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ECIU university

CHALLENGE-BASED RESEARCH FOR A STRONGER AND MORE SUSTAINABLE EUROPE

How Challenge-Based Research enhances the impact-driven approach of Europe and European universities.

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1. SUMMARY

The application of Challenge-Based Research (CBR) will help Europe to solve major societal challenges via a fundamental shift in focus from individual research projects formulated around specific research questions to serial research programmes formulated around challenges.

CBR is about a co-creating the research agenda with society and the active participation of external stakeholders. This forms the basis for the development of multi-project research programmes with a strong focus on societal impact while retaining the opportunity for flexible and unplanned research outputs. It also incorporates new modes of higher education 'challenge-based learning'.

The active participation of external stakeholders, multi-project research programmes, focus on societal impact and flexible research outputs are key elements in building the long-term sustainable partnerships that are required to comprehensively address complex societal challenges.

Programme-based research funding focused on nurturing productive longer-term collaborations within regional innovation ecosystems in Europe will support ecosystems to reach the level of maturity they need to collaborate effectively on a European scale.

Innovation hubs – taken to mean constellations that connect different stakeholders within a defined framework of engagement – can be an effective means to not only generate challenges, but also to connect CBR approaches from different local ecosystems across Europe. This provides the opportunity to disseminate and accelerate the take up of prospective solutions. Collaborative networks formed around universities and the development of 'European Universities' have a key role to play.

The ECIU University framework for CBR makes such collaborations concrete and practical, allowing for targeted support that will promote the development of a European impact-driven research approach which is aligned with the ambition of the Horizon Europe Missions to engage with citizens in order to boost societal uptake of implementable solutions to societal challenges.

CONTENTS

2. INTRODUCTION

Universities in Europe have a key role to play in working towards a European innovation powerhouse, solving societal challenges in an effective way. This is because innovative universities are the most natural connectors and drivers of international, local and regional ecosystems. Innovative universities can provide systemic change with the results of excellent research and their role in developing the talents of their student population. By practicing open science and innovation, universities allow their knowledge creation function to be accessible to wider society and citizens, thereby providing a route to the co-creation of solutions to complex societal challenges.

By connecting innovative universities at the European level, e.g., via the European Universities Initiative, local innovation ecosystems are brought together to create a European-wide ecosystem based upon open collaboration, connecting societal stakeholders, researchers and learners, to provide European answers to societal challenges.

To realise the innovation potential of universities, a shift towards open co-creation ecosystems to solve challenges that require specific European multi-disciplinary approaches is worthy of support. The collaboration of learners, teachers, researchers, companies, the public sector, NGOs and regional embedded ecosystems throughout Europe holds the key to accelerating the generation and adoption of solutions for a multitude of societal challenges as well as strengthening the role of universities.

With this paper, ECIU University launches the Challenge-Based Research (CBR) way of working as an opportunity to increase the impact of academic research. In CBR, working closely together with partners from business, education, government, civil society and citizens is intrinsic to an approach that seeks to ensure that the output of academic research makes a tangible contribution to challenges faced in reality. It is a way of directing innovation and the power of research to achieve wider social, policy and economic goals. Therefore, CBR contributes to more sustainable and equitable innovation-led growth. This approach precisely aligns with the impact-oriented mission approach developed under Horizon Europe[1].

ECIU member universities have a proven track record of collaboration in open ecosystems working with a variety of stakeholders and leading to relevant societal impact. ECIU University is currently piloting this CBR model in its virtual research institute SMART-ER, co-funded by Horizon 2020, and is eager to share the findings and recommendations with the wider European research community through this paper.

1 See also Mission-Oriented Research & Innovation in the European Union.
A problem-solving approach to fuel innovation-led growth, European Commission (February 2018).

3. ABOUT ECIU UNIVERSITY

ECIU University is a pioneering innovative European University Alliance where learners, teachers and researchers collaborate with a broad set of societal and economic stakeholders, such as urban governance bodies, employer groups, industry, NGOs and others, to solve real-life challenges. Furthermore, ECIU partner universities have a strong commitment and proven track record of promoting life-long learning and research.

ECIU University is one of the 41 prestigious European University alliances that are part of the European Universities Initiative, funded by the Erasmus+ Programme. ECIU University is the largest European University alliance.

ECIU has thirteen full members:

Aalborg University (Denmark)

Dublin City University (Ireland)

Hamburg University of Technology (Germany)

Groupe INSA (France)

Kaunas University of Technology (Lithuania)

Linköping University (Sweden)

Lodz University of Technology (Poland)

Tampere University (Finland)

Universitat Autònoma de Barcelona (Spain)

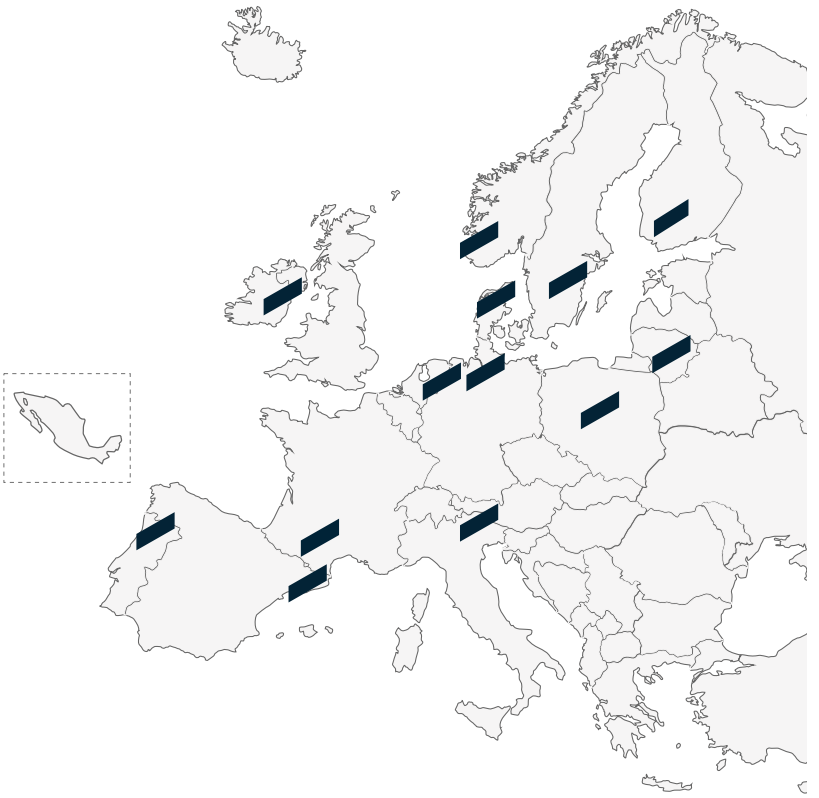
Universidade de Aveiro (Portugal)

University of Stavanger (Norway)

Università di Trento (Italy)

University of Twente (the Netherlands)

Technológico de Monterrey (Mexico)
is an Associate Member.



4. ECIU UNIVERSITY VISION 2030

ECIU University has a bold vision for the future. Research, innovation and education in ECIU University aim to drive European values and strengthen European culture and citizenship. ECIU believes in a European-wide ecosystem based on open and inclusive collaboration. This ecosystem will connect societal stakeholders, researchers and learners to provide European answers to future societal challenges, through both research and education.

The ECIU Vision 2030 is to create:
"A playground for solving multi-disciplinary challenges in entrepreneurial, innovative ways (...), enabled by a novel university model based upon co-creation" (ECIU, 2020b, p.3).

At the core of this vision is a commitment to creating spaces where communities of practice flourish around urgent and relevant societal topics aligned with Sustainable Development Goals (SDGs) to help Europe achieve a comprehensive sustainable future. More specifically, through the Smart-ER project, ECIU University is currently developing an ECIU Virtual Research Institute as an open innovation forum for citizen science. This will be based on long-term strategic collaborations with societal and industrial partners providing a solid basis for addressing societal challenges at the European level. The ECIU research agenda is based on the needs of society with an integral connection to education dissemination pathways. By adopting this approach, ECIU University researchers will conduct open research and innovation which will facilitate the development of career pathways that encourage mobility between the ECIU University stakeholder organisations in an inter-sectoral way. A comprehensive framework of innovative metrics is currently being developed within ECIU to assess the impact of research and innovation activities to support research careers. Therefore, ECIU University has the ambition to provide learning opportunities for researchers and a gateway for the ECIU member universities to connect as communities of practice throughout Europe in developing this CBR approach to address societal challenges.

It follows that ECIU University supports a CBR approach to develop joint European research and innovation programmes with local research agendas as a way for research to enhance its societal impact, and for researchers to increase their societal network.

5. HOW CBR SUPPORTS THE EU'S IMPACT-ORIENTATED RESEARCH AGENDA

CBR fits well with the EU impact-oriented research agenda, the ERA Agenda 2022-2024 and the mission-oriented research policy. In this context, CBR could be seen as a best practice to enhance the societal impact of research.

