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Shape the EU future citizen. Environmental education on the European Green Deal

Maria Amata Garito, Alessandro Caforio, Andrea Falegnami*, Andrea Tomassi*, Elpidio Romano

International Telematic University UniNettuno, Rome, Italy

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Abstract

The Green SCENT project aims to educate European citizens to acquire green skills within the eight Focus Areas identified by the EU Green Deal Communication. The funded project involves 15 partners from 10 European countries. The very first outcome of the project is to build a competence framework for shaping the future environmental education of European citizens. The task specifically involved 13 researchers, organised into 8 teams (one for each focus area addressed by the Green Deal communication) who worked on the project for approximately 11 months (January to November 2022). The aim of the project described in this study was to establish competences, and their specificities in terms of knowledge, skills and attitudes, creating a competence framework on sustainability issues and incorporating the feedback and insights of stakeholders by placing them as co-creators. From the developed competence framework, an interactive knowledge graph of competences was created as a practical tool to present and exploit the competence framework. This was then used to incorporate the bottom-up perspective and open up a discussion on research that hitherto had a top-down scientific approach only with competence elicited from literature data. In this paper the identified competences for the focus areas of Circular Economy, Clean Energy and Smart Mobility are used as case study. The main objective of this paper is to highlight the importance of innovative stakeholder contributions obtained through the Delphi study, the workshops and the assemblies with citizens of all ages, backgrounds and educational levels. The ultimate knowledge artefact consists of more than 120 competences articulated in over 2500 knowledge, skills and attitude descriptions.

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Keywords: Circular economy; Clean energy; Smart mobility; Education; Sustainability

1. Introduction

In a span of less than two centuries, environmental changes have accelerated dramatically due to the out-of-control exploitation of natural resources, producing passing impacts on the ecological balance [1–3]. This intensive

* Correspondence to: International Telematic University UniNettuno, Corso Vittorio Emanuele II, 39, Rome, Italy.
E-mail addresses: andrea.falegnami@uninettunouniversity.net (A. Falegnami), andrea.tomassi@uninettunouniversity.net (A. Tomassi).

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exploitation of mostly non-renewable resources, which has characterised recent human history, can be traced back to the simultaneous action of linear capitalist models of resource exploitation, short-sighted policies on the long-term effects of such exploitations, and the lack of public involvement on these issues [4–6]. For example, following the invention of the internal combustion engine, and the (albeit short-term) benefits of mass production in the automobile sector, both citizens and political institutions initially favoured a model of mobility development that has been making its harmful effects felt for some time now [7–9]. In order to counter this phenomenon, European political institutions are stimulating various actions, including formal agreements between the countries of the community and the simultaneous funding of research projects. For example, the European Green Deal (GD) aims to achieve zero emissions by 2050 and reduce the impact of industrialisation on the environment [10–12]. The expected positive effects are a reduction of the impact, both on the environment and on humans — in terms of economic conditions and well-being, both of which are sustainable. These goals cannot be achieved without political involvement, economic collaboration and citizen commitment [13–15]. For this purpose, for example, the European Union has funded, under the Horizon 2020 programme, the project Green SCENT — Smart Citizen Education for a greeN fuTure [https://www.green-scent.eu/]. The expected results of this audacious project are manifold, among them the first is the realisation of a framework of competences (understood as a combination of Knowledge, Skills, Attitudes) [16–19] that ideally the future European citizen should possess. The GD aims to address these issues to environmental awareness through eight critical focus areas named in the European Communication: *Increasing the EU's Climate Ambition for 2030 and 2050*; *Supplying Clean, Affordable and Secure Energy*; *Mobilising Industry for a Clean and Circular Economy*; *Building and Renovating in an Energy and Resource Efficient Way*; *Accelerating the Shift to Sustainable and Smart Mobility*; *From 'Farm to Fork': Designing a Fair, Healthy and Environmentally-Friendly Food System*; *Preserving and Restoring Ecosystems and Biodiversity*; *A Zero Pollution Ambition for a Toxic-Free Environment* (*Communication on The European Green Deal*) – hereinafter, we will use the corresponding following terms: *Climate Change*; *Clean Energy*; *Circular Economy*; *Green Building*; *Smart Mobility*; *From Farm to Fork*; *Biodiversity*; *Zero Pollution*. One of the objectives of this work is to emphasise the importance of innovative stakeholder input obtained by performing workshops and assemblies with citizens of all ages, backgrounds, and educational levels. The innovative contribute underling the proposed approach is to mix a bottom-up sense-making of research combined with the classical top-down taxonomy resulted from systematic literature review. The present article details the competences that have been identified for the areas of Circular Economy, Clean Energy, and Smart Mobility. An even further originality element of the research is represented by the calibration of each identified competence on the levels of the European Qualifications Framework (EQF) [20]; the same competence is declined on these levels so that a teacher, a professional, or a student, virtually every European citizen, can be guided towards principles of sustainability [21]. The remainder of the article is organised as follows: the next section (par. 2) briefly outlines the previous and relevant experiences reported in literature; Section 3 describes the methodologies adopted; this is followed by the results of the research, later discussed in Section 4; finally, Section 5 deals with conclusions.

