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# Bottom-Up and Reciprocal Citizen Science: Untapped Resources of Novel Ideas. Preliminary Experiences of a Citizen Science As Public Engagement Program

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## Abstract

In scientific research, citizen science is widely regarded as an involvement of the general public in scientific research initiated by universities, scientific organisations or research centres. In this top-down approach (top-down citizen science), participating citizens usually collect data or provide samples for research — that is, they are considered volunteer research assistants following instructions. This study analyses alternatives of top-down citizen science: one, widely known, which is the bottom-up way of citizen science and another, the reciprocal approach suggested by the authors. Bottom-up is based on local initiatives and is constituted by community-led projects. For bottom-up citizen science, scientific organisations may provide methodological and organisational frames. However, the idea and the implementation remain in the competence of the participant citizens. Reciprocal citizen science emerged from a need for a more holistic policy toward citizen science. As part of this, identifying viable citizen-initiated projects, measuring their scientific and/or innovation potential, and integrating them into a citizen science mentor program are questions to be systematically discussed and solved. This study addresses methodological challenges in mentoring citizen science projects, covering a mentor training concept for citizen science designed by the Institute of Transdisciplinary Discoveries. Encouraging citizen research is needed for a new impetus to scientific discoveries. The perspectives of people with no scientific background can also advance problems — mainly those that require fresh and unbiased approaches. Citizen science may also be a solution for leveraging the knowledge of science leavers.

## Keywords

citizen science, mentoring, bottom-up citizen science, empowerment

# Ciência Cidadã Recíproca e de Baixo Para Cima: Recursos Inexplorados de Novas Ideias. Experiências Preliminares de um Programa de Ciência Cidadã Como Envolvimento Público

**Resumo**

Na pesquisa científica, a ciência cidadã é amplamente considerada como o envolvimento do público geral em pesquisas científicas iniciadas por universidades, organizações científicas ou centros de investigação. Nessa abordagem de cima para baixo (ciência cidadã chamada top-down), os cidadãos participantes geralmente recolhem dados ou fornecem amostras para pesquisa — ou seja, são considerados assistentes voluntários de pesquisa que seguem instruções. O presente estudo analisa alternativas de ciência cidadã top-down: uma, amplamente conhecida, que é o método bottom-up (de baixo para cima) da ciência cidadã e outra, a abordagem recíproca sugerida pelos autores. Bottom-up é baseado em iniciativas locais e é constituído por projetos liderados pela comunidade. Para a ciência cidadã de baixo para cima, as organizações científicas podem fornecer estruturas metodológicas e organizacionais. No entanto, a ideia e a implementação continuam a pertencer à competência dos cidadãos participantes. A ciência cidadã recíproca surgiu da necessidade de uma abordagem mais holística da ciência cidadã. Como parte disso, identificar projetos viáveis, medir o seu potencial científico e/ou inovativo e integrá-los a um programa de mentores de ciência cidadã são questões a serem discutidas e resolvidas sistematicamente. Este estudo aborda desafios metodológicos na mentoria de projetos de ciência cidadã, abrangendo um conceito de formação de mentores concebido pelo Instituto de Descobertas Transdisciplinares. Incentivar a pesquisa dos cidadãos é necessário para dar um novo impulso às descobertas científicas. As perspectivas de pessoas sem formação científica também podem trazer problemas — principalmente aqueles que exigem abordagens novas e imparciais. A ciência cidadã também pode ser uma solução para alavancar o conhecimento dos que abandonaram a carreira científica.

**Palavras-chave**

ciência cidadã, mentoria, ciência cidadã de baixo para cima, empoderamento

## 1. Introduction: Citizen Science As Public Engagement

### 1.1. Bottom-Up Citizen Science: From Science Communication to Involvement of the Public in Scientific Activities

The trend of universities moving from entrepreneurial to civic universities indicates that higher education institutes recognised the necessity of embeddedness of education and scientific organisations in society. The involvement of non-scientifically qualified citizens in scientific projects goes back to the mid-1990s (Vohland, Göbel et al., 2021), although, in the 1920s, citizen involvement in scientific questions was also described by the term "scientific citizen" (Cohen, 1920). Initially, people volunteered their time and energy to help with various research projects. Despite the many decades of history, "citizen science" (CS) and "citizen scientist" expressions first appeared in the *Oxford English*

*Dictionary* in 2014. The dictionary describes it as: CS as a "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions" (Haklay, 2014, para. 4). Citizen scientist as "a member of the general public who engages in scientific work, often in collaboration with or under the direction of professional scientists and scientific institutions; an amateur scientist" (Haklay, 2014, para. 6).