5.1.1 ERA AGENDA

The ERA agenda 2022-2024 calls for actions on cooperation with the national, regional and local level, alignment of research agendas, tackling societal challenges, outreach to stakeholders, and involving citizens in research. **CBR represents the concrete method for organising research according to these principles, with clear roles and responsibilities for participating stakeholders and research funders**. CBR supports the broader ERA agenda, and more specifically supports ERA Actions 10, 12 and 14:

KEY ACTIONS

- **Action 10:** ***"In order to generate impact, both missions and partnerships require co-operation, coordination, alignment of agendas and outreach towards broad groups of stakeholders. They will contribute to the ERA by tackling societal challenges and key EU priorities. For missions, outreach to and cooperation with the national, regional and local level is vital".***
- **Action 12:** ***"Address the social adaptation of the green (and digital) transitions".***
- **Action 14:** ***"Propose a policy coordination mechanism on public engagement practices, including citizen involvement in scientific processes".***

5.1.2 MISSION ORIENTED RESEARCH POLICY

ECIU University's CBR model is aligned with the EU missions where clear targeted goals are formulated that closely link to the political agenda setting and civic engagement[22]. Missions aim to mobilise and activate public and private actors, such as EU Member States, regional and local authorities, research institutes, entrepreneurs and investors to create real and lasting impact. Missions will engage with citizens to boost societal uptake of new solutions and approaches. A portfolio of coordinated projects and bottom-up experimentations must result in the achievement of missions.

A clear example is the recently launched EU Mission on Climate Neutral and Smart Cities, which has the ambition of delivering 100 climate neutral and smart cities by 2030 and to ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow suit by 2050.

The EU missions have common overarching criteria that can be summarised as follows. EU missions will...

1. ... be bold, inspirational and widely relevant to society
2. ... be clearly framed: targeted, measurable and time-bound
3. ... establish impact-driven but realistic goals
4. ... mobilise resources on EU, national and local levels
5. ... link activities across different disciplines and different types of research and innovation
6. ... make it easier for citizens to understand the value of investments in research and innovation

The ECIU University CBR model facilitates the implementation of the EU mission-oriented approach at all levels. By taking local needs as a starting point, Smart Regions foster regional growth and development and strong societal engagement by providing relevant, bottom-up and innovative solutions to the most pressing problems and opportunities within respective communities and societies. By connecting these ecosystems within Smart European Regions, the ECIU framework provides the building blocks for ambitious collaboration to translate local innovations into the multi-faceted solutions needed to tackle the grand challenges we face. Through the alignment or integration of CBR programmes across borders (see Annex 1), we can achieve a dynamic and collective contribution (to EU missions) and maximise impact at regional, national, international and even global scale.

Working with a coordinated programme of multiple projects and strong societal engagement, enhances the impact of research. The ECIU CBR model fully aligns with the specific European Missions on Adaptation to Climate Change-and Climate Neutral and Smart Cities by fully integrating citizen participation to achieve the necessary transformational societal impact. The CBR model combines local needs shared with stakeholders in different European Regions and the move from individual projects to co-defined research programmes inherently increases the longevity of the CBR approach, strengthens international research communities, raises attractiveness of researchers' career and fosters a responsible European identity.

RECOMMENDATION 1: In order to organise genuine CBR, regional project-based and short-term (thus fragile) collaborative ecosystems need to be nurtured into durable, sustainable long-term networks to enable effective collaboration at the European scale. This requires programme-based (multiple years, multiple projects) research funding opportunities that highlight the quality and potential of regional ecosystems as an essential condition for awarding funds, in addition to the research merit of proposals. ECIU University is willing to pilot such an approach, using its CBR expertise as presented in this paper and practiced in ECIU University and its virtual research institute SMART-ER.

2 See also Mission-Oriented Research & Innovation in the European Union. A problem-solving approach to fuel innovation-led growth, European Commission (February 2018)

6. FROM VISION TO PRACTICE

Both excellence and impact in CBR require a shift in focus from individual research projects formulated around specific research questions to serial research programmes formulated around challenges.

6.1 WHAT ARE SMART REGIONS

Setting up and completing such programmes depends on creating and nurturing experienced regional research networks: Smart Regions. Smart Regions set strategic research and innovation-led priorities (in connection to national Smart Specialisation Strategies) to address local problems and maximise unique strengths for enhancing a region's competitiveness and stimulating growth. In these networks, universities work closely with their societal partners.

Within ECIU University, these networks act as Smart European Regions by collaborating on shared challenges in the form of aligned or jointly created CBR programmes. Implementing this joint strategy requires initiating CBR projects and embedding these into programmes, as well as advocacy for commensurate impact-driven national and European research agendas. Commitment by and shared expectations amongst ECIU members and their societal partners, as well as their ability to function as a single unit are key factors for successful implementation to ensure systemic change.

Through the inter-linking of regional innovation hubs and other local fora that bring together different perspectives on challenges currently existing within the ECIU alliance, universities can collaborate with their stakeholders and surroundings in a more structured way to achieve more impact and more effective use of resources. This will also help to connect regional ecosystems at a European level to ensure transnational collaboration. Innovation hubs provide societal stakeholders, students and research entrepreneurs with a gateway to address societal impact collectively and effectively, sharing resources, networks and expertise.[3]

6.2 WHAT IS CHALLENGE-BASED RESEARCH

ECIU University understands the following when referring to challenge-based research (CBR):

Challenge-based research (CBR) is research undertaken with partners from business, education, government, civil society and citizens, using the challenges they face in reality as a point of departure, with the objective of arriving at implementable solutions to these challenges.

Challenge-Based Research is strongly related to the concept of Responsible Research and Innovation (RRI), which implies that the different stakeholders (research staff, citizens, companies, etc.) work together throughout the research and innovation process, in order to better align the results with the values and needs of society (see also Section 8 and Annex 2).

3 More information about the ECIU University innovation hubs: https://challenges.eciu.org/for_partners/for-partners/

6.3 CHARACTERISTICS OF SUITABLE CHALLENGES

Challenges are problems that transcend a single research question as these present themselves in reality. Challenges that are suitable for research involvement typically have three key characteristics that align well with the characteristics of the above-mentioned EU missions and are explained in Figure 1.

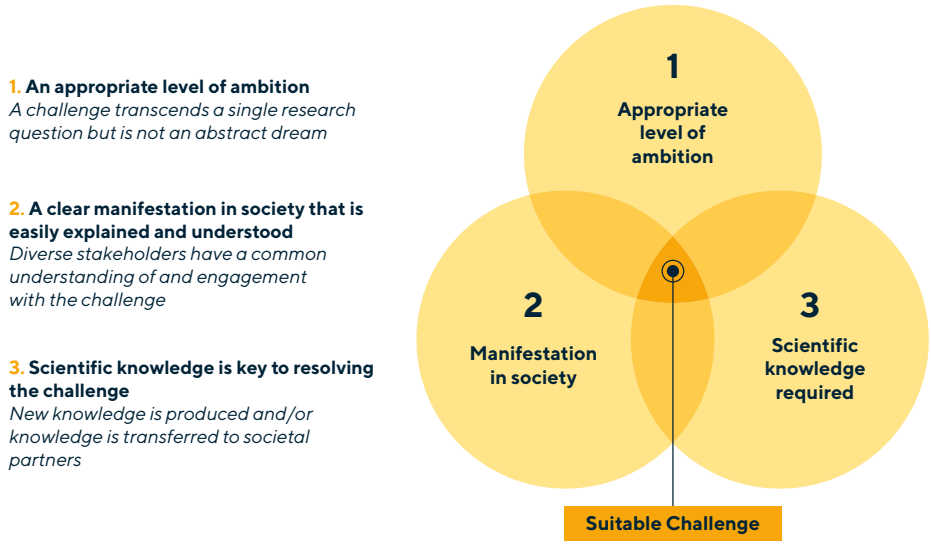


Figure 1: Characteristics of suitable challenges for CBR in the ECIU University

1. Appropriate level of ambition

The key shift in moving from generic forms of problem-based research towards CBR is a shift in ambition levels. It is about tackling the large, complex problems we face in society, with the people that are affected by these issues. Such challenges need to be specific enough to organise a collaboration around but are too big and multi-faceted to be resolved within a single research project. The consequence of this shift is a necessity to focus on a coherent set of research programmes, rather than whole-university research strategies or single research projects. This is further explained in Figure 2.

2. A clear manifestation in society

The ECIU University engages in CBR primarily to increase its societal impact. This requires that the challenges ECIU works on matter to stakeholders, that these are challenges they want to see resolved. As a consequence, challenges that form the starting point of CBR need to be problems as they are experienced in reality by the stakeholders. The formation of research questions around the underlying concepts or root causes of the challenge will likely introduce themselves as the constituent research projects evolve. However, they are not the strategic focus of collaborations with partners from society because the relevance of resolving them is derived from, and only part of, the solution to the main challenge.

3. Academic knowledge has a key role

ECIU University aims to contribute to forms of societal impact that fit the mission and purpose of a research University. Thus, a research endeavour is a necessary condition for the challenges, or particular aspects of the challenges, that ECIU University will engage with. It follows that a lack of (complete) knowledge around a challenge is a prerequisite for the types of challenges that will be addressed. Specific calls for proposals from research funders, aligned with addressing a particular challenge, will naturally contain a core research element that aims to identify an implementable solution pathway.

Characteristics of suitable challenges: ambition levels + examples

Figure 2: How challenges relate to research

6.4 THE IMPLICATIONS OF WORKING WITH CHALLENGE-BASED RESEARCH

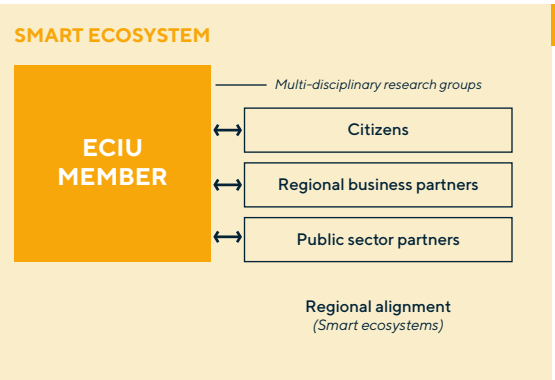
A shift towards (more) challenge-based research programmes and international collaboration as a European University looks seemingly simple on paper, but carries some important implications for how research is organised and carried out at the member institutions which include consideration of the following requirements:

1. Regional multi-stakeholder ecosystems form around programmes, not just projects
Single-project collaborations with societal stakeholders will have to develop into long-term, experienced networks that build trust and shared knowhow while working on larger-impact CBR programmes. ECIU University labels such networks Smart Research Ecosystems as schematically described in Figure 3 (also see Annex 1).