2. Remarkable precedents

The attempt to produce a competence framework does not trace back insofar. However, the European Union has published recently few competence frameworks: GreenComp, DigComp, DigCompEdu and EntreComp, produced by the Joint Research Centre (JRC) [22–26]. While DigComp and DigCompEdu address the digital competences of the European citizen and EntreComp the entrepreneurial competences, GreenComp aims to provide competences to sustainable behaviour. Differently from the latter, which proposes very broad and transversal topics (i.e., *embodying sustainability values, embracing complexity, envisioning futures, acting for sustainability*) as starting areas from which to elaborate competences, the competence frameworks developed within the Green SCENT project has a very vertical structure, using the eight focus areas included in the European GD communication as starting areas from which to elaborate competences.

Across the Atlantic, there is another comparable project recently developed in Canada called Climate Adaptation Competency Framework [27] that aims to promote related sustainability issues by identifying, defining and describing twenty-four competencies. This framework is also developed from scientific research, workshops and expert consultation similarly to the one developed in Green SCENT, which, however, differently identified and described over 120 competencies in total. To find other similar documents, however less focused on citizen engagement and environmental awareness, it is necessary to go further back in time to the Paris Agreement [28], the international climate change treaty adopted in 2015 that addresses climate change mitigation, adaptation and

finance, or even further back to the 1997 Kyoto Protocol [29], the international treaty that extended the 1992 United Nations Framework Convention on Climate Change (UNFCCC) [30] to reduce greenhouse gas emissions, on the basis of the scientific understanding that global warming is in progress and that human-generated CO2 emissions are the cause of it.

3. Methodology

Constructing the competence framework within the project schedule required intensive effort in a limited amount of time. Therefore, the research activities involved 13 researchers (7 experienced and 6 doctoral students), organised in 8 teams (one for each focus area addressed by the Green SCENT project) spread over approximately 11 months (January to November 2022). Fig. 1 shows the various stages of the methodological process addressed in the realisation of the competence framework, which are explained in detail in the corresponding sections below:

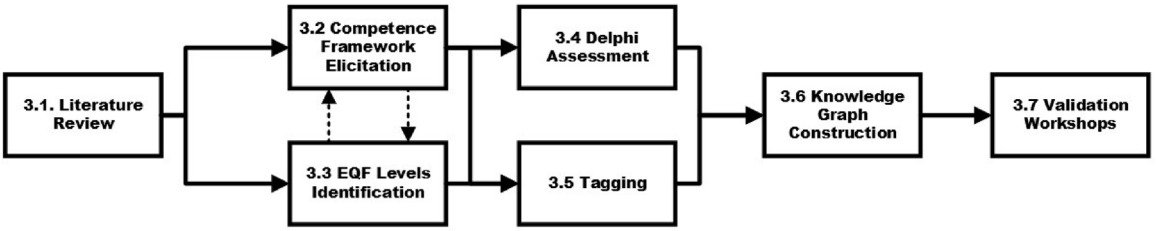

Fig. 1. Methodological workflow followed in the development of the competence framework.

3.1. Literature review

To each of the eight teams was assigned a focus area (e.g., *Climate Change; Clean Energy; Circular Economy; Green Building; Smart Mobility; From Farm to Fork; Biodiversity; Zero Pollution* – in the following, the names of the areas will coincide with the corresponding teams, except where explicitly expressed). At this stage, the teams mostly worked autonomously for organisational convenience, but it is nevertheless reasonable to consider that the process of collecting the documentary corpora took place in a similar manner for all of them. For illustrative purposes, the gathering process followed by the *Smart Mobility* team is shown below. Firstly, a preliminary scoping review was carried out aimed at an initial acquisition of the concepts of the relative domain (e.g., Smart Mobility; Transport Networks; Commutation Time; Public Transportation; Autonomous Vehicles; Carbon-free Transportation modes; Micromobility; Unmanned Vehicles; etc.). Consultation of the farmework previously produced by the Joint Research Centre was indeed very helpful at this stage (i.e., GreenComp by Bianchi et al. [24]. Having acquired sufficient knowledge of the relative terminology, academic databases relevant to the focus area under investigation were identified (e.g., Scopus, Eric) and appropriate relative queries were created, i.e., sufficiently broad so as not to preliminarily exclude potentially valuable documents. This inevitably led to the identification of a huge number of documents for every focus area. As an example, at this stage, the results obtained for Smart Mobility were 1339. A daily throughput of 20 can take 4 months. To build the competence framework and the subsequent dependencies, this duration would not be feasible. For these reasons, some proven Natural Language Processing methodologies were used to handle this large amount of data [31,32]. The items in the documental corpora were prioritised in terms of their relative relevance, and consequently, in the end, 118 documents were directly evaluated. Documents deemed significant during the reading were used in the following stage of competence framework elicitation.

