust participation pathways as the participant’s conditions involved change over time (Kraff, 2018), which means to be in constant investigation. Measuring and communicating the

Makerspace impact, through doing self-reflection of what is produced and the experiences that have resulted from it, is part of the co-creation and continuous research of the participant's engagement. Makerspaces that have a beneficial impact on individuals and communities have less risk of disappearing (Lotz et al., 2019).

2.5. Community Building Guidelines

- **Communication strategy.**
  Clear communication. A successful Digital Action relies on an effective communication strategy. Since people use social media for a variety of reasons, there is no one-size-fits-all method for an appropriate outreach strategy for events and activities. Communication between students, HEIs, and government agencies was specifically emphasized by all groups participating in roundtables about Digital Action within the HEIDI project. For example, using simple non-tech language and outlining students' goals and objectives contributes to improving communication between different stakeholders (McNamara et al., 2022).

  Description of the project. Describe how your initiative (or solution to an issue) contributes to the larger picture. Describe the background of the project (or environmental issue), any relevant prior research, and how this project fills in a data gap (including data from current sources) or adds to already existing information in this section.

  Establish connections with other projects. It is crucial to explain how and why the project is connected to other ongoing projects. The descriptions increase the chance of getting people involved in the project and adding data, the collaboration with others who are doing similar studies leading to better outcomes. Including citations to articles or studies that influenced your study is also beneficial since it might indicate that you have investigated and selected acceptable ways for gathering data that are applicable to the problem.

  Incorporate diverse backgrounds. There must be a special approach for incorporating vulnerable people (such as those with disabilities, mental health issues, or elderly people in remote locations). Posting on social media is not enough, it requires a more comprehensive strategy that includes personal meetings to key organizations as well as user groups, also addressing transportation and personal assistance difficulties (Bugarszki, 2021).

  Use social media and more traditional channels. Many organizers of Digital Action events want to use the media to promote their projects, but alternative, more reliable communication channels (e.g., interest group newsletters) should be explored. Also, social media (e.g. Twitter and Facebook) have created new ways to promote projects and engage people, and workshops, training and pre-activities may let project participants meet in person, know more about the Digital Action and attract new participants. Some

tips for communication on social media can be very useful, such as templates, pre-written messages, images and a social media strategy ready to use for the team and participants.

Develop a content strategy to meet users' needs. Segment audiences based on information requirements, preferences, and skill levels. Co-develop content with end-users to ensure it is clear and contextual. Always use gender-sensitive material, in communities where women and girls are less literate and less exposed to technology, material should include female users, visuals, and performers to promote female participants. Make use of suitable media and user interfaces for low-skilled and illiterate people (UNESCO, 2018)

- **Reporting, Feedback & Review.** Finding a mechanism to communicate the results between all stakeholders involved with HEIs can also help to foster trust and engagement. Establishing trust between HEIs and the society in order to promote proper involvement and dissemination of information on and about the events organized.

- **Incentives for engagement.** Organizing events and persuading people to attend is not difficult, but the true involvement of the participant is more challenging (McNamara et al., 2022). Some general incentives, such as showing participants their worth, making sure of the training, securing press coverage for the activities (Chari et al., 2019), and disseminating information in different channels to increase the visibility of participants, are attractive to different participants. In online events, there is a lack of accountability and commitment. In other, in person, events the initial entry barrier may be more of a problem than retention - e.g. participating in a two-day hackathon requires a greater commitment than signing up for a brief online activity.

  However, there are different incentives of interest that may attract different participants. Some incentives for students might be getting practical experience in problem solving and community-building, extending their networking connections or simply gaining experience to add to their CV. For staff and other HEI employees, professional recognition and alignment with their career goals would also be important. Also, more stakeholders would be drawn to Digital Action if their participation was known to other people perhaps from their circle (McNamara et al., 2022). Social acknowledgement of Digital Action participants would also boost interest. Ultimately, HEIs need to encourage students to be more entrepreneurial and this will encourage a visionary approach to problem solving (McNamara et al., 2022). Previous research has shown that a sense of community belonging is linked to a person's decision to stay in their community (Aristeidou et al., 2017).