2. Research funding will be organised predominantly at the programme level
Programme-based funding from the EU is pretty much a conditio sine qua non to truly make this 'connect local regions at the European level' dream a reality. Project results should coherently accumulate towards solutions to complex challenges and there should be room for trial and error. Appropriate long-term funding commitments are needed that are organised predominantly at the programme level and that come from multiple funding sources, including consortium partners.

3. Regional consortia will enable collaboration at a European level
Increased trust, shared knowhow and robust funding helps regional networks to function as a unit, which facilitates them to collaborate effectively with other regional networks in Europe around shared challenges and projects and in this way, Smart Research Ecosystems thus become Smart European Ecosystems.

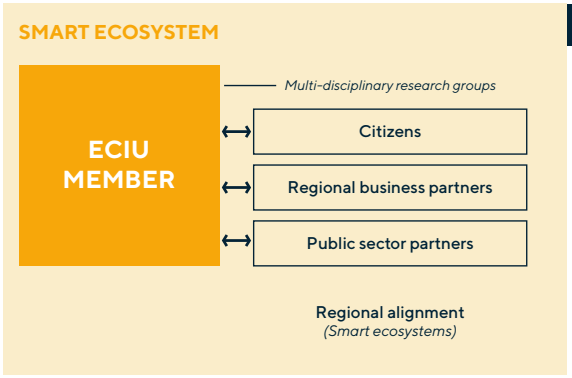
CBR starts by forming a Smart Ecosystem



Smart ecosystems

- In order to have a strong public sector partners and business partners involvement as well as investments, it is important that there is a shared understanding about the challenge, common goals in the strategic documents of all three stakeholders.
- Durable networks of research groups from universities and regional societal stakeholders that are connected by a desire to innovate and to jointly generate new knowledge.
- These networks may have started around a single project but have (to be) developed into networks characterised by high trust and an experienced track record that has proven valuable for all involved parties.
- Multiple research groups typically participate per university, as research and innovation with multiple societal stakeholders typically requires multiple expertises simultaneously.
- Such networks become 'SMART' when they have aligned regionally into a shared mission (challenge). Explicit agreements on governance, division of tasks and budgets have been reached. The network is able to ***operate as a single unit.***

...that defines a research programme around a challenge



Defining a regional CBR-programme means...

- **Jointly defining** one or several challenges that form the focus of the programme, including a shared understanding of what constitutes success.
- **Defining 1-2** projects to start with and organising a way of coming up with ideas for subsequent projects. In CBR, not all projects may be able to be defined up front.
- Securing **sufficiently stable funding** to embark on a multi-project, multi-year research programme. For example, through an agreement by the parties to put in 'risk capital' that can be used as a buffer should project-based research funding not be available/secured.

Challenge-based research programme

"Region fully solar-powered by 2030"

Figure 3: Smart Research Ecosystems define regional CBR programmes

RECOMMENDATION 2: The EU should invest in long-term sustainable networks of researchers from European Universities and regional societal stakeholders that are connected by a desire to innovate and generate new knowledge, to ensure a fruitful basis for enhancing the impact of research in addressing major societal challenges. The European Structural and Investment Funds, in synergy with Horizon Europe, have the potential to be configured to support the development of such networks. This would ensure better continuity of the knowledge base developed through projects, currently often dissipated once the project funding comes to an end.

7. HOW TO IMPLEMENT A CHALLENGE-BASED RESEARCH STRATEGY?

7.1 FOUR KEY TASKS

Implementing a joint research strategy will involve four key tasks, identified in Figure 4.

Figure 4: Four key tasks when implementing a joint research

7.1.1 SETTING UP AND NURTURING SMART RESEARCH ECOSYSTEMS

Leads:

- Research groups from the participating universities in the network
- Business development and PR-departments from involved stakeholders
- Executives from external stakeholders
- Coordinators of regional Innovation Hubs

Building up and maintaining a Smart Research Ecosystem is a structural task, as projects and programmes may not always be up and running and the network should be maintained beyond these collaborations. This will require the identification of common objectives, agreement on long-term commitment to the partnership and substantial investments from all partners in the network and structural involvement from business development and public relations departments.

Furthermore, the regional Smart Research Ecosystems should develop into a network of Smart European Research Ecosystems. This will require direct exchange between network partners (industry, governments, citizens) from different regions and should be fostered to support the development of new ideas around challenges. Higher education institutions may develop into 'brokers' between their network partners. This will require continuous investments by all ecosystem partners which should facilitate the mobility of research staff between involved higher education institutions and with the external stakeholders.

RECOMMENDATION 3: Mobility of research staff amongst academic institutions, and amongst the participating stakeholder organisations, is essential and needs European funding to enable the creation of Smart European Research Ecosystems. The MSCA Staff Exchange is an excellent example of such mobility support but is over-subscribed. Erasmus+ KA1 Mobility is another good example.

7.1.2 SETTING UP CHALLENGE-BASED RESEARCH PROGRAMMES

Leads:

- Research groups from the participating universities in the network
- Executives from universities
- Societal stakeholders, including regional/national governments

Multi-year multi-project research programmes around 1-2 challenges each with partners from a Smart Research Ecosystem must be defined and designed. An inclusive debate around the selection of challenges is essential, e.g., by involving citizens and other stakeholders to jointly co-create a research agenda. Alignment can be via coordinated objectives, outputs, dissemination to jointly co-create the ECIU research agenda. More elaboration on citizen participation can be found in Section 8 and in Annex 2 on the Mollet Del Vallès case study.

Some key requirements are at play:

- CBR requires flexible funding so that programmes can respond to local and (inter)national dynamics that affect how a challenge can be resolved by teams of researchers.
- This implies that grant-based funding for projects should be combined with the universities' own investments for programmes (in addition to resource allocation by all Smart Research Ecosystem partners, including in-kind). Typically, this means that executives and governing bodies (from all involved partners) must also be involved.
- Organised commitment at all governance levels, between regional partners and higher education institutions is key for the success of CBR programmes.

RECOMMENDATION 4: To realise a CBR approach in Europe, executive and governing bodies of universities, national, regional partners and European partners, must be involved in defining multi-year and multi-project research programmes aimed at addressing major societal challenges and make proportionate funding commitments to provide a base level of long-term support.

7.1.3 SETTING UP CHALLENGE-BASED RESEARCH PROJECTS

Leads:

- Research groups from the participating universities in the network.

This tasks brings CBR into practice within the universities.

Key activities include:

- Forming a consortium with interested societal partners from the Smart Research Ecosystem
- Combining multiple funding streams to support the project to allow for flexibility
    - Investments from industry/businesses
    - Contracts with government partners
    - Grants from national/European/regional funders
- Submitting grant applications jointly with Smart Research Ecosystem partners

RECOMMENDATION 5: Support the synergies between multiple funding streams to ensure it is possible to combine investments from private entities, public partners and grants from European, national and regional funders.

7.1.4 SETTING (INTER)NATIONAL RESEARCH AGENDAS

Leads:

- European, national and regional research funders

The Horizon Europe focus on large scale missions provides a context for the alignment of national and regional research agendas to maximise the prospects of developing solutions that can be implemented for the benefit of all European citizens.

RECOMMENDATION 6: To help strengthen the sustainability of a CBR approach across Europe, it is important to include the challenge-based approach in the programmes of regional, national and European funders. This includes:

- A focus on societal impact
- Flexible research outputs that are suitable for unpredictable impact
- Applications in Quadruple Helix consortia (see also section 8)

7.2 KEY FACTORS FOR SUCCESSFUL IMPLEMENTATION

Successful implementation of this joint long-term research strategy depends foremost on three success factors (Figure 5):

1 Commitment at all levels of all participating organisations

Carrying out joint CBR programmes requires long-term commitment of all stakeholders. Developing solutions with significant societal impact at the level of grand challenges requires bold leadership at all levels of organisations. Therefore, the success of CBR programmes depends to a large extent on the commitment at all levels of all participating organisations, including a commitment to invest and experiment, and to accept the possibility of initial failures.

2. Explicit and shared expectations

Due to the complex nature of CBR at the European level, it is important that expectations on what constitutes success and what each party should contribute to that success are made explicit. These expectations should be shared by all parties involved at the start of the process.

3. Smart Research Ecosystems should be able to function as single units

Whether working together on actual projects and programmes or merely aligning programmes strategically, CBR at the European level is a complex task that requires extensive involvement of all parties involved in Smart Research Ecosystems, not just the universities. This necessitates a continuous process of liaising between networks as a whole, not just universities representing the networks, which implicitly recognises the equal status of all partners.