CS emerged from the recognition that science, technology, and innovation could respond better to environmental, social and economic challenges if a wider circulation of scientific findings is ensured. It is possible when local, national, regional and global participation in the research is available for any entity of the society. Since the first appearance of the expression CS in the literature, its meaning has changed. New expressions emerged to describe the level of involvement of citizens in scientific projects. The most common form of CS to date is when a university or other academic institution encourages citizens to collect data for research initiated by a person or institution with authority in the scientific field. That is the so-called top-down (TD) approach of CS. TD CS often serves for observing or monitoring environmental phenomena, and data are used at the national or international level (cf., Eicken et al., 2021, p. 468).

Bonney et al. (2009) developed an often-used categorisation of CS projects. Their framework defines:

- *contributory* projects as projects where scientists design the project and participants are involved in collecting and analysing data according to predefined protocols;
- *collaborative* projects, participants may also be involved in adjusting protocols, drawing conclusions, and proposing new directions for research;
- *co-created* projects include citizens in all stages of the scientific process; scientists and citizens collectively design and develop the project.

Another categorisation often cited is based on the levels of participation. In Haklay's (2013) classification, levels range from

- citizens as *sensors* (crowdsourcing), and
- citizens as *interpreters* (distributed intelligence),
- to levels where participants are more involved in problem definition and collection protocols (participatory science) or are *even part of the entire development of the scientific process* (extreme CS).

Growing dissatisfaction within academia and industry hot environmental and societal topics of interest to the public, leading to the more active participation of the public in science. The UNESCO Recommendation on Open Science (2021) is one of the most important international documents, stating that science must be open to the widest possible public and that scientific data from stakeholders must also be incorporated into research. Open science (broadly in line with the concept of CS), according to the recommendation,

> should not only foster enhanced sharing of scientific knowledge but also promote inclusion of scholarly knowledge from marginalised groups (such

> as women, minorities, Indigenous scholars, non-Anglophone scholars, scholars from less-advantaged countries) and contribute to reducing inequalities in access to scientific development, infrastructures and capabilities among different countries and regions. (UNESCO Recommendation on Open Science, 2021, p. 5)

This approach is the same as that represented by the so-called bottom-up (BU) CS. BU CS is a growing method of public engagement with science, in which citizens perform scientific activities, including data collection or even complex research, in order to address local and global issues. Contrary to TD CS projects in which citizens collect data in institutionally controlled projects, the BU approach is citizen-initiated. "Observing or monitoring efforts defined and undertaken at the local scale and brought forward to higher-level bodies, often with a focus on supporting outcomes desired by a local community" (Eicken et al., 2021, p. 468).

### 1.2. Criticism of Top-Down Citizen Science

In general, citizens can engage in different levels of the scientific process, including the development of research questions and hypotheses, data collection, data analysis, drawing conclusions, and disseminating data. The most popular form of CS, as described above, is when citizens collect data under the direction of professional scientific institutions (TD approach, cf., Haklay et al., 2021, pp. 15–18). In these scientist-led projects, the level of citizen engagement varies but is limited: citizens can be involved only in data collection, or they can analyse and evaluate gathered data. The advantage of this type of CS is that professionals regulate research projects. Therefore, the collected data are more reliable. Some critics of TD CS mention that these projects exploit citizens by making them collect data and/or be scientific assistants for free, or these projects do not give eureka moments to citizens (Vohland, Land-Zandstra, et al., 2021, pp. 2, 5). In addition, the TD CS strategy emphasises unequal relationships between the academic sector and the citizens. Although it can be viewed as an exercise to connect research and citizens, it rarely allows ordinary citizens to peek behind the doors of a research lab or institute. Thus it is an insufficient exercise to break down the "ivory tower" image of universities. However, some researchers continue to suggest that valid scientific results can only come from scientist-led research legitimised by a scientific institution (Haklay, 2013).