- **Training & Skills.** Some Digital Action require participants to have specific digital skills; e.g. use of non-code platforms, social media skills or more advanced skills such as python programming, experience in machine learning algorithms etc. Additionally, during the roundtables held as part of the HEIDI project, students expressed concerns of legitimacy,

specifically, they did not feel like they were qualified to be active participants in Digital Action, as for example, data analysis may require skills and experience they do not have. (McNamara et al., 2022). Among different stakeholders, students might be the most flexible to learn new skills in order to take part in a Digital Action, but generally it is necessary to minimize any barriers caused by asking for a set of very specialized skills (McNamara et al., 2022). Digital Action activities should therefore start by making relevant training materials available to potential participants, in accessible and easy to access format. This can help both students and people in the community to participate in the training and become more skilled (McNamara et al., 2022).

- **New roles in Digital Action.** To solve organizational support and leadership structure, Digital Action managers/coordinators could extend leadership circles (distributed leadership), build strong relationships with local-base volunteers (e.g. local hubs), identify devoted volunteers/participants, and create leadership training programs (Chari et al., 2019).

- **Strategic collaboration & Partnerships.** To solve partnership and funding problems, project leaders should diversify funding sources and seek assistance from unusual sources. Organizational reputation might be established in areas where resources are sought, or personal connections could be developed with prominent community or organizational players, independent of current project demands, to achieve this goal (Chari et al., 2019)

- **Transparency and Trust.** Digital Action and the methods involved should be clearly and openly explained to the people who take part in them and to anyone else who might be interested in them. If people agree to be involved and are fully aware of what they're doing, Special attention should be paid to transparency between the stakeholders. A set of rules (e.g. Code of conduct) should be set to ensure research integrity and quality (McNamara et al., 2022).

- **Strategy of digital inclusivity.** From the focus groups with the partners consortium, students expressed that digital environments, being “permanently online”, can create a division among the students, because several students couldn't participate in Digital Action or online activities caused by the digital divide (unequal access, affordability, skills). The digital divide is a barrier expresed by all the consortium partners as a major point to be addressed, as it is particularly relevant to guarantee the inclusion of the most vulnerable communities or individuals (McNamara et al., 2022). Therefore, a strategy of digital inclusivity is important that guarantees a proper internet connection, appropriate equipment and access to software and equipment necessary for the participation.

3. Repositories of Tools, Guidelines and Platforms for Digital Action

This section provides a quick overview of repositories and the specific guidelines and platforms that support the creation, management and dissemination of Citizen Science projects, hackathons and maker movement.

Tools and Materials for Designing and planning Digital Action

Table 3. Tools and Materials for Designing and planning Digital Action

Topic of the Tool/ Material	Organization | Description	Link
Understanding of the problem	GovLab developed a Canvas and a framework of 20 questions to help those working on projects with communities to become more impactful.	Questions: https://github.com/dylanrees/citizen-science Canvas: https://drive.google.com/file/d/0B-BTzZGOWDTHTV9DTnRaZ096NGc/view?resourcekey=0-V9MohIdoMnRd5ptfy8i1oQ
Template Theory of Change	Practical tools for Social innovation	https://diytoolkit.org/tools/theory-of-change/
Resources to identify the problem, vision and theory of change	Tools and template to develop an impact management	https://www.sopact.com/hubfs/Resources/AIM/AIM%20All%204%20Chapters.pdf

Repositories of Tools for Citizen Science Projects

Table 4. Repositories of Tools for Citizen Science Projects

Name	Description	Link
Open Repository of Tools, software & resources	Curated list of awesome software, tool and other resources from data collection, analysis, publication and finantiation	https://github.com/dylanrees/citizen-science

FAIRsharing. Repository of tools for Data management.	A curated, informative and educational resource on data and metadata standards, inter-related to databases and data policies.	https://fairsharing.org/
CitizenLab. Tool for Communication	A digital democracy platform that facilitates communication and co-creation between cities and their communities	https://www.citizenlab.co/platform-online-engagement-toolbox
RRI. Tools for Responsible Research and Innovation	Repository of tools, practices, and publications to develop responsible research and innovation	https://rri-tools.eu/search-engine
Citizen Science Toolkit for teaching	Toolkit designed to help educators integrate Citizen Science projects into classroom curricula or afterschool programming	https://www.calacademy.org/educators/citizen-science-toolkit
Ten principles of Citizen Science. Repository	Document with the principles translate into 26 languages	https://zenodo.org/record/5127534#.Yg6SMBso8_B
Citizen Science Toolkit. Teaching science through Citizen Science	Toolkit to integrate Citizen Science projects into classroom curricula or afterschool programming	https://www.calacademy.org/sites/default/files/assets/docs/pdf/cascitizensciencetoolkit_jd_edits_2019_03_v3.pdf
Journal. Citizen Science: Theory and Practice.	An open-access, peer-reviewed journal dedicated to discussion about methods in Citizen Science.	https://theoryandpractice.citizenscienceassociation.org/