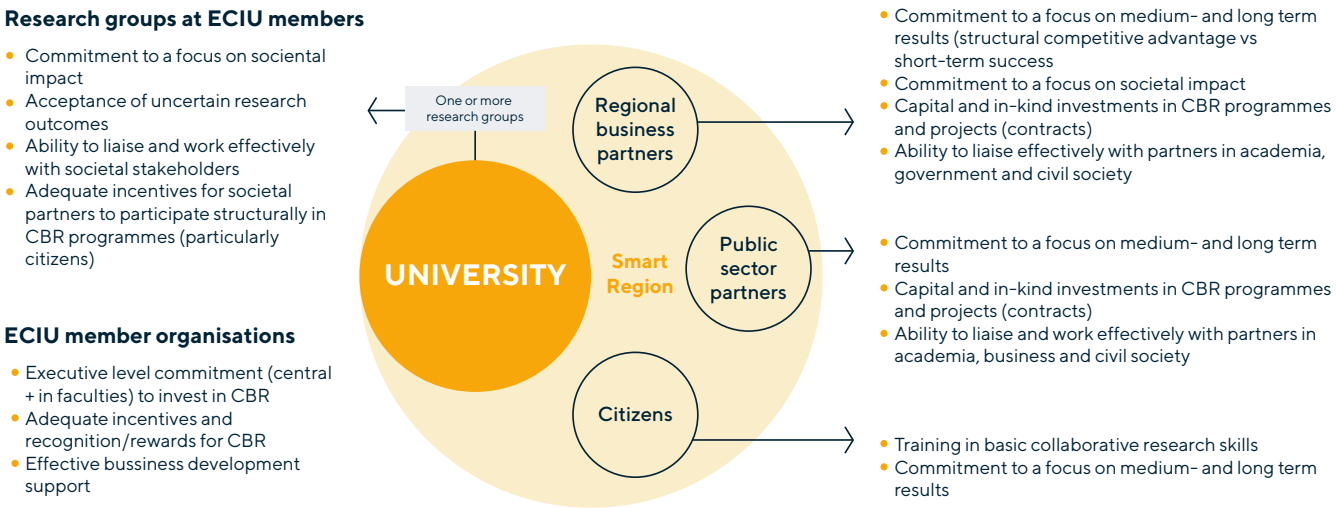


Figure 5: Key success factors per stakeholder group in a Smart Research Ecosystem

When connecting the Smart Research Ecosystems of universities and external partners, again three main success factors are at play.

1. Adequate representation
To effectively work together, each network needs to function as a unit. It needs be represented adequately and with broad support, so that multi-network decision making leads to effective decisions that can actually be implemented in each participating network.

2. Goal alignment
All participating stakeholders in the networks should have an explicit and shared understanding of the goals of the collaboration.

3. Agreed collaborative terms
All participating networks agree on the formal collaborative terms, including decisions on formulating joint CBR programmes and/or merely aligning existing programmes.

8. CO-CREATION OF THE RESEARCH AGENDA WITH CITIZENS[4]

CBR is deeply connected with Responsible Research and Innovation (RRI), a term used to identify the processes of research and innovation that involve the active participation of the key-actors of the Quadruple Helix (university, industry, government, and the public environment). This contribution boosts the consistency of the research processes with the societal values and needs and enhances the prospects of achieving implementable solutions.

Both Challenge-Based Learning (CBL, see also Section 9) and CBR programmes can hugely benefit from a citizen science approach to setting the research agenda by undertaking an inclusive debate around the selection of challenges. This approach leads to a more democratic research agenda definition process, as well as to valuable results directly connected to societal needs, particularly in the context of the Horizon Europe Missions. It also goes a step further: by defining a potential seamless integration between CBL and CBR, a challenge can, in the first instance, be addressed from a learning perspective by students and citizens. The result of this process may lead to a known solution or identify the need for new knowledge creation through a research project that will be undertaken by the stakeholder partners. In this way, this whole co-creative process sets up a continuum between CBL and CBR, under the constant paradigm of citizen science. Correspondingly, the new knowledge created as a result of the CBR project may well be the basis for the development of a micro-module to disseminate this knowledge to a wider audience.

4 This chapter is based on the Case Study Challenge-Based approach at the Universitat Autònoma de Barcelona. The Pilot of Mollet del Vallès by Myra Ronzoni and Fernando Vilariño. This case-study contents excerpts from Vetter, L. et al. (2021). Citizen Science as a transformation tool for public policies – The case of Mollet del Valles. Assignment for 104528 Urban Open Innovation. Smart Cities Degree. Supervisor: Fernando Vilariño. Universitat Autònoma de Barcelona.

Citizen science involves members of the public in active participation in scientific research. It brings together public administration, science and citizens in order to collaborate on projects and decision-making and aims to democratise scientific processes and produce new relevant knowledge[5]. It is important to highlight the distinction between different participatory science projects. They can be:

- contributory, meaning that participants contribute data to scientific research
- collaborative, where scientists design the project, and members of the public are involved in refining it or analysing data
- co-created, where scientists and the public work together.

Only a small percentage of citizen science projects get to the level of co-creation[6] where - in the optimal case - they have a say on what to investigate, with which methods and what conclusions should be drawn from it. According to Sauermann et. al., the value of the knowledge created by science depends on the needs and preferences of the broader public. Therefore, it is necessary to investigate the citizens' needs and wishes in advance of the initiation of a public project. However, the challenges associated with addressing the Horizon Europe Missions, specifically, Mission 1: Adaptation to climate change including societal transformation and Mission 3: Climate neutral and smart cities inherently require broad levels of societal participation to develop workable solutions that can be implemented at the scale require to effect change.

The points to consider in developing a citizen science project are the:

- Coordination
- Participation (demographic parameters, expertise requirements)
- Community Evaluation (How and who decides outcomes?)
- Openness (open data, contribution acknowledgement, public access)
- Entrepreneurship (funding and profits)

5 H. Sauermann, K. Vohland, V. Antoniou, et al. Citizen science and sustainability transitions. Research Policy, 5(103978), 2020.

6 H.E. Roy et al. Understanding Citizen Science and Environmental Monitoring. NERC Centre for Ecology & Hydrology and Natural History Museum, 2012.

Furthermore, it is important to consider the 5 citizen engagement principles, as worked out by the iSCAPE Citizen Manifesto[7]. Those principles help in order to address the complexity of the problems and to make them digestible to the citizens. One of those principles can be called gamification -"make it playful"- which helps to engage with the problems in a fun and inspiring way, encouraging creativity and motivation.

RECOMMENDATION 7: To empower citizens more it seems necessary to not only create awareness about the topic itself, but also about the process (citizen science). This could be done by actively inviting citizens to bring stories, listen and start discussions in their environment, and bring these findings to the sessions. This material could then be included into the scenarios, to make them more vivid and closely related to the people. Thus, in order to implement a co-creation process, instead of only a collaborative one, it is necessary to include the citizens into the process of game design.

RECOMMENDATION 8: Measures need to be taken to include more diverse voices, on the one hand from citizens that do not have the possibility to come to the meetings, and on the other hand from citizens that might not be so closely related with the local administration. For the latter, one possibility could be incentives or discounts for the actively participating citizens.

9. CHALLENGE-BASED RESEARCH, CHALLENGE-BASED INNOVATION AND CHALLENGE-BASED LEARNING

ECIU University has the ambition to deliver on all of the constituent universities' common challenge-based methodologies and the missions of education, research, innovation and service to society, creating a network for knowledge utilisation at the European level. Therefore, ECIU University does not limit the Challenge-Based mode of working to just research. There are multiple ways in which universities can use knowledge within a challenge-based approach which encompasses challenge-based research, learning and innovation. These three elements have also aspects in common (Figure 6), like **engaging** partners in essential questions and ideas, **investigating** guiding questions and **acting** on possible solutions.

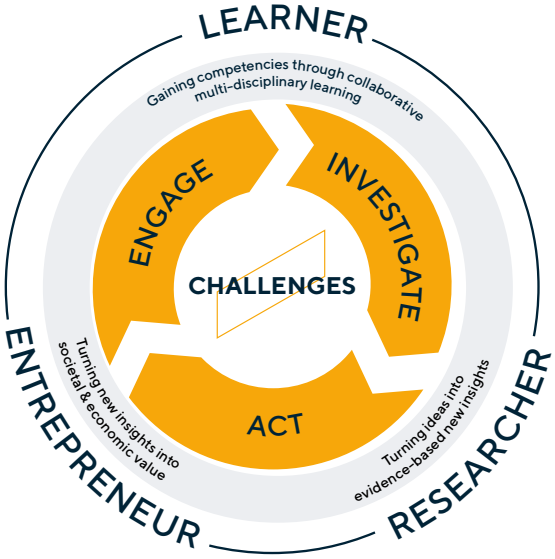


Figure 6: The challenge-based approach in research, learning and innovation

The continuity between CBL and CBR is also clear in the framework of citizen science: From a CBL training challenge experience involving students and citizens, a CBR project can be generated that necessitates the participation of researchers and citizens.

7 iSCAPE Project. Manifesto for citizen engagement in science and policy. https://www.iscapeproject.eu/wp-content/uploads/2020/01/

Citizens are always present, from the perspective of citizen science, and the whole process is based on co-creation by the actors involved. See also the Mollet challenge (Annex 2), highlighting the relationship between CBL and CBR and the importance of citizen science in both aspects.

the whole process is based on co-creation by the actors involved. See also the Mollet challenge (Annex 2), highlighting the relationship between Challenge-Based Learning (CBL) and CBR and the importance of citizen science in both aspects.

In practice, the boundaries between CBR, Challenge-Based Learning and Challenge-Based Innovation (CBI) are fluid. Newly produced knowledge may subsequently or simultaneously be used for innovative or educational purposes, and these activities may in turn initiate or support the production of new knowledge and as pictorially illustrated in Figure 6.