Universities in the most developed countries exercise the civic university ethos and even integrate citizens actively in the design and planning of the research (Follett & Strezov, 2015; Haklay et al., 2021, p. 14). Therefore, we find some examples of scientific institutions supporting the BU approach. The most typical BU projects are more active (and activist) because citizens lead their own projects, which are mostly related to solving some community problems or needs, but in most cases, the idea or the encouragement is from a scientific institute (Ostermann-Miyashita et al., 2021, p. 5). BU type of CS is focused on the needs of stakeholders.

However, BU has weaknesses as well. The danger of BU projects is that the citizens can be personally involved and/or interested in the project, so they can easily be biased. Another difficulty is that they do do-it-yourself research without sufficient scientific methodological knowledge resulting in wasted efforts and outputs that the scientific community cannot accept, further inserting a wedge between the research and citizen community.

BU calls attention to the potential of citizens' own discoveries and suggests that the role of scientists can also be supportive. In BU projects, citizens can approach scientists looking for assistance with their projects.

Citizens can also be involved in scientific projects in a more extreme way than BU. In the extreme CS approach (Haklay, 2013), participants try to design and develop new devices and knowledge creation processes that can be useful for society, considering local needs, practices, culture and works. It enables any community, regardless of their literacy or scientific qualifications. Stakeholders can be an active part of the whole process — from problem definition, data collection, and analysis, and visualisation to action. Therefore, those people who do extreme CS are empowered to be part of the entire development of the scientific project. Of course, using this method, there is a threat that citizens use scientific data from unchecked sources or draw incorrect conclusions. That is particularly dangerous when citizens are involved in sensitive local affairs as hobby researchers.

Given the above, there is a need for an approach to CS that builds on stakeholder issues but works with a methodology that meets the highest possible scientific criteria. In our paper, we propose such an approach by combining the benefits of TD and BU CS.

## 2. Methods of Reciprocal Citizen Science

A novel approach to CS, the so-called "reciprocal CS" (RCS), introduced by the Institute of Transdisciplinary Discoveries (ITD), University of Pécs, Hungary, in the "International Transdisciplinarity Conference" (Sík et al., 2021), combines the advantages of TD, and BU approaches. RCS is based on citizen-initiated research ideas and is citizen-led. In order to avoid pseudoscientific or biased approaches, the university (or other scientific institution) provides scientific support, especially in the field of methodology and equipment, if needed. RCS differs from the BU approach in that the former is more organised and systematised due to the supervision and because the support provided for the citizens is useful for the university as well because it helps to elaborate more modern and efficient ways of scientific mentoring and it can lead to novel approaches of scientific problems. We call this approach reciprocal (see Table 1) because the university also benefits from a research project that solves a local community or even individual problem. In RCS, the source of the research idea is the citizen, and the role of the scientific institution is support, encouragement, and scientific coaching (research design, methods, scientific presentation and writing). If the citizen needs it, the institution can provide equipment as well.

| Approaches to citizen science | Motivation | Stakeholder benefit | Methodological accuracy | Scientific networking | Main characteristics |
|---|---|---|---|---|---|
| Top-down | ↓ | ↓ | ↑ | ↑ | Citizens involved in data collection<br>Research regulated by professionals |
| Bottom-up | ↑ | ↑ | ↓ | ↓ | Projects based on citizens' ideas and needs<br>Research regulated by citizens |
| Unleash your inner scientist (reciprocal citizen science) | ↑ | ↑ | ↑ | ↑ | University encouraged and supported projects<br>Citizen-initiated topics and citizen-led research |

**Table 1** *Reciprocal citizen science compared to top-down and bottom-up approaches*

RCS can be implemented through a comprehensive *mentoring programme*. In the field of CS, almost all the mentoring programmes represent the TD approach. That is, a scientific institution prepares the citizens for the scientific data collection and possibly for the use of the application or other data organisation solution that the institution uses for the scientific research (cf., Haklay 2013). A huge difference from TD mentoring programmes is that in RCS, citizens get specific mentoring according to their needs. After an initial assessment, similar to a placement test, the mentoring program's organisers decide what training the mentee needs. In addition to developing research methodology, scientific database searching, scientific writing, and presentation skills, mentees can be provided with entrepreneurship coaching and incubation programmes if their ideas are worth enlarging into a startup.