Citizen Science Guidelines by topics

Table 5. Citizen Science Guidelines by topics

Topic	Name	Description	Link
Citizen Science Principles	Ten principles of Citizen Science	key principles for good practice in Citizen Science from European Citizen Science Association	https://ecsa.citizen-science.net/wp-content/uploads/2021/05/ECSA_Ten_Principles_of_CS_English.pdf
Participation	Powercube.net	A resource for understanding power relations in efforts to bring about social change.	https://www.powercube.net/an-introduction-to-power-analysis/
Open Science	The Open Science Guide of Guides	Open Science guides with their specific features and fields of application	https://zenodo.org/record/4740163#.Yg2ewhso8_B
Citizen observatories	WeObserve Cookbook	Guidelines for creating successful and sustainable Citizens Observatories	https://www.weobserve.eu/weobserve-cookbook/
Communication	Communication in Citizen Science	Set of tactics and tools, to secure the initial and continued participation of your citizen scientists	https://www.scivil.be/sites/default/files/paragraph/files/2020-01/Scivil%20Communication%20Guide.pdf
Communication	Using Arts-based Methods in Science Communication	Pop-up guidebook for testing ideas and getting feedback from users applying arts-based methods in the context of science communication	https://hackmd.io/@art-based-methods-guidebook/HJMVIhHFL/%2FjcW-JYxQQz6noMxXwp0uAw

Citizen Science Project inventories and communities

Table 6. Citizen Science Project inventories and communities

Name	Description	Link
SciStarter	A digital platform to find, join, and contribute to science through more than 3,000 formal and informal research projects, events and tools.	https://scistarter.org/finder
ZooUniverse	A Citizen Science web portal owned and operated by the Citizen Science Alliance	https://www.zooniverse.org/
CitSci	Global Citizen Science support platform focus on designing and implementing projects for greater impact	https://citsci.org/
iNaturalist	Joint initiative of the California Academy of Sciences and the National Geographic Society	https://www.inaturalist.org/
European Citizen Science Association	A central hub for new and existing Citizen Science initiatives and networks, in Europe and beyond	https://ecsa.citizen-science.net/
EU-Citizen.Science	Online platform for sharing knowledge, tools, training and resources for Citizen Science – by the community, for the community.	https://eu-citizen.science/
The Observatory of Citizen Science	The Observatory is a web platform in Spanish that promotes a variety of activities - meetings, interviews, publications, hackathons, etc. - and collaborates in other activities organized by different entities.	https://ciencia-ciudadana.es/observatorio/
Participedia	A global network and crowdsourcing platform for researchers, educators, practitioners, policymakers, activists, and anyone interested in public participation and democratic innovations	https://participedia.net/

Crowd4SDG	Promote the development of Citizen Science projects aimed at tackling the Sustainable Development Goals (SDGs), with a focus on climate action.	https://crowd4sdg.eu/about-2/methodology/
Österreich forscht	Online platform of the Citizen Science Network Austria and coordinated by the University of Natural Resources and Life Sciences, Vienna,	https://www.citizen-science.at/en/
Medborgarforskning.s	Online platform to help Swedish universities to use Citizen Science in a responsible and sustainable way, to interact with society.	https://medborgarforskning.se/
InSPIRES Open Platform	Online crowdsourced platform featuring citizen-led participatory R&I projects promoted by knowledge intermediary units, such as Science Shops, Citizen Science groups, etc	https://app.inspiresproject.com/
Geo-wiki	Platform for engaging citizens in both biophysical and socioeconomic monitoring. It aids in both the validation of existing geographical information and the collection of new geographical information through crowdsourcing.	https://www.geo-wiki.org/
#CitizenSData Hub	space to examine the use and practices of Citizen Science for EU policies	https://ec.europa.eu/jrc/communities/en/community/citizensdata
Global Citizen Science Partnership	Network-of-networks that seeks to promote and advance Citizen Science for a sustainable world. Launched in December 2017 at the UN Science-Policy-Business Forum on the Environment	http://citizenscienceglobal.org/