RECOMMMENDATION 9: Europe needs a more holistic approach to university funding, combining education, research, innovation and service to society. As it is impossible to manage the patchwork of funding coming from Erasmus+, Horizon Europe and other European and national sources, building European Universities covering all the missions of the participating universities in these complementary domains offers a structured pathway to achieve this objective.

10. SUMMARY

RECOMMENDATIONS TO INCREASE THE IMPACT OF ACADEMIC RESEARCH THROUGH ADOPTING A CBR APPROACH

RECOMMENDATION 1

In order to organise genuine CBR, regional project-based and short-term (thus fragile) colIn order to organise genuine CBR, regional project-based and short-term (thus fragile) collaborative ecosystems need to be nurtured into durable, sustainable long-term networks to enable effective collaboration at the European scale. This requires programme-based (multiple years, multiple projects) research funding opportunities that highlight the quality and potential of regional ecosystems as an essential condition for awarding funds, in addition to the research merit of proposals. ECIU University is willing to pilot such an approach, using its CBR expertise as presented in this paper and practiced in ECIU University and its virtual research institute SMART-ER.

RECOMMENDATION 2

The EU should invest in long-term sustainable networks of researchers from European Universities and regional societal stakeholders that are connected by a desire to innovate and generate new knowledge, to ensure a fruitful basis for enhancing the impact of research in addressing major societal challenges. The European Structural and Investment Funds, in synergy with Horizon Europe, have the potential to be configured to support the development of such networks. This would ensure better continuity of the knowledge base developed through projects, currently often dissipated once the project funding comes to an end.

Programme-based funding from the EU is crucial to truly make this 'connect local regions at the European level' dream a reality. Project results should coherently accumulate towards solutions to complex challenges and there should be room for trial and error. Appropriate long-term funding commitments are needed that are organised predominantly at the programme level and that come from multiple funding sources, including consortium partners.

RECOMMENDATION 3

Mobility of research staff amongst academic institutions, and amongst the participating stakeholder organisations, is essential and needs European funding to enable the creation of Smart European Research Ecosystems. The MSCA Staff Exchange is an excellent example of such mobility support but is very over-subscribed. Erasmus+ KA1 Mobility is another good example.

RECOMMENDATION 4

To realise a CBR approach in Europe, executive and governing bodies of universities, national, regional partners and European partners, must be involved in defining multi-year and multi-project research programmes aimed at addressing major societal challenges and make proportionate funding commitments to provide a base level of long-term support.

RECOMMENDATION 5

Support the synergies between multiple funding streams to ensure it is possible to combine investments from private entities, public partners and grants from European, national and regional funders.

RECOMMENDATION 6

To help strengthen the sustainability of a CBR approach across Europe, it is important to include the challenge-based approach in the programmes of regional, national and European funders. This includes:

- A focus on societal impact
- Flexible research outputs that are suitable for unpredictable impact
- Applications in Quadruple Helix consortia

RECOMMENDATION 7

To empower citizens more it seems necessary to not only create awareness about the topic itself, but also about the process (citizen science). This could be done by actively inviting citizens to bring stories, listen and start discussions in their environment, and bring these findings to the sessions. This material could then be included into the scenarios, to make them more vivid and closely related to the people. Thus, in order to implement a co-creation process, instead of only a collaborative one, it is necessary to include the citizens into the process of game design.

RECOMMENDATION 8

Measures need to be taken to include more diverse voices, on the one hand from citizens that do not have the possibility to come to the meetings, and on the other hand from citizens that might not be so closely related with the local administration. For the latter, one possibility could be incentives or discounts for the actively participating citizens.

RECOMMENDATION 9

Europe needs a more holistic approach to university funding, combining education, research, innovation and service to society. As it is impossible to manage the patchwork of funding coming from Erasmus+, Horizon Europe and other European and national sources, building European Universities covering all the missions of the participating universities in these complementary domains offers a structured pathway to achieve this objective.

RECOMMENDATION 10

The role of the skills of intermediaries such as knowledge / tech transfer officers in putting together these complex coalitions of interests needs more wider acknowledgement as often this is an underfunded resource that is crucial to achieving impact.

11. CONCLUSION

ECIU University believes that the imperative for systemic change in research in Europe is overwhelming and is forging a new path with speed and a sense of purpose. We are developing more multi-project research programmes with a stronger focus on societal impact, more flexible deliverables to serve unpredictable needs, with a stronger innovation dimension and involvement of wider society.

ECIU University is committed to supporting the move towards CBR, creating a functioning European ecosystem connecting cities, regions, enterprises, stakeholders, researchers and learners to solve challenges requiring specific European multi-disciplinary approaches and leading to societal impact.

ECIU University commends the work of the European Commission in moving towards impact-driven research, and strongly believes that this approach can be brought to many more regions. With this paper, ECIU adds new layers to the EC initiative, explaining how boundaries can be dissolved and the development of CBR and research with strong societal impact can be supported.

ABOUT ECIU

14 PIONNEERS

- **University of Twente** (The Netherlands)
- **Aalborg University** (Denmark)
- **Dublin City University** (Ireland)
- **Hamburg University of Technology** (Germany)
- **Kaunas University of Technology** (Lithuania)
- **Linkoping University** (Sweden)
- **Lodz University of Technology** (Poland)
- **Tampere University** (Finland)
- **Universitat Autonoma de Barcelona** (Spain)
- **University of Aveiro** (Portugal)
- **University of Stavanger** (Norway)
- **University of Trento** (Italy)
- **Institut National des Sciences Appliquees** (France)
- **TEC de Monterrey, associated partner** (Mexico)

32 ASSOCIATES

1 NATIONAL AUTHORITY
6 REGIONAL AUTHORITIES
8 CITIES
13 ENTERPRISES
2 ASSOCIATIONS
2 AGENCIES

UNITING OVER...

693
RESEARCH GROUPS

156
FACULTIES

49,417
STAFF, INCLUDING 28,385 ACADEMIC STAFF/RESEARCHERS

309,000
STUDENTS

ANNEX 1: HOW ECIU UNIVERSITY WORKS WITH JOINT CHALLENGE-BASED RESEARCH PROGRAMMES

A programmatic approach towards CBR

The key implication of the way challenges and CBR are conceptualised within the ECIU University is that the member institutions will work together on CBR in the form of joint CBR programmes (see Figure A1.1 for an example). There are three main reasons for this:

1. Serial research programmes are the logical form for organising research endeavours around big, multi-faceted challenges.

2. Programmes with multiple projects allow for flexibility in organising regional collaboration with societal stakeholders as well as European collaboration between ECIU partners.

3. Multi-project research programmes allow for a structure under which innovative consortia and R&I approaches can be formed and tried while connecting effectively with current European and national research funding systems and approaches.

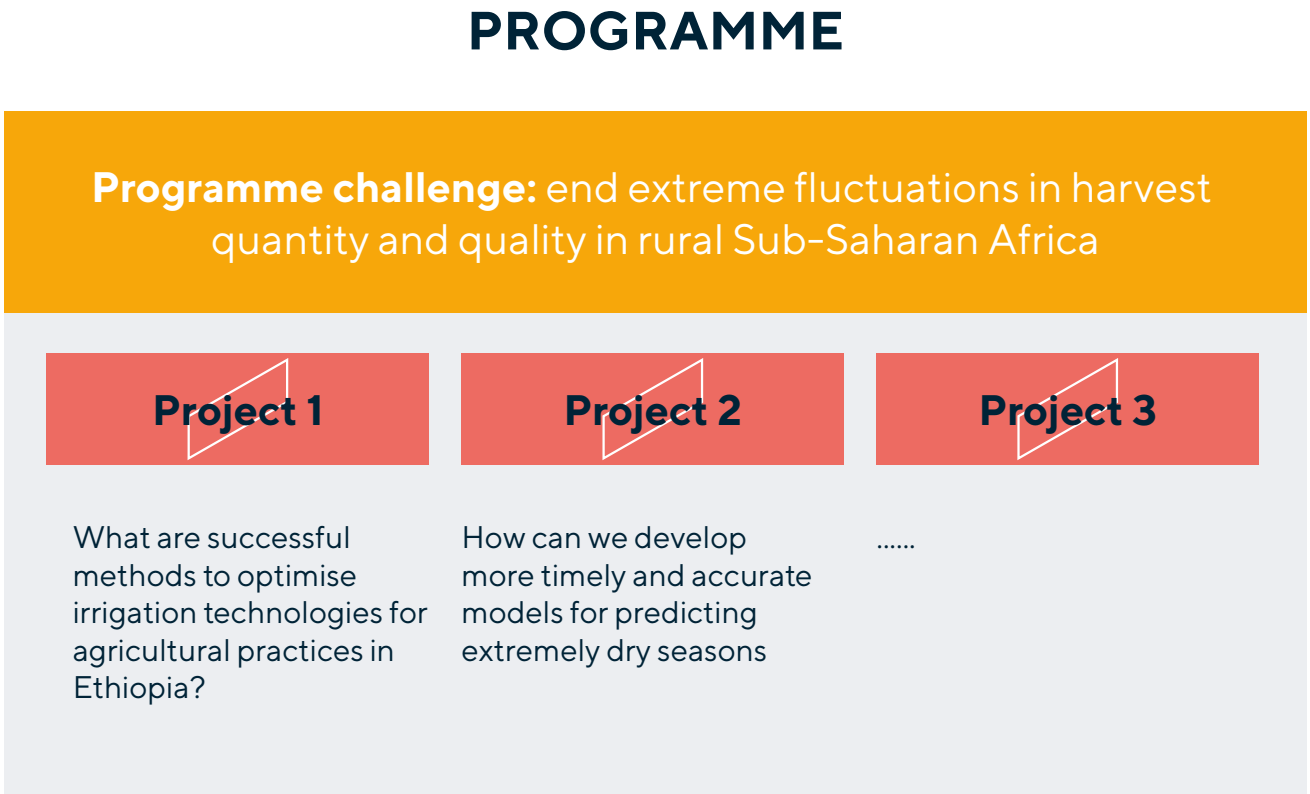


Figure A 1.1: A CBR programme is built up from a series of CBR projects

WORKING TOGETHER AS SMART RESEARCH ECOSYSTEMS

Supported by the European Commission through a Horizon 2020 grant, the ECIU University is currently building the SMART-ER[8] virtual research institute. Within this institute, the member universities and their Smart Research Ecosystems will work together on challenges. This is done by aligning the research programmes of the regional Smart Research Ecosystems as illustrated in Figure 2.