The main novelty of the RCS approach is that it applies citizen engagement through mentoring. RCS encourages citizens to bring their own ideas to scientific institutions, which provides them mentoring, and support and gives scientific assistance tailored to the needs of the citizen. RCS uses a BU methodology because incubated research projects are based on citizens' ideas. They initiate and lead their own projects based on local or own interests or public issues. However, RCS uses the advantage of the TD approach to the extent that it is academy-encouraged and -supported. In addition, RCS provides methodological knowledge, research tools and infrastructure and entrepreneurial training in the case of projects with innovation potential. This multifaceted approach encourages citizens to publish their results or start a venture in the business field.

Considering that this combination of TD and BU approaches, by its very nature, leads to mutual knowledge and experience exchange among all levels of academic representatives and citizens, we define our approach as RCS. ITD of the University of Pécs elaborated a RCS mentoring program with the title of Unleash Your Inner Scientist. Unleash Your Inner Scientist is a transdisciplinary program that provides a mentoring framework for supporting citizen-initiated and -led scientific and innovation projects while developing

a complete, practical-based methodological strategy for the scientific mentoring of citizens. Unleash Your Inner Scientist is currently in the pilot phase. It combines the benefits of TD and BU, making it RCS-based and unique in that it provides a comprehensive mentoring program for citizens, which aims to make the scientific or innovative results developed in the program known to the general scientific public. The scientific institute's role is to provide support and scientific coaching (research design, methods, scientific presentation and writing), equipment and entrepreneurship coaching (if needed). At the societal level, the RCS-based mentoring program's benefit is the encouragement of civic activism in a scientific way avoiding or at least controlling pseudoscience.

### 2.1. Advantages of Reciprocal Citizen Science in Approaching the University and Society

#### 2.1.1. Reciprocal Citizen Science As a Transdisciplinary Method

Since CS is conducted by lay people, or at least by people who do not practice scientific research within an institutional, standardised framework, it is surprising that there are few CS mentoring programs. We can find among the few examples a mentoring and training program for open science ambassadors whose purpose is to empower citizen scientists to become effective open science ambassadors in their communities. However, this project is only for life science. Other CS mentoring programmes are focused on TD approaches and training citizen scientists as data collectors.

RCS offers a novel approach to CS and opens opportunities for involving lay people more extensively in science while maintaining all the advantages of the TD and BU approaches as researchers-led projects. Also, civil activism and social innovations remain viable. This approach exploits the citizens' scientific and/or innovation potentials while consistently contributing to their skill development. Importantly, the RSC implements a crucial aspect of the citizen-academy relationship: transdisciplinarity. When universities or research institutes look beyond the organisation's wall and seek the involvement of external stakeholders, then they create transdisciplinary projects and implement what is in the ethos of the civic university model.

#### 2.1.2. Reciprocal Citizen Science As Innovation Potential

RCS can be embedded in the civic university approach. Civic university (Goddard et al., 2016) is based on the societal embeddedness of the university, when higher education institutes collaborate with local area and community, in partnership with local organisations, taking social responsibility.

The overall goal of RCS is to create a new way of citizen involvement in scientific research. Even the most extreme citizen involvement approach, the idea to be developed is either created or co-created by a scientist neglecting the huge potential of the non-scientific community. Considering that scientists make up only a small fraction of the adult human population, it would be unreasonable to think that citizens are not full of ideas that have *innovation potential*. In this project, we tap into this pool of ideas by

creating the citizen-led project development approach. This unique approach also has a *knock-on effect on the academia-public relationship*. Since universities gradually move to "civic university" engagement recognising the embeddedness of universities in society, this approach brings the two sectors closer together. It builds trust in the academic sectors from the civil and general public points of view.