3.2. Competence framework elicitation

The documents that have passed the stage 3.1 were used to build a competence matrix for each of the eight Focus Areas, each structured similarly: every focus area is detailed in several competence areas, each of which in turn is divided into competences (Fig. 2). Each competence is further detailed by a description and some keywords.

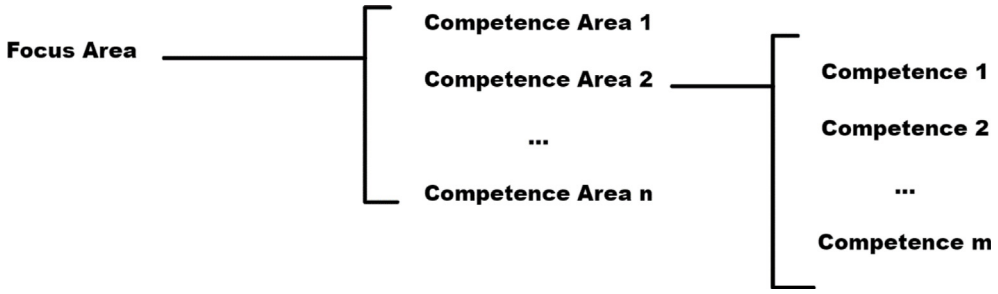

Fig. 2. Taxonomy resulting by the top-down approach followed during the elicitation process.

The first-order *Clean Energy*, *Circular Economy,* and *Smart Mobility matrices* show a subdivision into competence areas populated by competences derived from literature review. The only matrix of the Clean Energy Focus Area as an example is given below, as a discussion of the results of all the competencies identified for the three case study focus areas covered in this article would result in an excessively long dissertation (Table 1).

3.3. EQF levels identification

At this point, it was necessary to identify the EQFs in order to build the second-order matrices of each competency per GD focus area. The matrix of the competence *2.1 Renewable energies* of the Clean Energy Focus Area is reported below as example (Table 2).

In the second-order matrix every competence identified for GD focus area is categorised in a first column as a set of Knowledge, Skills, and Attitudes (KSA) that define addressed sustainable behaviours. In a second column the EQF education levels are crossed with the KSA covering behaviours for the full educational spectrum from elementary school to post-docs via professional workers. In the third column of the second-order matrix each KSA is explained with a statement that declares the knowledge, the skill or the attitude to be obtained. The last two columns are dedicated to keywords and tags which will be useful in the construction of the knowledge graph (see onward Section 3.6).

3.4. Delphi assessment

A Delphi study was launched once the first draft of the competence framework was completed. Developed as an interactive forecasting method, it relies on a group of experts asking open-ended questions and refining their predictions about uncertain events. [33,34]. This study aimed to document and define competencies in terms of knowledge, skills, and attitudes. As part of the process, the partners' experts were presented with statements and asked to express an opinion or provide comments on the elements presented. The feedback received informed the refinements of the matrixes. Every GD focus area was prepared with a document asking partners whether the competences covered should be included in the framework for online, open, smart, and technology-powered education. In addition, partners were asked to suggest modifications, reorganisations, or additions to other relevant competence areas for the Green Deal focus areas, indicating why. Either in case of reorganisation, or in case of addition of a brand-new competence area, the need to provide details on the implementation of the suggested adjustment and references to scientific/political literature and a draft of specific competencies and related descriptors in terms of Knowledge, Skills and Attitudes (KSA) also with reference to educational level (using European Qualification Framework – EQF – standards) was advanced. Partners were asked to rate each competency's usefulness and quality. Therefore, partners could reformulate competencies.

Table 1. Clean energy competence areas and competences' descriptors. Note as the specific GD topic (e.g., clean energy) is categorised in competences areas, which in turn cluster different competences, tracing the taxonomic structure showed in Fig. 2.

Clean energy focus area		
Competence Areas	Competence	Descriptor
1. Understanding the challenge	1.1 Ethical and sustainable thinking	Envision access to affordable, reliable and sustainable clean energy for all; Empathy and respect for the environment; spirit of cooperation between everyone in work, family and social contexts
	1.2 System thinking	The abilities to think how different systems are embedded; awareness of complexity of global system and thinking in terms of an interrelated system; The ability to anticipate the effects caused by the use of unsustainable energy and to be able to change own behaviour; understanding multiple ways of knowing, including their respective methodologies, applications, benefits, and limitations. Also entails collaboratively and inclusively applying sustainability competencies to foster social change.
	1.3 Collaboration	Promote the spirit of collaboration in different social contexts and actively engage with environmental challenges and sustainable initiatives on both individual and collective levels.
	1.4 Strategic action	Promote the ability to collectively demand, develop and implement innovative actions and plans for energy transition.
2. Embodying Clean Energy	2.1 Renewable energies	Commit to the use of renewable energy, implement relevant laws and regulations and promote the necessary infrastructures to produce energy
	2.2 Secure and Affordable Clean energy	Ensure access to affordable, reliable, sustainable and renewable energy for all
	2.3 Responsible Production and Consumption	Ensure sustainable production and consumption patterns
	2.4 Sustainable city and communities	Make cities and human settlements inclusive, safe, resilient, efficient and sustainable
3. Industry, Employment, Finance	3.1 Industry, Innovation & Infrastructure	Promote more sustainable industrial models, build resilient infrastructure and foster research and innovation
	3.2 Employment opportunities	Build job opportunities related to energy transition and renewable energy technologies using natural and non-impacting resources
	3.3 Financial & economy literacy	Management and business development to foster plannings towards clean energy