Tools for Hackathons

Table 7. Tools for Hackathons

Name	Description	Link
Judging criteria	A guidelines for judges	https://hobbyhacks.techtogether.io/judging_criteria
Judging projects	Guidelines to organize judging	https://medium.com/techtogether/how-to-organize-judging-for-your-virtual-hackathon-43ce715f95dd
Template to submit projects	Example of Form to submit a project	https://techtogether.typeform.com/to/e8cvB0AF?typeform-source=medium.com
List of of Gender-responsive Hackathons	2021–2022 Edition. Examples of Gender-responsive Hackathons	https://medium.com/techtogether/2021-2022-edition-upcoming-gender-focused-hackathons-cc9ce5fbea8
Hackathon Toolkit (v1.2) for participants	Includes Canvas of: Golden Circle, #MASSIVE Canvas, Pixar Canvas, Lean Canvas, Value Proposition Canvas, Business Model Canvas, Mission Model Canvas, Value Chain Canvas, Target Customer, Interview Context Planner, Interview Questions, Interview Discussion Planner, Interview Notes, Jobs to be Done, Problem as a Comic, Solution as a Comic, Universal Pitch Deck, Jobs, Build and Measure.	https://docs.google.com/presentation/d/182d-2wea42xeYk4jnoeiS9uhsEgkMkbVw7lizBOwpIM/edit#slide=id.g1c229317cb_0_6 Website. https://startupscience.com/hackathon-toolkit/
Hackathon Tools for participants	Tools used by hackers community	https://nyhackathons.com/tools/
Repository of tools and resources for	Repository contains information useful to hackathon organisers and managers. Tips, Tricks, and Resources to help you plan, organise, and execute your hackathons. You can use these to help	https://github.com/github/hackathons

Hackathons for Organisers	Guide you when planning your next hackathon.	
How to organize a hackathon – A planning kit	Planning kit that is organized around 12 key decisions that organizers need to make when preparing and running a hackathon, and the tradeoffs that drive decision-making.	https://arxiv.org/pdf/2008.08025v2.pdf
Guidelines from Open Data Day DC	Guide from Open Data Day DC	https://hackathon.guide/
MLH Hackathon Organizer Guide	Contains a lot of the lessons that we and the hackathon community around the world have learned from organizing hackathons	https://guide.mlh.io/in-person-hackathons/hacker-experience/plan-engaging-workshops
Hacking Culture: a guide	A how to guide for hackathons in the cultural sector	https://waag.org/en/article/hacking-culture-guide

Table 8. Workshops (pre-hacks) for Hackathons

Name	Link
Workshops from HobbyHacks 2021	https://drive.google.com/drive/folders/1i4FFCmlHcd7cSZGBeyGovBscBP8U9IwV?usp=sharing
Workshops from TechTogether Boston 2021	https://drive.google.com/drive/folders/1AYFc5NadNDdlWgi1Hhv7LqlRCWLqK6Zx
Workshops from TechTogether Seattle 2021	https://drive.google.com/drive/folders/1EfMZerg82ZHZ2BX9nTizfwRvlsfOQJC4?usp=sharing
Workshops from TechTogether New York 2021	https://drive.google.com/drive/folders/1goarrEEcrVx-nMkHgyBaC5VCQvKOIEFh?usp=sharing
Hack club Workshops. Learning to code	https://workshops.hackclub.com/

Table 9. Hackathons communities

Name	Description	Link
Hackathon Hackers Europe	Organisation targeted at helping student lead hackathons around europe	https://hackathonhackers.eu/
Major League Hacking (MLH)	Official student hackathon league	https://mlh.io/

Maker Movement Project inventories and communities

Table 17. Maker Movement Project inventories and communities

Name	Description	Link
Biofabricate	A design-focused annual conference that focuses on biotechnology-affiliated design, materials, and techniques	https://www.biofabricate.co/
Innovative Citizen	An annual Citizen Science festival in the Ruhr area, Germany, with an emphasis on organic fabrication, bio-hacking, mobile agriculture, and sustainability in urban ecosystems	http://www.innovative-citizen.de/
MakerFaire	Magazine, repositories, YouTube Videos, and conventions of do it yourself enthusiasts	https://make.co/
Guide for Gender equality in Makerspaces	Steps to address disparities in the MakerMovement	http://www.jspac.org/files/u/a6/f4/attractingwomentomovemaker.pdf
Organizations & Networks FabLabs	organizations and networks have assembled to serve labs and users globally	http://wiki.fablab.is/wiki/Portal:Organizations
Resources and tools	Resources for Maker in Education	https://resources.makered.org/learning
Resources and tools	Database of Maker culture in education	https://oedb.org/ilibrarian/the-maker-culture-in-libraries-and-education/
Bechdel Test - Gender assessment	Questions to Maker spaces to assess their gender balance	https://make-it.io/take-the-bechdel-test/