The core concept is that the knowledge and innovation potential of lay and/or non-scientific people often do not receive enough visibility, although many inventions and discoveries are also tied to these people. The knowledge generated by these people cannot be ignored in the information society.

> Involving citizens and broader communities beyond universities and traditional research institutions as participants in research systems has been defined as one of the megatrends that will influence future research policy. There is an increasing focus on how laypeople and other communities outside of traditional research institutions can be involved in all levels of research activities, including data collection and categorisation. (Magnussen, 2017, p. 394)

There are few researchers in society, so in scientific research and innovation, it would be a waste to miss someone who is not an institutional researcher.

Laypeople's inventions cannot be underestimated because some of them changed humanity. For example, the first operational aircraft was invented by the Wright Brothers. In these projects mentoring plays a crucial role in the success and effective progression.

RCS's development goals align with the *most in-demand core skills for work and life*. According to the *Future of Jobs Report 2020* of the World Economic Forum (2020), some of the top skills for 2025 are analytical thinking and innovation, active learning and learning strategies, complex critical thinking and analysis, problem-solving, creativity, originality and initiative, reasoning, problem-solving and ideation. Besides individual skill development, RCS is expected to have impacts at several levels in the lives of individuals and smaller or larger communities.

### 2.1.3. Reciprocal Citizen Science As Bridge of the Gender Gap

Even in the 21st century, relatively few women choose a career in science, and many leave the research career. According to UNESCO Institute for Statistics (2019) data, less than 30% of the world's researchers are women and women leave science careers in greater numbers than men. CS is an ideal option for women who do not have the time or opportunity to conduct scientific research professionally but would continue their previously discontinued research or embark on a career in science and/or innovation. In this way, these women can satisfy their desire for scientific success and have the opportunity to develop their ideas. Because the RCS can be done on a flexible schedule, it also fits into the agenda of mothers with children. Our preliminary market research shows the same: 62% of the respondents are female. Therefore, RCS can reduce the gender gap, providing empowerment to women and other underrepresented genders in scientific

research. RCS can also be a solution for disadvantaged citizens who have not had access to higher education or cannot engage in scientific research due to financial constraints.

#### 2.1.4. Reciprocal Citizen Science As Empowerment of Less-Advantaged Communities

RCS is not only able to solve local social and environmental problems but also to bring more citizens closer to academia. In the long run, this could even reduce university dropouts. Eurostat (2018) data show that 25% of students drop out of universities in the European Union. That means millions of students in a few years who will no longer make use of their academic knowledge after a few years. If a small portion of this group can be kept in the circle of scientific thinking with the help of RCS, it means that the knowledge taught at the university is not wasted, nor is it such a loss for individuals. The advantages of RCS are deepening and expanding scientific knowledge, improving understanding of research methods, deepening and expanding their knowledge of scientific research methodology, strengthening their researcher confidence, and developing their presentation and scientific writing skills. Moreover, what is important from the point of view of the labour market, is increased potential for career mobility and promotion and the opportunity to be in a supportive environment in which successes and further development opportunities can be evaluated. RCS provides people networking opportunities and empowerment.

#### 2.1.5. General Motivational Factors

To better understand why people are participating in CS projects and why CS projects can attract people from non-scientific communities, firstly, we need to understand why people do voluntary activities. The following six motivational factors (volunteer functions inventory; Clary et al., 1998) can give us an explanation:

1. values — a possibility to express altruistic and humanitarian values;
2. understanding — an opportunity to earn knowledge, skills, and abilities;
3. social — an opportunity to strengthen and develop relations with others;
4. career — an opportunity to gain career-related benefits from volunteering activities;
5. protective — an opportunity to reduce guilt over being more fortunate than others;
6. enhancement — a possibility to aid the ego to grow and develop.

Therefore, CS is an ideal voluntary activity because CS projects can be based on altruistic and/or community goals, and at the same time, citizens' research activities can widen their knowledge base. CS provides an ideal opportunity to develop social relations, that is, in a local community. Citizens' projects often need new competencies which can be used in the labour market as well, and, hopefully, and this is not a very utopian idea, CS can contribute to the citizen's personal development.