3.5. Tagging

Due to the prior steps, eight distinct information structures were developed, which, contrary to the general intention of the Green SCENT project, are not held together by cross-cutting and multidisciplinary themes, but are formally distinct, considering that each team had to work independently at distilling the knowledge distilled from the documentary corpora gathered during the literature review. This, inevitably, led to the construction of eight distinct taxonomies living in enclosures that lack any communication link. This phenomenon is known as the "Information Silos" problem [35,36]. Hierarchically structured information from subject matter experts (SMEs) belonging to different teams is at risk of remaining compartmentalised, ending up not promoting any interdisciplinarity (Fig. 3).

Researchers labelled competencies with tags based on the concepts enucleated during the reading stage (see Table 2), so that the non-explicit meaning of the framework could be conveyed. As shown in the bottom side of Fig. 3, the objective is to gather these tags, standardise them, and based on them, establish meaning plexuses that will unite different focus areas. By forming these plexuses, silos dissolve and explicit information exchange occurs. The collection, management, and uniformity of the many tags was made practically viable by adopting Obsidian personal knowledge management software to that end [37–39]. The adoption of this software, in addition to the management of tags and associated folksonomy, has made possible the creation of a communicative and cognitive artefact that is extremely suitable for pursuing the goals of the project: a knowledge graph that will be described extensively in the following section.

Table 2. Clean energy renewable energies competence definition. The table shows the details about the knowledge, skills and attitudes (first column) identified for this competence. EQF levels are marked in the second column while statements describing KSAs are reported in the third column. The fourth and the fifth columns are dedicated to some keywords and hashtag related to the identified KSAs.

Clean energy - 2.1 Renewable energies				
KSA	EQF	Statements	Keywords	Tags
Knowledges	from 1 to 5	Awareness among students about the nature and causes of energy related challenges being faced by humankind (such as increasing scarcity and prices of fossil fuels, climate change concerns etc.)	Resource scarcity awareness	#resource #scarcity
		Awareness on efficient and effective harnessing of renewable sources of energy	Efficient energy	#renewable_source #efficiency
		Develop functional values and attitudes in the students towards harnessing of renewable energy sources and associated socio-economic and environmental dimensions	Renewable energy awareness	#renewable_soruce #efficiency
		Knowledge renewable energy sources using appropriate technologies by demonstrating direct relevance of renewable energy utilisation for human beings and their environment.	Renewable energy awareness	#renewable_source #efficiency #technologies
		Basics knowledge of renewable energy resources and technologies	Renewable energy awareness	#renewable_source
		Awareness of various types of non-renewable and renewable sources of energy, their resource potential, existing technologies to harness them, economics and energetics of these technologies, and socio-cultural, environmental and institutional issues related to their development and utilisation	Renewable energy awareness	#renewable_source #renewable_use
		Understanding the benefits of using marine energy	Exploring renewable resources	#marine_energy #water_energy #renewable_source
		Understanding the relevance of wind energy as a natural and clean source	Exploring renewable resources	#wind_energy #renewable_source
		Understanding the importance of water resources and water saving	Exploring renewable resources	#water_energy #legislation #renewable_source
Skills	from 1 to 5	Ability to make efforts towards development of alternative strategies to deal with various challenges faced by energy sector	Clean energy strategies	#sustanaible_energy #renewable_source #renewable_use
		Ability to make efforts towards implementation of alternative energy production to deal with different environmental challenges	Clean energy strategies	#sustanaible_energy #renewable_source #renewable_use
		Ability to make efforts in order to include provision of more energy for satisfying increasing global energy requirement in an environmentally sustainable manner	Clean energy strategies	#sustanaible_energy #renewable_source #renewable_use
		Ability to make an effort to conserve resources in own home, such as electricity, natural gas, and water for environmental reasons	Clean energy strategies	#sustanaible_energy #renewable_source #renewable_use
		Ability to distinguish which applications/tools/media use renewable energy sources	Clean energy strategies	#sustanaible_energy #renewable_source #renewable_use
		Purchase energy-efficient products	Clean energy strategies	#sustanaible_energy #renewable_source #renewable_use

(*continued on next page*)

Table 2 (*continued*).