Map of Fablabs	Map with Fablabs around the world	https://www.fablabs.io/labs/map
FabWiki	Tutorias, software, tools locations	http://wiki.fablab.is/wiki/Portal:Software
Fab Lab/Class Inventory	Kit Inventory of equipment for Fablabs	https://academy.cba.mit.edu/classes/inventory/
MaerTour	French non-profit organisation exploring, sharing and connecting community workshops & makers around the world.	https://www.makertour.fr/workshops
open source software	Resources of open source software for different purposes	http://academy.cba.mit.edu/classes/

4. Impact Assessment Methodology for HEIDI Digital Action

The purpose of this section is to aid practitioners in analyzing Digital Action impacts

To begin an assessment, it is necessary to have a thorough understanding of the program, including its context, stakeholders, and information requirements (Patton, 2018). Assessment is a key component in the project life cycle, ensuring the accountability and social inquiry that are concerned with the usage, methods and values in a process.

An impact assessment is used to enhance or refocus an intervention or to help make decisions about whether an initiative should continue, replicate or scale up (i.e., for summative purposes). It involves searching for the change that a Digital Action brings in terms of socio-economic and/or environmental impacts. Beyond explaining or evaluating the effects of an intervention, it is also important to determine how they are caused - their causal attribution - and investigate unintended consequences (BetterEvaluation, 2015).

To accomplish an impact assessment it is necessary to map and assess the Digital Action' inputs, activities, outputs, anticipated outcomes, and anticipated impacts.

These three terms - outputs, outcomes, and impact - are used to describe various types of change. Outputs are the products, goods, and/or services that are produced as a result. The Outputs lead the short- and medium-term effects (Outcomes), as well as long-term effects (Impacts). The definitions of those terms are presented in Box 7.

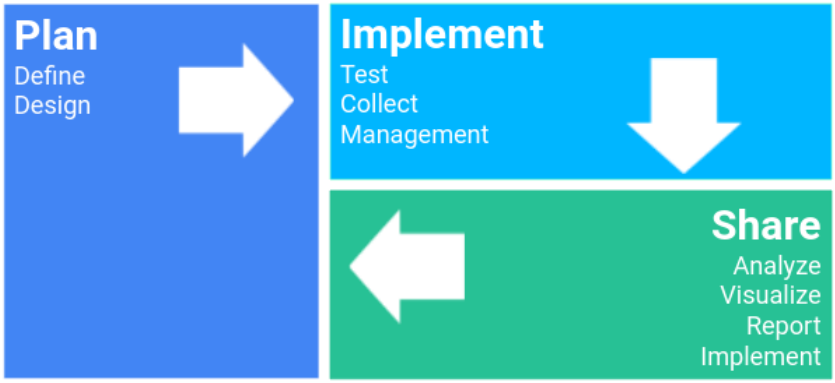
Box 7. Key concepts in Impact Assessment

- **IMPACT**: Long-term outcomes that are broad in scope; aimed at expanding knowledge and capacity for a particular field of study and meant to provide benefits to society. Difficult to measure
- **OUTCOMES**: Changes that are intended to obtain as a result of the Digital Action. They are more difficult to quantify than outputs; often described as short-, medium- and long-term.
- **OUTPUTS**: Direct products - immediate results - of the activities; easy to quantify and focus on things done by participants. e.g. code, products, scientific publications, repositories
- **ACTIVITIES**: Ways the project uses the inputs. Focused on tasks that directly relate to the participants (e.g. data collection, training, workshops).
- **INPUTS**: Resources dedicated or consumed by the Digital Action. It typically includes funding agencies, scientists, staff, volunteers, materials, equipment and technology infrastructure.
- **ASSUMPTIONS.** Factors that may influence the desired improvements. They may be evaluated and modified if necessary. Theory of Change can thus strengthen or refute ideas about how change occurs.