Parthenos (2019) also collected CS's benefits for the citizens. These outcomes, of course, are ideally aligned with participant motivations:

- new/increased scientific knowledge and understanding;
- building/belonging to a community; social learning;
- empowerment;

- raised awareness;
- data access;
- development of personal capacities — the experience of self-efficacy and a sense of purpose.

These benefits are especially true if the CS project is implemented in an organised manner, linked to monitoring, and the citizen receives scientific assistance. Therefore, we believe that RCS is the ideal form of CS because it includes organised supervision and assistance for the citizens, and all the support is tailored to citizens' needs.

#### 2.1.6. Reciprocal Citizen Science As a Solution for Burnout of Academic Researchers

RCS brings benefits not only to citizens but also to academic institutions. Involving university researchers in CS projects, such as mentors, can help them think from a broader perspective and face new social, environmental or other issues. Burnout in researchers and academics is a little-studied phenomenon. One of the best-known theories of burnout was provided by Maslach and Jackson (1982). They reveal the burnout phenomenon in three dimensions: first, emotional exhaustion (which is the leading symptom of burnout and suggests that the person's deep emotional resources have run out). Second, negative attitudes and impatience towards clients, colleagues and the job itself and third, reduced sense of effectiveness (a high degree of negative self-esteem is also associated).

While in other sectors of the economy, employees are increasingly appearing as key players in corporate performance, as their competence, efforts, motivation and commitment fundamentally affect competitiveness, the key role of employees in educational organisations is uninteresting for the employer in this respect (Jármai, 2018, p. 116). Large companies (especially multinational companies) are taking more and more serious care to organise their employees' mental, physical, and rest needs. However, there is no organised opportunity for teachers to discuss problems, supervise, maintain and develop their own personalities (work equipment). So, because of this feature, the quality of work can only be assessed indirectly, as there is no acceptable, standardised way or consequence of direct superior and student assessment, or not even its social recognition. Education plays a key role in society. The subjective well-being of its workers hardly preoccupies economic, professional, or even institutional decision-makers. There are aspirations for change and initial attempts to introduce various incentive systems to motivate employees based on performance to improve their work, but the information they receive reflects a mixed experience. The basic condition of subjective well-being is the feeling of satisfaction arising from professional self-fulfilment and self-realisation.

Burnout caused by overload particularly affects researchers in the science, technology, engineering, and math sectors (Site, 2017). Burnout is a direct consequence of competition. When scientists reach their goals, win an award, or are promoted, those successes help their recovery from stress. However, scientists' lives consist of more unsuccess and lack of time and money, or even the lack of positive feedback are extra factors of burnout.

Among the solutions to mental burnout, in addition to consulting a professional and having more rest, we also find knowledge transfer. A *Nature* article from 2020 (Gewin, 2020) encourages researchers to spread their knowledge. The article emphasises the importance of knowledge transfer not only from the societal point of view. The author believes that knowledge sharing helps researchers achieve a more balanced mental state. From this, we can deduce that CS is a possible form of researcher burnout prevention or treatment. Of course, it is not the only solution, but it can expand the repertoire of offerings and societal functions of universities. Another important factor in academic burnout is that the researchers need to build relationships for recognition. Publications and conference presentations are often exhausting for researchers (Site, 2017). CS offers a more relaxing network because it is based on more informal relationships and communication forms.

CS offers a new kind of connection for researchers, in which they do not need to solve difficult scientific tasks but can use their existing knowledge, learn new perspectives, and successfully solve scientific or social problems. Positive impacts of RCS for researchers as mentors are different and vary a lot according to their motivation and fields of interest. In general, scientists may encounter approaches to scientific phenomena and problems, which can serve as an inspiration even in their own research careers through challenging discussions with people who have fresh perspectives. Academic lecturers can benefit from developing their mentoring (communication, interpersonal, conflict management) skills by expanding their mentoring tools. The out-of-the-box thinking can provide them opportunities to test new ideas and gain further knowledge, improve their ability to share experience, knowledge, competencies and skills, and capacity to motivate another person. Finally, RCS provides a potential to renew enthusiasm for their role as experienced researchers and opportunities to reflect upon and articulate roles and responsibilities.