Clean energy - 2.1 Renewable energies				
KSA	EQF	Statements	Keywords	Tags
Attitudes	from 1 to 8	Establish an individual and collective lifestyle based on energy saving	Clean energy strategies	#sustanaible_energy #renewable_source #renewable_use
		Benefits of energy saving on the environment	Exploring renewable resources	#sustanaible_energy #renewable_source #renewable_use
		Importance of renewable energy sources (wind, water)	Exploring renewable resources	#sustanaible_energy #renewable_source #renewable_use

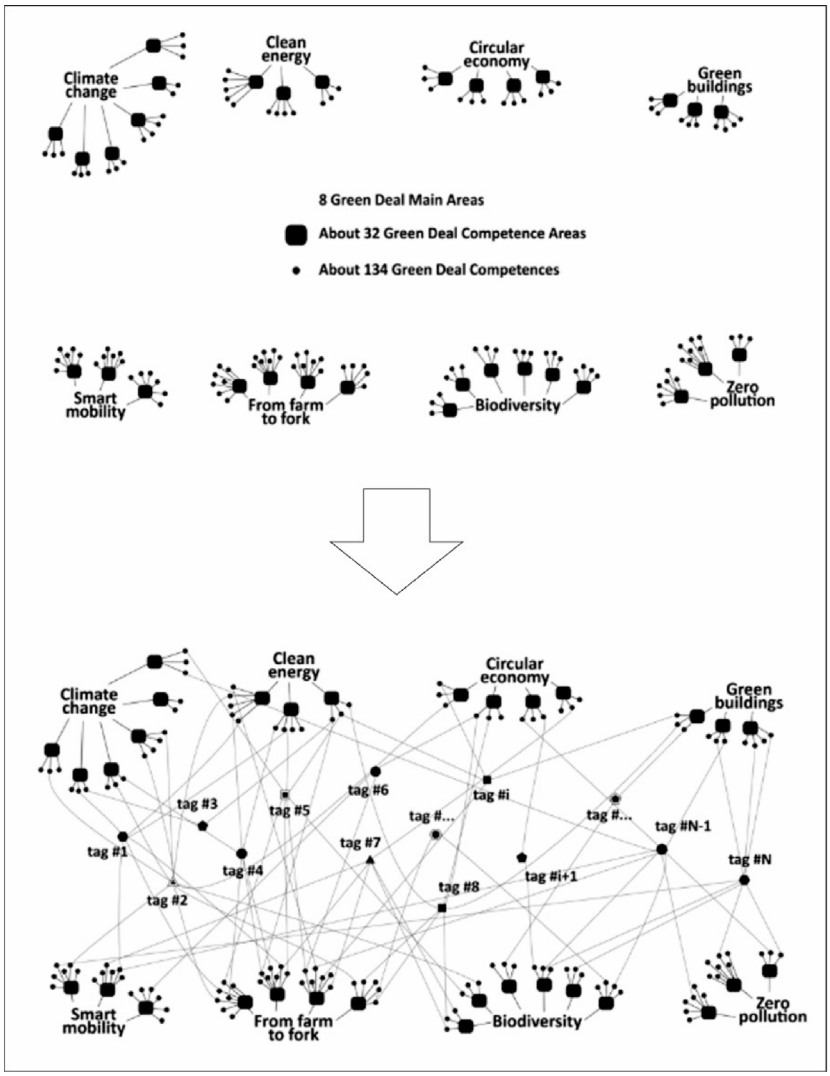

Fig. 3. The "Information Silos" problem with compartmentalised information (on the left); tags connecting information breaks down the walls through the silos.

3.6. Knowledge graph construction

As humans evolved, most of our cognitive activities are based on image recognition [40,41]. To provide EU citizens with an affordable tool regarding matrices, the researchers have converted these into an aggregated knowledge graph. A knowledge graph is a knowledge base using a graph-structured topology to integrate data [37,38,42]. While such data representation enables efficient handling of a large amount of complex information [43], it also alleviates the well-known information silo problem [44]. In Obsidian software application is also possible to manage knowledge in a graph and, therefore, to make explicit the underlying connections among the different competences. In fact, a tag shared by two or more competences belonging to different focus areas implies the existence of a latent topic with binding functionality. Tags (brownish dots in Fig. 4) that have been used more frequently can be consolidated under common topics as part of the tag harmonisation process. Consolidation of this kind does not occur as a result of direct external intervention, but rather emerges as a result of multiple associations working together.