European CBR requires Smart Regions that work together in/on programmes

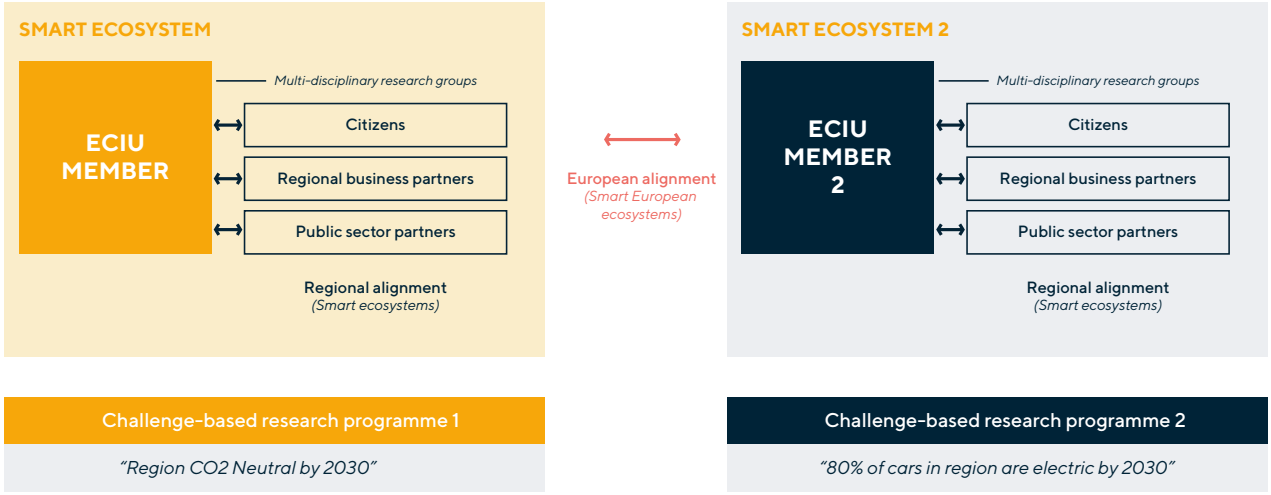


Figure A 1.2: Aligning Smart Research Ecosystems into Smart European Ecosystems

While doing this, it is important that the regional ecosystems as a whole align their programmes, not just via their universities. Genuine buy-in from all stakeholders is a necessity for European CBR. ECIU members can, however, act as representatives of their ecosystems until their partners from society can find each other directly.

ALIGNING THE CBR PROGRAMMES OF THE REGIONAL ECOSYSTEMS: 2 OPTIONS

Aligning CBR programmes across multiple ECIU members can essentially be done in two ways:

1. Defining and collaborating on joint CBR programmes in which multiple members' ecosystems participate.
2. Aligning the separately executed CBR programmes of multiple members' ecosystems.

This is illustrated by Figure A 1.3.

8 SMART-ER stands for Smart European Regions

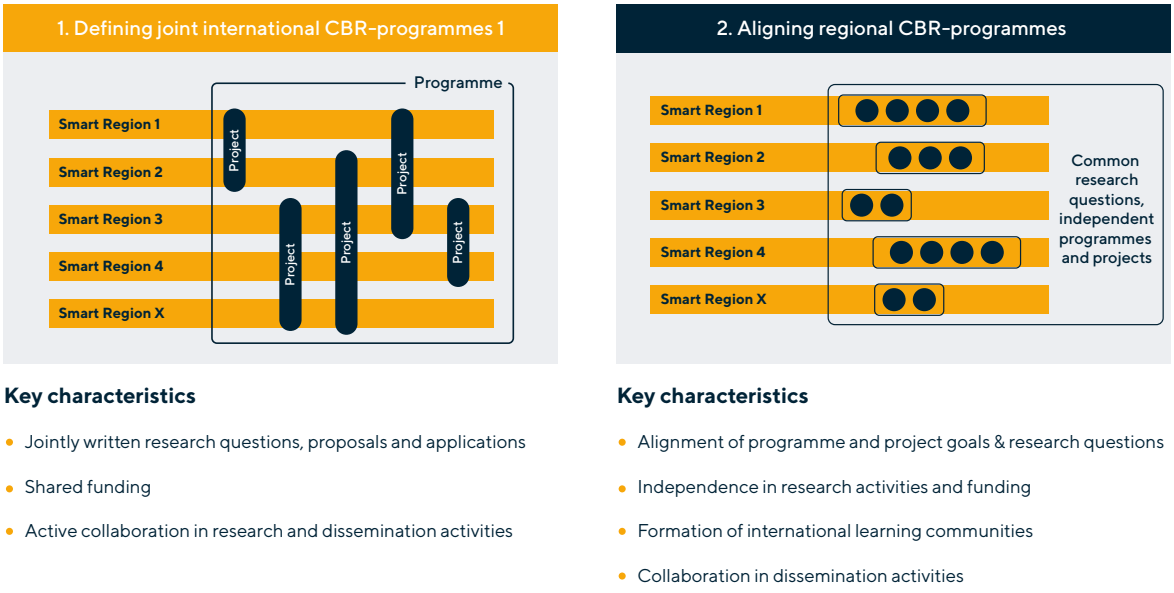


Figure A 1.3: Aligning Smart Research Ecosystems around programmes: two main options

In practice, these options are not mutually exclusive. Some research groups from an ECIU member may engage with their own Smart Research Ecosystem in programmes jointly formulated with the Smart Research Ecosystems of other ECIU members. Other research groups from that same ECIU member may only want to engage in alignment of their independent research programme. What matters is that routes for increasing our collective impact at the European level are explored in ways that suit the way our research groups work with their regional stakeholders

12. ANNEX 2: CASE STUDY

Challenge-Based approach at the Universitat Autònoma de Barcelona. The Pilot of Mollet del Vallès [9]

by Myra Ronzoni[10] , Fernando Vilariño[11]

1. INTRODUCTION

In recent years, Challenge-Based Methodology is being implemented at the Autonomous University of Barcelona (UAB), both in the teaching and the research fields.

In the teaching field, several bachelor and master programmes are being updated in order to include the Challenge-Based Learning (CBL) methodology. In this way, the experience of the challenge does not fall outside the scope of teaching, but it becomes an integral part of it, complementing the more traditional and theoretical education.
In the research field, an increasing number of research projects are currently based on challenges (CBR).

9 This case-study contents excerpts from Vetter, L. et al. (2021). Citizen Science as a transformation tool for public policies – The case of Mollet del Vallès. Assignment for 104528 Urban Open Innovation. Smart Cities Degree. Supervisor: Fernando Vilariño. Universitat Autònoma de Barcelona.

10 Universitat Autònoma de Barcelona, Catalonia, Spain.

11 Computer Vision Center-Universitat Autònoma de Barcelona

CBR is deeply connected with Responsible Research and Innovation (RRI), a term used to identify the processes of research and innovation that involve the active participation of the key-actors of the Quadruple Helix (university, industry, government, and the public environment). This contribution boosts the consistency of the research processes with the societal values and needs.

At the UAB, it has become increasingly evident that both CBL and CBR programmes can hugely benefit from the citizen science approach. According to its guidelines, citizens must be actively involved in these programmes, in order to contribute during the whole project development. This approach leads to a more democratic scientific process, as well as to valuable results deeply connected to societal needs. But it also goes a step further, by defining a potential seamless integration between CBL and CBR: a challenge can be, in the first instance, worked under a learning perspective by students and citizens. Then, the result of this programme leads to a research project, that will be investigated at the university and, again, will seek the active collaboration of the public environment. In this way, this whole co-creative process sets up a continuum between CBL and CBR, under the constant paradigm of citizen science.

At the UAB, the Challenge-Based Approach is the connector thread linking the university to a multitude of local institutions, both public and private, which are also characterised by a significant innovative vision, such as the UAB Research Park[12] , HubB30[13] , and Mollet Hub[14] .

The Challenge-Based Approach brings a wide range of benefits to the UAB: not only through implementing an innovative methodology in education and research, but also increasing the impact on civil society and strengthening connections with citizens and the local region. Last but not least, it contributes to putting the UAB at the forefront of the European university institutions, which is further enhanced by participation in ECIU University[15].

The future vision of the Challenge-Based Approach at the UAB is thus the consolidation of an open environment in which the institution, the students, the teaching staff and the researchers will consolidate a deep relationship with public and private entities in the region and with the citizens who live there, creating a learning and research environment that is innovative, practical and directly beneficial to the society. The following example illustrates a case study using Transformative Innovation or Transformative Change as a framework to address these societal challenges[16] . In this case study, we will investigate how far citizen science can contribute to that goal by observing and analysing the participatory process for citizen-centric innovation in waste-management processes in the Municipality of Mollet del Vallès, metropolitan area of Barcelona, Catalunya, Spain.