4.1. Guide for Impact Assessment of Digital Action

There are high (and growing) expectations from research funders, society, and researchers themselves to have a positive social and environmental impact. There is also a need for appropriate assessment methods for both accountability and learning, so that researchers can both be accountable and learn from their work (Belcher et al., 2020).

Before starting with the suggested method to perform an impact assessment, it is helpful to see the stages of the impact assessment. The activities are divided into planning, implementation, and sharing stages. As shown in Figure 2, every stage is composed of different steps. All the stages are important, however the planning stage defines the impact assessment and is important to have the time and resources to define and design the methods, instruments and questions to use.



Here we will define a methodology for measuring the impact of Digital Action events in the context of the HEIDI project, specifically by using a questionnaire.

Each individual needs to know why the change is happening and why it is necessary. Without a full understanding of why Digital Action to address community needs is necessary, participants will be unmotivated. Subsequently, this makes the expected results less likely. This questionnaire will assist the efforts towards social change by asking questions on impact and change at the individual level in staff and students in Higher Education Institutions. It will help identify gaps and ways to improve the methodology in the future.

The questionnaire also helps identify actions to strengthen the dynamics (motivation and roles) and performance (skills and level of engagement) of participants in Digital Action. The questions are based on a general approach and aim to provide a way of comparing different Digital Action events, containing only one (final) question that could - and should - be tailored to the specific event and the upcoming ones (or simply omitted if not applicable).

It should be noted - and communicated to the respondents - that there are no "correct" answers. Instead, the questions would lead the responders to reflect on actions to take and communicate the reasons for change (or not), and ultimately to develop and participate in Digital Action with social impact. The questionnaire should take no more than 10-15 minutes to finish.

This awareness assessment should be applied to all Digital Action of the HEIDI project.

4.2. Objective

The aim of the questionnaire is to identify whether there is a significant increase of awareness between before and after the Digital Action.

4.3. Target Audience

Staff and Students from Higher Education institutions. Since we have extended the use of the questionnaire for IO3 our target audience further includes Community Members participating in Digital Action.

4.4. Expected Outcomes of Digital Action events

- To encourage participants to engage in further Digital Action towards community needs, either in the design process, in management or as attendants.
- To promote learning from experience without fear of negative consequences.
- To allow for recognition by stakeholders of their own challenges, resistances and interests towards change.

4.5. Building Awareness - background and goals

Building awareness is part of the process in change management inside of organizations. In this report, awareness building is defined by the ADKAR model ((Hiatt & Creasey, 2003)).

The model consists of five moments, with the first three being necessary for *enablement* and the last two being crucial for *engagement*.

1. **Awareness** of the need to change
2. **Desire** to participate in and support the change
3. **Knowledge** of how to change
4. **Ability** to implement the change
5. **Reinforcement** to sustain the change

To build awareness in the participants, the messages and explanations need to focus on the drivers and opportunities for the change (Digital Action that responds to the community needs), on the reasons why change is necessary and on the risks of not changing.

Awareness building can be considered successful if the participant understands the nature of change and what the change requires.

4.6. Awareness assessment implementation

The awareness assessment should be performed both at the start and at the end of the activity.

The organizers should communicate to the responders that there are no *right* or *wrong* answers. It is also important to inform them that the data will be anonymized in the analysis, with only general information being kept (type of action, their stakeholder category, etc.). The questions are meant to assess the change of opinion and attitude that can be triggered by participating in the activities, but also to obtain information that would help in organization of future Digital Action.

The questions proposed can be tailored to different organizations, contexts, people and Digital Action. The questionnaire below should be used as a template and adapted to local situations, e.g. by adding the name of the Digital Action(s) that is being evaluated. The answers obtained will enable organizers to identify the participants' expectations for future activities, as well as their requirements and needs.

4.6.1. Initial Questions - distributed before the activity

Table 10. Initial questions, distributed before the DA activity

Question No	Question text	Metric
1	Have you ever participated in Digital Action that addresses community needs, or aims to address a sustainable development goal? (one option)	1. Not a all 2. Occasionally 3. On regular basis 4. Deeply involved
2	If yes to (1), what was your role in the Digital Action(s) you joined?	1. Participant 2. Designer 3. Manager 4. Both
3	Are you familiar with the concept of theory of change?	1. Never heard of it 2. I am aware but I haven't use it 3. I have use sometimes 4. I use most of the time
4	What are your expectations for this activity?	Open question