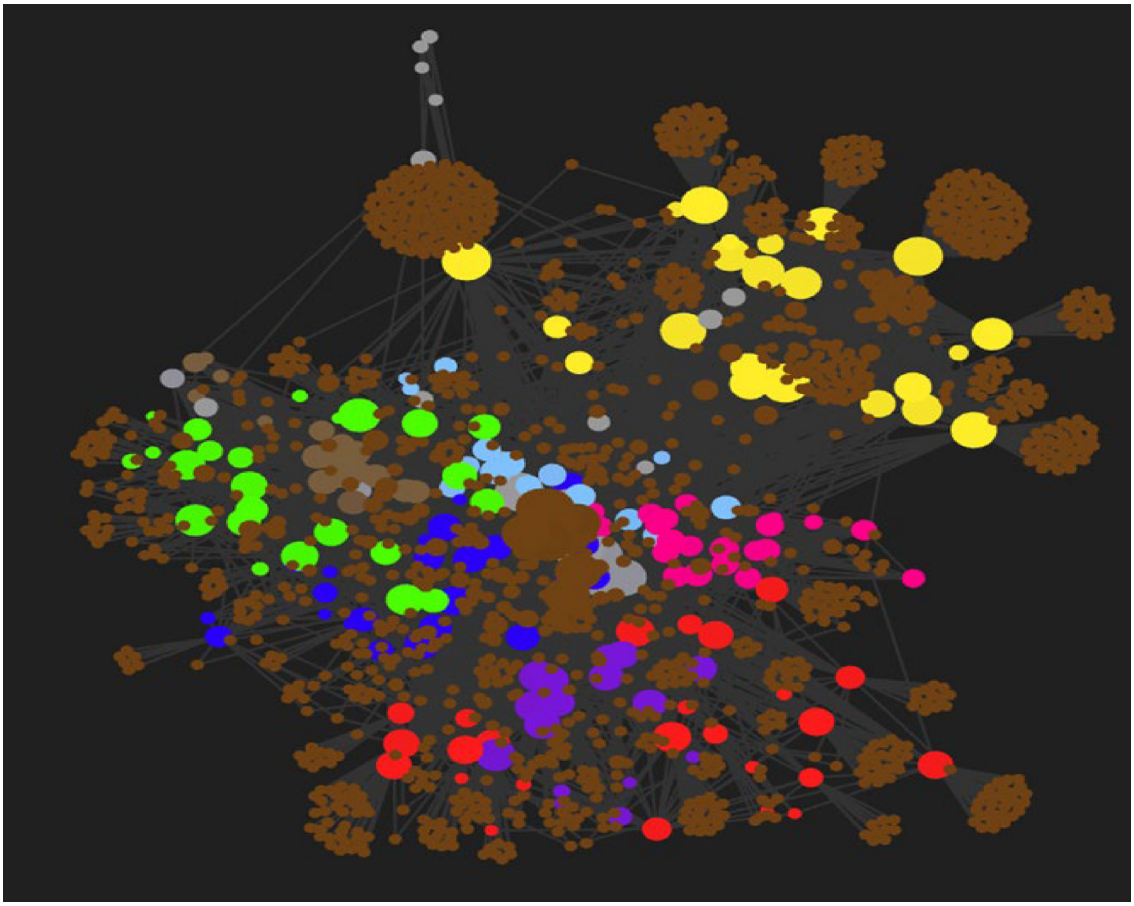

Fig. 4. The knowledge graph derived from the competence framework matrices with the display of the tags (brownish dots) connecting the other elements and information (coloured dots). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3.7. Validation workshops

The knowledge graph's accessibility and usability were tested during some collaborative design workshops, in which some of the participants have not been involved in the graph's development process. Several co-design

activities were designed to collect qualitative data and to assess the affordance of the graph as educational artefact; other proposed activities were intended to harmonise the competences in the eight focus areas; furthermore, from the freely bottom-up exploration of the graph, the users' activity was used to identify emerging categories of meaning previously unrevealed. Three different categories of participants were involved in three different stages of co-design workshops:

- the project partners in an in-presence meeting;
- the external advisory board;
- the young people involved in the youth design assemblies (YDA) in collaboration with the Danish Board of Technology (DBT).

To conduct the co-design activities, the research team designed a toolkit (i.e., a visual template presenting the entire competence framework arranged as an octagon — see Fig. 5 in appendix) to interact with the workshop's participants, which were allowed for both writing down observations, tagging, and connecting existing competences. The interaction activity with the octagon followed the stage of freely exploration of the graph. Only during the YDA, the process was flipped.

3.7.1. In-presence meeting

The in-presence workshop was held on October 13th 2022 in Rome, and it involved the project partners in a co-design activity that lasted 2 h. The agenda consisted in: Workshop presentation (10 min); Creation of 8 work groups (5 min); 1st session: Exploration of the competence framework knowledge graph (35 min); Presentation of the semantic graph (10 min); 2nd session: Exploration of the semantic graph (45 min); Session wraps up (10 min). After a preliminary explanatory introduction, the research team divided the participants into eight groups. Each group received a printed version of the octagon and access to an instance of the knowledge graph that could be explored independently. Any observations from the participants were in this activity documented onto the octagons. During the next activity, the research team introduced the purpose of the semantic graph to allow the partners to explore the competence framework from a bottom-up perspective. That session helped the team to find new categories which could be implemented in the knowledge graph. On that occasion, the participants reflected on the existing relations between the competencies and, again, reported their considerations about new keywords and connections on the competence octagon layout.