12 Parc de Recerca de la UAB. https://www.uab.cat/web/parc-de-recerca-1345468452273.html

13 Hub B30. http://hubb30.cat/es

14 Mollet Hub. https://www.mollethub.cat/, only available in Catalan.
The Mollet Hub is the municipal institution where the challenge of Mollet del Vallès has been developed.

15 ECIU. Challenge based education as a core for teaching and research. ECIU University Magazine,3:14–17, 2020.

16 J. Schot and W. Edward Steinmueller. Three frames for innovation policy: R&D, systems of innovation and transformative change. Research Policy, 47(9), 2018.

2. THE CITY OF MOLLET DEL VALLÈS

Mollet is a Spanish city located near Barcelona, with 51.600 inhabitants and a surface of 10,77 square kilometres[17]. The waste segregation model used in Mollet is the 5-fraction model, the most common in Catalonia, based on five separate waste collection containers: organic matter, glass, paper and cardboard, packaging and other waste. The current waste prevention plan was designed for a 3-year period, which began in 2018 and ended on January 1, 2021[18] [19].

The framework for the innovation action is the project TRANSFORM[20] , in which a number of stakeholders are participating to develop a pilot project in Mollet in the scope of circular economy, one of the main axes of the Catalan Smart Specialisation Strategy (RIS3CAT)[21] , which integrates the RRI (Responsible Research and Innovation[22]) approach and a shared agenda[23] within projects like TRANSFORM and SeeRRI[24]. Within this framework, the cluster B30 is situated, a territory close to Barcelona, including numerous research centres, businesses, industrial parks, the Municipality of Mollet, and also the Universitat Autònoma de Barcelona (UAB). The research team consists of four students from the UAB that are included in the CBL[25] pilot project on the topic of Open Urban Innovation in the Bachelor Degree of Smart Cities[26]. The government of Catalunya (Generalitat de Catalunya) commissioned the SME Science for Change (SfC) with the task of guiding the citizenry through the process of citizen science aiming to transform the waste treatment system.

3. THEORETICAL CONCEPTS

This Pilot embraces a joint approach for sustainable transition, with the involvement of the 4-helix for open innovation, the implementation of shared agendas, with the support of theories on social norms theory and theory of change.

17 Idescat. The municipality in numbers. Technical report, Institut d'Estadistica de Catalunya, 2020.
18 Generalitat de Catalunya. Selective collection. https://residus.gencat.cat/ca/ambits_dactuacio/recollida_selectiva/ , 2021.

19 Ajuntament de Mollet de Valès. Local waste prevention plan from Mollet del Vallès. https://www.molletvalles.cat/assets/Documents/Pla-Local-Prevencio-Residus-Mollet-Valles-ilovepdf-compressed.pdf

20 Transform project: Territories as responsible and accountable networks of S3 through new forms ofopen and responsible decision making. https://www.transform-project.eu/ , 2020.

21 M. Cortijo Arellano. Monitoring report on the RIS3CAT 2015-2020 Action Plan. RIS3CAT monitoring collection, Number 11. Technical report, Generalitat de Catalunya, 2020.

22 European Commission. Responsible research & innovation. https://ec.europa.eu/%20programmes/horizon2020/en/h2020-%20section/responsible-researchinnovation , 2020.

23 T. Fernández, M. Romagosa, X. Ariño, et al. Articulating shared agendas for sustainability and social change. RIS3CAT monitoring collection. Number 8. Technical report, Generalitat de Catalunya, 2020.

24 Seerri project: Self-sustaining research and innovation. https://seerri.eu/ , 2020.

25 R. Loohuis and L. Bosch-Chapel. Strategising with challenge-based learning to boost student's transferable competence development (White paper), 2021.

26 104538 Urban Open Innovation. Smart Cities Degree. https://guies.uab.cat/guies_docents/public/portal/html/2021/assignatura/104538/e

Sustainability Transition

The concept of Sustainability Transition was framed by the European Environment agency in 2019 responding to an ever-growing need for feasible solutions to the climate crisis, waste of resources and growing social inequality. Sustainability transitions can be defined as "long-term processes that involve transformations of society as the result of the emergence and dissemination of new forms of innovation that promote new ways of thinking and living (new social practices, new technologies, new business models, etc.)"[27]. This sustainability transition needs to be carried out considering all the stakeholders (Quadruple Helix) in the context of regional needs (shared agendas) tackling actual challenges (CBL). Particularly, citizen engagement appears as a relevant tool, including the strategy of citizen science that allows a transition trough a Theory of Change approach to induce new behaviours.

Quadruple helix and Open Innovation

Two key concepts that are applied in the Sustainability Transition strategies are the concept of Open Innovation and the Quadruple Helix[28] (which is also extended to a "Multiple Helix" approach[29]) of Innovation. The Quadruple Helix of Innovation is defined by its four key entities: academia, industry, government and the public environment. These key-actors work together to establish a holistic and realistic view on the specific problem, trying to establish effective solutions to societal challenges. According to the European Commission (2020) Open Innovation is the "Outcome of a complex co-creation process involving knowledge flows across the entire economic and social environment"[30] . Instead of closed business, university or administration environments, all the agents open up to the other entities and collaborate in order to share knowledge and find new solutions for social and environmental challenges.

In the case of the Mollet Project, the different stakeholders are:

- The Local Authorities of Mollet
- The Citizens of Mollet
- The company Science for Change
- The Universities UAB and UB and
- The Government of Catalunya

Shared agendas

Shared agendas can "help to develop more effective, innovative responses to the challenges facing the territory and to meet the ambitious targets that the European Community has established for the coming years"[31]. They consist of a bottom-up approach for collective experimental projects with a high transformation potential. They include various actors and aim to generate shared knowledge and shared values.

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27 T. Fernández, M. Romagosa, X. Ariño, et al., op. cit.

28 L. Höglund and G. Linton. Smart specialization in regional innovation systems: a quadruple helix perspective. GAIA, 48(1):60–72, 2018.

29 F. Vilariño. Living labs as social technologies for the smart cities and communities. Smart City Global Journal, 1:70, 2021.

30 European Commission. Open Innovation, Open Science, Open to the World - a vision for Europe. European Commission, 2016.

31 T. Fernández, M. Romagosa, X. Ariño, et al., op. cit.

The shared agenda established by the government in Catalunya includes the so-called PECTs (Projectes d'especialització i competitivitat territorial) which can be translated as "territorial specialisation and competitiveness projects". Both Mollet and the UAB are part of the PECT, which has the goal to foster collaborations between institutions such as universities and local authorities. The shared agendas include a zero-waste management strategy, in which the UAB as well as the Local Authorities of Mollet are included.

Citizen Science

Citizen science involves members of the public in active participation in scientific research. It brings together public administration, science and the citizens to collaborate on projects and decision making and aims to democratise scientific processes and produce new relevant knowledge[32]. It is important to highlight the distinction between different participatory science projects.

They can be:

- contributory, meaning that participants contribute data to scientific research
- collaborative, where scientists design the project and members of the public are involved in refining it or analysing data, or
- co-created, where scientists and the public work together.

Only a small percentage of citizen science projects get to the level of co-creation[33] where - in the optimal case - they have a say on what to investigate, with which methods and what conclusions should be drawn from it. According to Sauermann et. al.[34], the value of the knowledge created by science depends on the needs and preferences of the broader public. Therefore, it is necessary to investigate the citizens' needs and wishes in advance of the initiation of a public project.

The points to consider in developing a citizen science project are the:

- Coordination
- Participation (demographic parameters, expertise requirements)
- Community Evaluation (How and who decides outcomes?)
- Openness (open data, contribution acknowledgement, public access)
- Entrepreneurship (funding and profits)

32 H. Sauermann, K. Vohland, V. Antoniou, et al. Citizen science and sustainability transitions. Research Policy, 5(103978), 2020.

33 H.E. Roy et al. Understanding Citizen Science and Environmental Monitoring. NERC Centre for Ecology & Hydrology and Natural History Museum, 2012.

34 H. Sauermann, K. Vohland, V. Antoniou, et al. op. cit.

Furthermore, it is important to consider the five citizen engagement principles, as worked out by the iSCAPE Citizen Manifesto[35]. Those principles help in order to address the complexity of the problems and to make them digestible to the citizens. One of those principles can be called gamification, "make it playful", which helps to engage with the problems in a fun and inspiring way, encouraging creativity and motivation.

Social Norms Theory

According to the National Social Norms Center at the Michigan University[36], social norms are explicit or implicit rules that guide behaviours occurring in a social context. Those norms are transmitted through formal channels like policies or informal channels such as stories. They vary between one social group and another, and an individual may alter their behaviour to adapt in different groups.

There are two different but related kinds of social norms:

- Descriptive norms refer to how a majority in a group actually behaves
- Injunctive norms refer to the beliefs among a majority about how people "ought" to behave.

For example, people living in a residential neighbourhood may believe they ought to recycle as much of their waste as possible (injunctive norms). However, they see that only a few houses on their street have recycling bins next to the general waste bin on refuse recollection day, leading to the perception that most people do not recycle (descriptive norm).