4.6.2. Final Questions - distributed after the activity

Table 11. Final questions, distributed after the DA activity

Question No	Question text	Metric
1	Has the activity you just participated in met your expectations?	1. Not a all 2. I am not sure 3. I am sure 4. Why?
2	How likely are you to participate in a Digital Action that tackles the community needs or sustainable development goals in the future?	1. Very Unlikely 2. Somewhat Unlikely 3. Not sure 4. Somewhat likely 5. Very likely
3	Digital Action can address the needs of different stakeholders. Which targets do you prefer? (circle all that apply)	1. Companies 2. Researchers 3. Community 4. Government
4	What skills do you think you would need to have in order to successfully participate in a Digital Action?	Open question
5	Do you think the activity has increased your motivation or interest for participating in Digital Action that addresses community needs?	1. Not a all 2. Slightly 3. Very much 4. I am not sure
6	What are your motivations or interests to be engaged with a Digital Action that addresses the community needs?	Open question
7	In the context of participating in Digital Action, what do you think you will do differently in the future, as a result of what you learned today?	Open question
8	Would you recommend participating in Digital Action that addresses community needs to a friend or associate?	1. Definitely Not 2. Probably Not 3. Not sure 4. Probably 5. Definitely

9	On a scale from 1 to 10, rate your satisfaction with this event	Scale 1-10

4.6.3. Open Dialogue. Sharing perspectives

Enabling open dialogue between participants is important to have them reflect, ask questions, and share their own examples and experiences. Sharing various perspectives will help make a strong case for change.

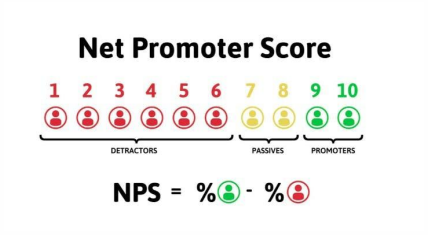
To conclude your activity, we advise that you ask each participant to share 4 phrases:

I discovered…
I feel…
I learned…
I suggest …

4.7. Indicators and metrics calculations

The answers to the questionnaires should be analyzed to show attitudes and opinions of the participants. Some specific metrics are offered below.

Table 12. Indicators and metrics calculations for assessment of DA

Indicator	Metrics
Participant satisfaction	Use of the Net Promoter Score (or NPS) is an indicator of the overall satisfaction rate of the event. $a = Rate\ of\ promoters$ $b = Rate\ of\ detractors$ *Net Promoter Score = (a - b) x100* 
Participants growth	$a = Number\ of\ Participants\ 1st\ event$ $b = Number\ of\ Participants\ 2nd\ event$ $Participant\ growth = (b - a) / a * 100$
Newsletter subscriber growth	$a = Number\ of\ subscribers\ 1\ week\ after\ the\ event$ $b = Number\ of\ subscribers\ 1\ month\ before\ the\ event$ $Subscribers\ growth = (a - b) / a * 100$

Source: (Satmetrix, 2022)

4.2.1. Impact Assessment criteria and supporting questions

Scientific dimension

Table 13. Scientific Dimension. Impact Assessment criteria and supporting questions

Dimension	Outcome and impact	Supporting questions
Scientific	Scientific knowledge, skills, and publications	•Does the DA demonstrate an appropriate publication strategy, both in scientific and other media outlets? •Are citizen scientists recognised in publications and if so, can they participate in the dissemination of results?
	New research fields and structures	•Did the DA generate new research questions, projects or proposals? •Did the DA contribute to any institutional or structural changes?
	New knowledge resources	•Does the DA ease access to traditional and local knowledge resources? •Does the DA contribute to a better understanding of science in society?
	New technologies	•Does the project foster the use or development of new technologies?

(Kieslinger et al., 2018; Wehn et al., 2017)

Participant Dimension

Dimension	Outcome and impact	Supporting questions
Individual	Knowledge & skills	• What are the learning outcomes with regards to new knowledge, skills and competencies for the participants?
	Science literacy	• Does the DA contribute to a better understanding of science? • Does the DA contribute to a better understanding of the scientific topic?
	Behavior and ownership	• Does the DA foster ownership amongst participants? • Does the DA contribute to facilitating individual change behavior or political citizenship?
	Communication	• Was the DA disseminated in diverse channels to ensure broad participation (gender, ethnicity, and disability)?
	Motivation and engagement	• Does the DA raise motivation, self-esteem and empowerment amongst participants? • Are the participants motivated to continue the DA or involve in similar activities? • Does the DA provide mentorship, incubator program, monetary support or other implementation that supports product development? *(applied to Hackathons)*