3.7.2. External advisory board meeting

The second 1-hour workshop involved only members of the external advisory board. The co-design workshop was held on November 16th and 22nd in two separate but identical online meetings, including as many participants as possible, according to their availability. The participatory activities were conducted on a virtual Miro Board, a visual collaboration platform which featured a digital version of the Octagon. The agenda this time was: Presentation of the interactive knowledge graph (10 min); Competences exploration (20 min); Comment & impressions (5 min); Semantic graph exploration (25 min). After having introduced the Miro board platform, the researchers successfully guided the participants through an analysis and exploration of the knowledge graph from a bottom-up perspective, and encouraged them to take part in an open discussion about the current state of competence frameworks in the interactive network systems provided by Obsidian. Afterwards, the participants discussed the competence framework and its existing correlations to enrich the quality of the knowledge graph. In addition, the research team posted their comments on the Miro board. The results were analysed after two meetings and summarised in a report. With the exploratory workshop framework in place, participants were free to analyse the knowledge graph and voice their opinions through an open debate with the facilitators. That allows the research team to obtain and evaluate feedback from the participants, in terms of suggestions, ideas and expectations. This feedback is related to the usability of the interactive knowledge graph, and the structure of the competence framework.

3.7.3. Youth design assemblies

In a 3-hour workshop meeting on November 17th and 18th 2022, the YDA provided useful feedback and helped co-create the competence framework in collaboration with the DBT research team which facilitated the workshop.

The YDA acted as an expert panel by providing guidance, innovative ideas, and constructive feedback on the first version of the framework, presented both as the Octagon and on the competence framework knowledge graph web page. This was the first step in starting the bottom-up approach to improve and increase the clarity of the competence framework. The workshop was divided into several sections:

- The participants reflected on their everyday contribution to the green transition, and their abilities to achieve political influence. They discussed what competences or green KSA they need to achieve their desires for participation and contribution.
- The participants shared their thoughts on the competences described in the Octagon. They worked in groups of interest, and each participant shared their feedback on two different competences. All competences received feedback in the process.
- The participants individually explored the competence framework knowledge graph web page and answered yes/no questions, guiding them to get an overview of the framework.
- The participants explored the web page in groups with 4–5 participants. They answered questions regarding the competence framework, which encouraged the participants to share innovative ideas, questions, and constructive feedback.

Questions about the wording, content-relevant, and oriented towards overall expressions were asked. Thus, the questions allowed for feedback on multiple levels of the competence framework. The feedback from the meeting was gathered in Mural board, another visual collaboration platform during the workshop and then analysed and summarised (Fig. 6 in appendix). Thus, the data/feedback were collected by open dialogue, as the participants share their thoughts guided by open questions. The qualitative approach offers opportunities to gain knowledge about the competence framework that are difficult to quantify and measure with numbers, e.g., the first impression and the understanding of the competencies.

4. Results and discussions

4.1. Delphi study

In general, the Delphi study results were positive after sharing the first draft with partners. Researchers identified and developed all the main competence areas within the competence framework. There were 13 competences rated as excellent, 36 as very good, 34 as good and 10 as poor. Competences considered ‘poor’ were excluded from the competence framework. ‘Good’ competencies were modified or recalibrated in accordance with research team and partner discussions. Except for some minor, non-content-related adjustments, the ‘Excellent’ and ’Very Good’ competencies were maintained. The framework includes a number of new competencies proposed by the partners to cover as many topics as possible within the 8 GD focus areas. Partner suggestions were taken into account when making adjustments to each competence, both in terms of content and in reformulating items to improve their adequacy and relevance. Several KSAs were added or modified based on EQF levels. Thanks to discussions between the research team and partners in the Delphi study, sharing ideas and experience, led to a great improvement of the work and on the outcome of the competence framework. Main outcomes are reported in Table 3.

Table 3. Main findings of the Delphi study.

Competence rating	Number of competencies	Actions taken
Excellent	13	Maintained with minor adjustments
Very Good	36	Maintained with minor adjustments
Good	34	Modified or recalibrated based on discussions
Poor	10	Excluded from the competence framework

Actions Taken:

- Competencies rated as excellent and very good were maintained with minor adjustments.

- Competencies rated as good were modified or recalibrated based on discussions with the research team and partners.
- Competencies rated as poor were excluded from the competence framework.

Additionally:

- New competencies proposed by partners were added to cover topics within the 8 GD focus areas.
- Partner suggestions were taken into account in terms of both content and item formulation to improve adequacy and relevance.
- Several KSAs were added or modified based on EQF levels.
- Discussions and collaboration between the research team and partners during the Delphi study led to significant improvements in the work and the outcome of the competence framework.