## 3. Preliminary Experiences of a Reciprocal Citizen Science-Based Mentoring Program

### 3.1. Unleash Your Inner Scientist Program

Combining the benefits of TD and BU and implementing an RCS-based practice, ITD of the University of Pécs elaborated an RCS mentoring program titled Unleash Your Inner Scientist. It provides a comprehensive mentoring program for citizens which aims to make the scientific or innovative results developed in the program known to the general scientific public. The scientific institute provides support, scientific coaching (research design, methods, scientific presentation and writing), and equipment and entrepreneurship coaching (if needed). At the societal level, the RCS-based mentoring program's benefit is the encouragement of civic activism in a scientific way avoiding or at least controlling pseudoscience.

Unleash Your Inner Scientist is based on transdisciplinarity, providing a mentoring framework for supporting citizens' scientific and innovation projects through a complete,

practical-based methodological strategy for empowering local initiatives. The project aims at the general public (lay people, citizens) interested in science to develop primarily their scientific and, secondarily, their entrepreneurial and communication skills. The programme aims to support citizens in elaborating their area of interest on a scientific level, however, without integrating them into formal educational frameworks. The core element of the programme, that is, the citizen empowerment process, uses the tools of scientific and business mentoring, coaching and project consultation and provides scientific training to citizens (mentees). Parallelly, another important part of the core element is network building for mentors who form a learning community, sharing methodological expertise and the experience generated during the mentoring process. The experience share is cyclic: the experience and data collected in the pilot are used in the second cycle and so on (see Figure 1).

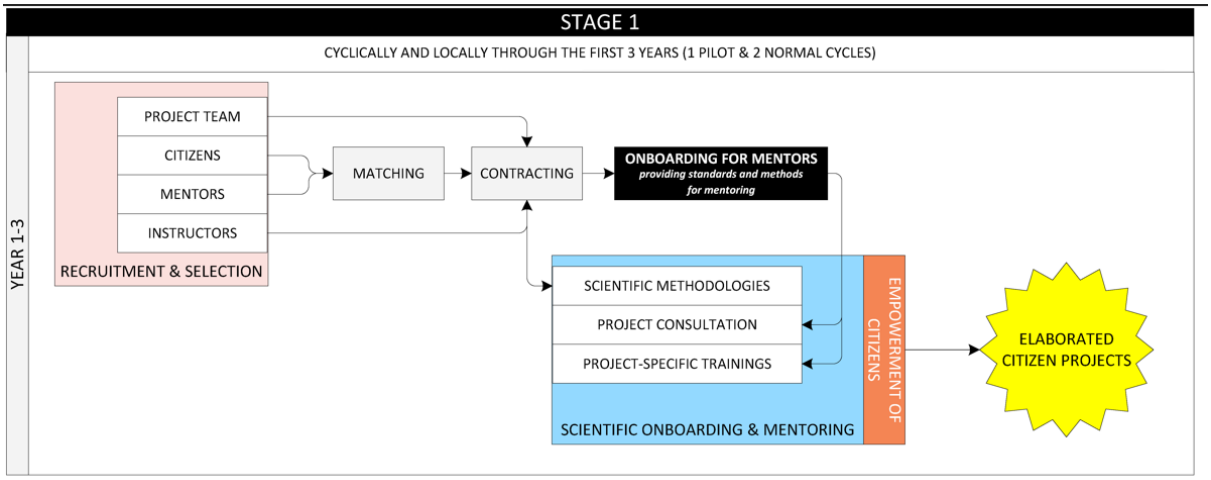


**Figure 1** *Unleash Your Inner Scientist's process*

The advantage of the mentoring method is that the mentees (citizens) are supported by involving them as active leaders in their own learning and developing processes.

Beyond the project-specific scientific mentoring support, it is also reasonable to apply coaching methods and tools to encourage and empower citizens and tackle the natural anxiety that former experiences in institutional learning can cause.