Theory of Change

Theory of Change (hereafter, ToC) refers to a tool to generate a description of events that are expected to lead to a particular long-term outcome. This description is usually captured in a diagram and narrative to provide a guiding framework that shows how the desired goals can be reached. For the development of a theory of change, a discussion should take place between the stakeholders about the context, the long-term outcomes, the sequence of events and the assumptions on how the changes happen[37]. These theories of change are often formulated by entities that want to apply a certain change in their organisation or processes[38]. ToC in sustainability science articulates the relationships between sustainability goals, diagnoses, knowledge gaps, context conditions, activities, pathways to impact, and epistemological assumptions[39]. One particular type of ToC, the multiple stakeholder-process, includes the supporting co-production of knowledge, social learning, technical cooperation, creation of new actor networks and conflict transformation[40].

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35 i SCAPE Project. Manifesto for citizen engagement in science and policy. https://www.iscapeproject.eu/wp-content/uploads/2020/01/iSCAPE_Policy_Brief_No2_iSCAPE-manifesto-for-citizen-engagement-in-science-and-policy.pdf

36 J. Schot and W. Edward Steinmueller. Three frames for innovation policy: R&D, systems of innovation and transformative change. Research Policy, 47(9), 2018.

37 Learning for Sustainability. Theory of change. https://learningforsustainability.net/theory-of-change/ , 2016.

38 P. Brest. The power of theories of change. Stanford Social Innovation Review, 8(2):47–51, 2010.

39 L. Dhillon and S. Vaca. Refining theories of change. Evaluation, 14(30), 2018.

40 C. Oberlack C. and T. Breu. Theories of change in sustainability science: Understanding how changehappens. GAIA, 28(2):106–111, 2019.

Implementing Challenge-Based Learning

CBL is an innovative approach to learning at universities that aims to advance the students skills by addressing real-life problems[41]. Firstly, this leads to new collaborations between external parties, the so-called "challenge providers", and universities, thus creating social impact[42]. Secondly, it allows the students to work in a field where they can develop skills such as self-management, social intelligence and reasoning for complexity and see the direct impact of their contribution[43]. In the Mollet case, this means that the university stakeholders can input their knowledge into various steps of the process, one example being the creation of the digital game by the programmers of the engineering school, implemented through a hackathon. Furthermore, future professionals can gain insight into their work, as was the case with the research team in the first phase of the project.

4 CASE-STUDY: MOLLET DEL VALLÈS

4.1 CONTEXT

The Mollet case study is embedded into the TRANSFORM project, a European project from 2020- 2022 which includes three different regions in Europe. The aim is to investigate citizen science as a potential tool to integrate citizen participation within the public policies. Further involved actors are the Generalitat de Catalunya with the RIS3CAT strategy and the shared agendas[44], who commissioned Science for Change[45], together with the University of Barcelona with its multi-disciplinary Open Systems group to support the Municipality of Mollet with citizen participation in the project. Within this frame, SfC and the UB are designing a participatory process that the citizens are able to take part in. According to SfC, the project is using an "Extreme Citizen Science Approach", which consists of an inclusive model that engages the citizens in every step of the process[46], without limits because of educational, sociocultural, economic, gender or age factors. The whole project consists of eight phases, including the analysis of the state of art, the selection of interest groups, participatory sessions with the local authorities and the citizens, the development of the interactive game, implementation of such, the analysis of the generated data and, finally, the return of this data.

41 K. Kohn Radberg, U. Lundqvist, J. Malmqvist, et al. From CDIO to challenge-based learning experiences–expanding student learning as well as societal impact? European Journal of Engineering Education, 45(1):22–37, 2020.

42 K. Vohland, A. Land-Zandstra, L. Ceccaroni, et al. The science of citizen science. Elsevier, 2021.

43 R. Loohuis and L. Bosch-Chapel, op. cit.

44 T. Fernández, M. Romagosa, X. Ariño, et al., op. cit.

45 M. Cortijo Arellano, op. cit.

46 K. Vohland, A. Land-Zandstra, L. Ceccaroni, et al., op. cit.

The 8 phases are as follows:

- Phase 1: Background analysis (January-April 2021)
- Phase 2: Analysis and selection of groups of interest (February-April 2021)
- Phase 3: Participatory dynamics with local government agents (April-May 2021)
- Phase 4: Participatory process with key citizen profiles (April-May 2021)
- Phase 5: Development of the interactive game with a gamification perspective (April - July 2021)
- Phase 6: Implementation of the digital game in public schools in Mollet del Vallès (October-December 2021)
- Phase 7: Data analysis (January - February 2022)
- Phase 8: Return (March 2022)

4.2 METHODOLOGY

The research team assisted in the project's third and fourth phases which were conducted from April to May 2021. In these phases, first contacts between the different stakeholders were established and two activities were developed for the sessions that were taking place in Mollet with the citizens. The third phase consisted of an online joint meeting with the technicians and deputies from the city's council with the Science for Change moderator in a guiding role. The "indirect" actors were also invited to this meeting, including the waste treatment workers, the policemen that were responsible for fines in case of wrong garbage separation and others. In that meeting, the technicians developed a Pros and Cons list of the current garbage collection system, thinking about possible arguments that the citizens could legitimately make. Just after this first meeting of the technicians and other actors, the research team for this paper was introduced the project.

In the fourth phase, two joint meetings together with a sample of citizens were held, which were guided by SfC and the UB and accompanied by the research team from the UAB. Before that, a preparatory session took place in which the UAB research team were briefed on the short-term plans and the role that they had to play. The first citizen session was conducted with a number of invited citizens from Mollet del Vallès, who were directly contacted by the City Hall, thus including mostly citizens already acquainted with the City Hall. It took 2 hours and consisted of a brief introduction to the different garbage collection systems (ca. 5 mins each) with an active task carried out by the citizens (ca. 30 min each). This included the writing of Pros and Cons onto Post-its. These Post-its provided the framework for a discussion afterwards. This was also done with the two prospective models (intelligent containers, door-to-door) that the local authorities are thinking of implementing.

In between the first and second sessions there was a specific meeting held with the UAB research team in order to test the method that was going to be used in the second session. Each student adopted the role of a fictitious person (persona), with some distinctive characteristics (age, work, family and economic situation, perception of the current environmental situation) provided by SfC. The students then had to identify the advantages and disadvantages of each model (selective collection, smart containers, door-to-door). Then (without adopting the role of a fictitious person), Pros and Cons of each model were elaborated and possible concrete situations for the specific character were described. The second session was attended by the SfC team, the UB and UAB who guided the citizens through the session. This session was more focused on the representations of scenarios rather than the citizens expressing their own opinions They were faced with different characters and had to imagine scenarios that these characters could encounter with the different models of garbage recollection. Labels with Pros and Cons were distributed to the citizens in order to identify potential behaviours of the personas for each scenario.

4.3 RESULTS

First Session

The first session was conducted in the "Mercat Vell" in the heart of the city and took 2 hours. Twelve citizens attended, all over 35 years old, including many retired people. The participation of these citizens was high, they were motivated to contribute their opinions and open to understanding the mechanisms of each model. However, some of the citizens were not able to fully comprehend all the explanations that were made at the beginning, as they consisted of a relatively quick oral presentation. Interestingly, the majority of the citizens declared that they already recycle and separate their waste, while they complained about other people not doing so. Many of them were in favour of more control (they did not care so much about being supervised by the government), in exchange for cleaner streets and less noise.

Some of the attendees also addressed topics that were not intended to be part of the discussion, such as the financial situation of the government, and possible debts it had with private cleaning companies. While it was intended to assess the advantages and disadvantages of this model, noting it down on paper, the citizens preferred to enter into an active discussion, including expressing their opinions rather than a set articulation of Pros and Cons. The discussions of the first session were rather free, therefore, it appeared to indicate that the citizens were not really conscious of the specific goal for the meeting.

Second Session

The second session was attended by eight citizens with the same age profile as in the first session. Although some of the citizens did not like the characters that they were assigned, no one rejected the game and all of them came up with several scenarios. This time, the groups consisted of two people and the work was more effective, in the sense that there was less latitude for open discussion and a more concentrated atmosphere resulted (see Fig. 3 for a picture of a setup). In the end, the citizens presented their findings for the characters considering the two future models, door-to-door and intelligent containers.

4.4 CONCLUSIONS

In order to extract significant conclusions that can be applied to other cases of citizen participation, it is necessary to observe the process as a whole and not only look at the early stage. However, already in the first sessions one can observe certain tendencies that lead us to the following preliminary conclusions:

- In order to empower the citizens more, it seems necessary to not only create awareness about the topic itself (garbage recollection), but also about the process (citizen science). This could be done by actively inviting the citizens to bring stories, listen and start discussions in their environment, and bring these findings to the sessions. This material could then be included into the scenarios, to make them more vivid and closely related to the people.
- Thus, in order to implement a co-creation process, instead of only a collaborative one, it is necessary to include the citizens into the process of the game design.
- Furthermore, measures need to be taken to include more diverse voices, on the one hand, from citizens that do not have the possibility to come to the joint meetings, and, on the other hand, from citizens that might not be so closely associated with the local administration. For the latter, one possibility could be an incentive in waste-fee-reduction or discounts for actively participating citizens.

- We can observe that a change of the current system might not be necessary, but instead introducing small changes in the actual system. These small changes could consist of educating the people that throw waste besides containers or don't recycle or collect certain fractions more often (plastic and paper).
- Challenge-based learning is a powerful tool for improving the capacity building of students in the universities, by giving students the opportunity to obtain useful skills and experience in real-life settings.
- However, we recommended adapting the participation periods to the scholar calendars, in advance. Another key aspect would be the involvement, even passively as spectators, of the students in the internal meetings and decision-making processes.
- Finally, regarding further steps, it is essential to pursue this case study, as it can evolve into a valid tool to implement the sustainability transition. There is evidence that the results could be relevant for the local administration and has the potential to be replicated in other locations.