Collective	Collective capacity	•Does the project contribute to the collective capacity of the participants in achieving common goals?
	Working together	• What is the perception of the community members about the influence they have as a group? • Does the project increase the frequency of formal collaborations between stakeholders?
	Access to data	• Have changed the access restrictions/control to the data for the different stakeholder groups?
	Political participation	• Does the DA stimulate political Participation? (onsite, online) • Does the DA impact on policy processes and decision-making (e.g., through agenda-setting or data contribution for policy evaluation)?
	Multilevel interactions of actors	•Does the DA increase the coordination mechanisms between governmental and non-governmental stakeholders?

Table 14. Participant Dimension. Impact Assessment criteria and supporting questions (Kieslinger et al., 2018; Wehn et al., 2017)

Environmental, Economic and Sustainability Dimension

Table 15. Environmental, Economic and Sustainability Dimension. Impact Assessment criteria and supporting questions

Dimension	**Outcome and impact**	**Supporting questions**
Environmental	Targeted Interventions	•Does the project include objectives that protect and enhance natural resources and/or foster environmental protection?
	Awareness	•Does the project contribute to higher awareness, knowledge and responsibility for the natural environment?
Sustainability	Sustainable practices	•Does the project consider sustainability (environmental impact or sustained social relations) as part of the DA planning?
	Social innovation practice	•Are the DA results transferable to other contexts or organizations? •Does the project contribute to social, technical or political innovation?
Economic	Economic potential	•Does the DA generate any economic impact or competitive advantages, (e.g., cost reduction, new job creation, new business models, etc.)
	Market opportunities	•Does the DA foster cooperation for exploitation, (e.g., with social entrepreneurs)?

(Kieslinger et al., 2018; Wehn et al., 2017)

4.3. Summary of elements in Impact Assessment of Digital Action

Digital Action in the HEIDI Project are processes that involve various stakeholders in an active participatory approach. There are different generic approaches that can be used to measure progress in terms of outcomes and impacts, but they must be tailored to the specific context in which the project is taking place.

Table 16 presents impact assessment approaches focused on social change (community needs and transformation of conditions) that involve local organizations, differentiated by the three types of DA of interest in this project.

Table 16. Elements of Impact Assessment of Digital Action

Feature	**Citizen Science project**	**Hackathon**	**Maker Movement**
Impact design	Impact value chain- ToC	Impact value chain- ToC	Impact value chain- ToC
Assessment framework	((Kieslinger et al., 2018) CSIAF IA4SI	IA4SI	MAKE-IT IA4SI
Outputs (products)	-Written Publications -Policies recommendation -Communication -Datasets -Open repositories -Digital platform -Training	-Documentation -Product innovation -Social innovation -Digital Products - Code -Databases -Open repositories -Events / Training	-Documentation -Product innovation -Digital products - Code -Open repositories -Collection of tools -Events / Training
Learning outcomes	-Behavior -Awareness -Data collection -Science Concepts -Data Storytelling	-Coding and hacking -Design thinking -Ideation -Prototyping -Pitching	-DIY Science -Coding and hacking -Ideation & Prototyping -Use of tools & equipment -Awareness -Science concepts

Impact indicator	-Individual development -Collective development -Data points collected -Data quality -Attitude change -Actions taken -Policy change -Scientific impact -Awareness raised -Personal development -Environmental impact	-Individual development -Awareness raised -New products -Program increment -Innovation -Actions taken -Environmental impact -Social impact (Experience, Networking, Collaborations) -Economic impact	-Individual/ Collective development -New products -Innovation -Attitude change -Technological citizenship -Actions taken -Awareness raised -Personal development -Environmental impact -Social impact -Economic impact
Communication methods	Impact stories	Pitching / Slide decks	Storymaking Pitching / Slide decks
Data collection methods	-Surveys -Interviews -Focus groups -Digital platform behavior -Data from blogs/forums	-Surveys -Interviews -Feedback questionnaire -Interactions -Code & repositories	-Surveys -Interviews -Publications -Self-reflection (individual/collective)
Who collects the information?	-Citizen scientist -stakeholders -Users / Beneficiaries	-Hackers -stakeholders -Users	-Makers -stakeholders -Users

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