Since the individuals in the target public may have no or only rudimentary experiences in scientific research, mentoring is preceded by a capacity-building programme where basic scientific knowledge is learned (research methodology, academic writing, scientific presentation). Besides basic scientific training, the programme includes a mini-course on entrepreneurial skills and knowledge development for those who want to launch a startup based on their innovation. The capacity-building programme is provided by an instructor board.

Onboarding, mentoring and continuous supervision is provided for mentors as well, in order to provide them with standards and methods and develop their

mentoring-coaching skills and help them work effectively with citizens from potentially different backgrounds.

### 3.2. Preliminary Experiences of Unleash Your Inner Scientist

Unleash Your Inner Scientist is currently in the pilot phase. The pilot is based on *preliminary market research* made in Hungary by ITD. A quick quantitative and qualitative survey assessed potential mentees' needs and research interest areas. A total of 52 people with specific research ideas showed interest in the mentoring program. The main needs of citizens ($n = 52$) are mentoring and scientific consulting (90% of respondents marked this need), access to scientific databases (49%), financing (49%) and access to laboratories (20%). About 43% of the potential mentees are willing to do research in the field of psychology, and 25% want to conduct a project in cultural studies, followed by literary studies (18%) and other fields (14%). That means that, according to the needs assessment results, citizens need not expensive tools but rather scientific guidance.

The pilot program started in June 2022 with three mentees, but ITD formed a consortium with five European universities that would apply the same project in their local communities. The three mentees were selected by simple criteria: motivation, immediate availability of mentors and, for practical reasons, organisers selected proposals without the need for specific tools.

The pilot's preliminary experience shows that the mentees started the program with good basic knowledge and methodological background. The organisers and mentors of the program had the preliminary assumption that among the applicants, there would be a large proportion of people with pseudoscientific views or at least very simplistic scientific attitudes. It did not turn out that way. The three mentees are strongly committed to their research and are motivated to learn about scientific research methodologies.

### 3.3. Sustainability and Impact Measurement of the Unleash Your Inner Scientist Programme

The project's sustainability is based on, among others, the inclusion of prototyping environments (makerspaces or FabLabs) in the process. Citizens whose projects require tools and equipment can use the resources of the university's subcontracted local prototyping institution(s). Moreover, a digital infrastructure will be developed that allows citizen scientists to identify, obtain, and set up the technical aspects of their work (which today virtually always include a digital component in hardware or software, and usually both) and to document them with scientific rigour to support replicability and further research. The tailor-made Unleash Your Inner Scientist knowledge and data infrastructure for CS projects addresses the key challenges in citizen scientists' successful engagement in obtaining and documenting the "materials and methods" for their work.

CS can have broad-spectrum effects, influencing science itself and having societal, environmental, and economic impacts. However, as Somerwill and Wehn (2022) emphasise, in many CS projects, impact assessment is simplistic. After a systematic literature review, the authors identified best practices and approaches for measuring attitudes, behaviour and knowledge change in environmental CS projects. However, this approach, although it criticises superficial impact assessment practices, uses a qualitative method. Therefore, ITD elaborated a quantitative approach for measuring Unleash Your Inner Scientist's impact. The method can be applied to other projects as well.

The method is based on a quantitative questionnaire. The mentees fill out the questionnaire at the beginning and end of the mentoring programme, and the change over time is assumed to show the project's impact. In order to ensure the accuracy of the measurement, we use a control group which does not get any scientific mentoring. One part of the questionnaire is an attitude measurement related to science and the university, and in the other part, the mentees must analyse case studies from the point of view of which scientific research methods they would use.

## 4. Conclusion

The literature on CS has been analysing the potential of BU CS for years. RCS offers more than BU in that it includes more organised scientific oversight, which prevents citizens' projects from pseudoscience, and offers reversible benefits for scientific institutions. Examples of such benefits are reducing research burnout and the application of new scientific and innovative perspectives. RCS is also worth introducing in an international context because of various successful CS projects, although the vast majority are based on the TD approach. RCS offers an important component to CS: organised mentoring has been missing from a significant proportion of CS projects. RCS not only provides benefits to the academic sectors but also has the potential to improve the critical thinking skills of citizens, thus reducing the spread of pseudoscience on a large scale.

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