4.2. Workshops

4.2.1. In-person and external advisory board workshops

The results gathered during the three co-design activities are reported below. The interactive system appears as a practical tool to present the competence framework. The emerging topics are useful to enrich the quality of the research and to create a shared and bottom-up view of the competence framework. Navigation appears complicated at first, but reading the homepage will provide instructions on how to use it. One group reported that exploring the graph using the left menu was an easy and understandable operation. So, its contents are well structured providing a more accessible navigation system for all. Another suggestion was to provide different languages to make the knowledge graph more accessible to a broader group of people from different cultural backgrounds. Regarding the clarity and understandability of the framework, the descriptions of the competencies, such as Critical thinking, System thinking, Learning, Communication, Transdisciplinary, Monitoring, and Collaboration, appear general and broad although necessary. The term is linked to practical examples in order to generate direct comprehension of a particular competency. An interesting piece of advice was to implement a novel way of navigating the knowledge graph beyond the mere visualisation of information to stimulate the user to explore the competencies through "self-critical" navigation by replying, for example, to predefined questions or creating hypotheses to solve particular sustainability issues. Furthermore, participants offered suggestions for improving semantic graph systems and emerging categories from a bottom-up perspective.

4.2.2. Workshop with Youth Design Assembly

The results gathered during the YDA co-design activities are reported below. The participants reflected on the competence areas presented in the Octagon and generally found the competences in the competence framework important and relevant. The participants presented a lot of ideas, questions, and feedback regarding each of the competence areas. Here are the most important points from the feedback: The participants find the competencies relevant and important; The participants suggest new competencies, new perspectives and ask questions regarding the competence areas; The participants suggest that some of the competencies could be simpler described;

The participants have a constructive approach to the competence framework knowledge graph web page. They think it is a relevant tool. The most important points, ideas and suggestions are briefly reported below: The participants encourage to move the 'start here' page to the top of the content list, or to automatically make it the start page on the web page; The participants propose to make a drop menu, to strengthen the organisation and overlook of the competence framework; The participants ask for more introductions and simpler language, to make sure that the users will understand the competence framework and how to use it.

Main outcomes of the workshops are reported in Table 4.

5. Conclusions

In this article, we have presented our preliminary findings from the ongoing Green SCENT project, which aims to foster green competences among European citizens within the eight Focus Areas identified by the EU Green Deal Communication. Our approach involved engaging stakeholders as active co-researchers, departing from the

Table 4. Main findings of the workshops.

Workshop/activity	Feedback points
In-person and external advisory board workshops	- Interactive system is seen as a practical tool. - Navigation may initially appear complicated, but instructions are provided. - Left menu navigation is found easy and understandable by one group. - Suggestions to provide different languages for accessibility. - Competency descriptions are seen as general but linked to practical examples. - Advice to implement novel ways of navigating the knowledge graph. - Suggestions for improving semantic graph systems and emerging categories from a bottom-up perspective.
Workshop with Youth Design Assembly	- Participants find competencies relevant and important. - Suggestions for new competencies, perspectives, and questions. - Suggestions to simplify competency descriptions. - Constructive approach to the competence framework knowledge graph web page. - Suggestions to move "start here" page to the top or make it automatic start page. - Proposal for a drop menu for better organisation.- Request for more introductions and simpler language for better understanding.

traditional top-down approach to knowledge acquisition and instead adopting a bottom-up expansion of a pre-existing folksonomy to uncover latent concepts not yet identified in the literature. However, while participatory approaches are valuable, it is important to acknowledge that included groups are not independent producers of knowledge and may require mediation by academic scholars. These observations raise important ethical questions for citizen science projects, such as how to create space for different types of knowledge to coexist and contribute to a more just world. Although the Green SCENT project does not aim to answer these questions at present, it does highlight the need for ongoing reflection and inquiry. Moving forward, the project should explore opportunities to link participants' knowledge and initiatives with scientific research goals, particularly in supporting citizen engagement and learning of green skills. The project plans to develop demonstration applications to instil such skills in young European citizens, which can be facilitated by designing the development process in a way that emphasises participants' choices during data collection and considers understanding and emerging ideas as opportunities to (re)orient and extend research. Early involvement of stakeholders in the knowledge elicitation stage has shown promise in building knowledge, skills, and attitudes that underpin the desired competencies in this journey. The Green SCENT project's preliminary findings have important implications for the development of demonstration applications aimed at instilling green skills in young European citizens. By involving stakeholders as active co-researchers and emphasising participant choices during data collection, the project seeks to link participants' knowledge and initiatives with scientific research goals, supporting citizen engagement and learning of green competencies within the eight Focus Areas identified by the EU Green Deal Communication. This approach holds promise for building knowledge, skills, and attitudes that underpin the desired competencies in fostering a more sustainable and just world.

- Green SCENT project aims to foster green competences among European citizens within the eight Focus Areas identified by the EU Green Deal Communication.
- Stakeholders were engaged as active co-researchers in a bottom-up approach to knowledge acquisition.
- Participatory approaches require mediation by academic scholars to ensure authenticity and ethical considerations.
- Ongoing reflection and inquiry are needed to create space for different types of knowledge in citizen science projects.
- Future opportunities should be explored to link participants' knowledge and initiatives with scientific research goals.
- Demonstration applications will be developed to instill green skills in young European citizens.
- Early involvement of stakeholders in the knowledge elicitation stage can build knowledge, skills, and attitudes for desired competencies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix

See Figs. 5 and 6.

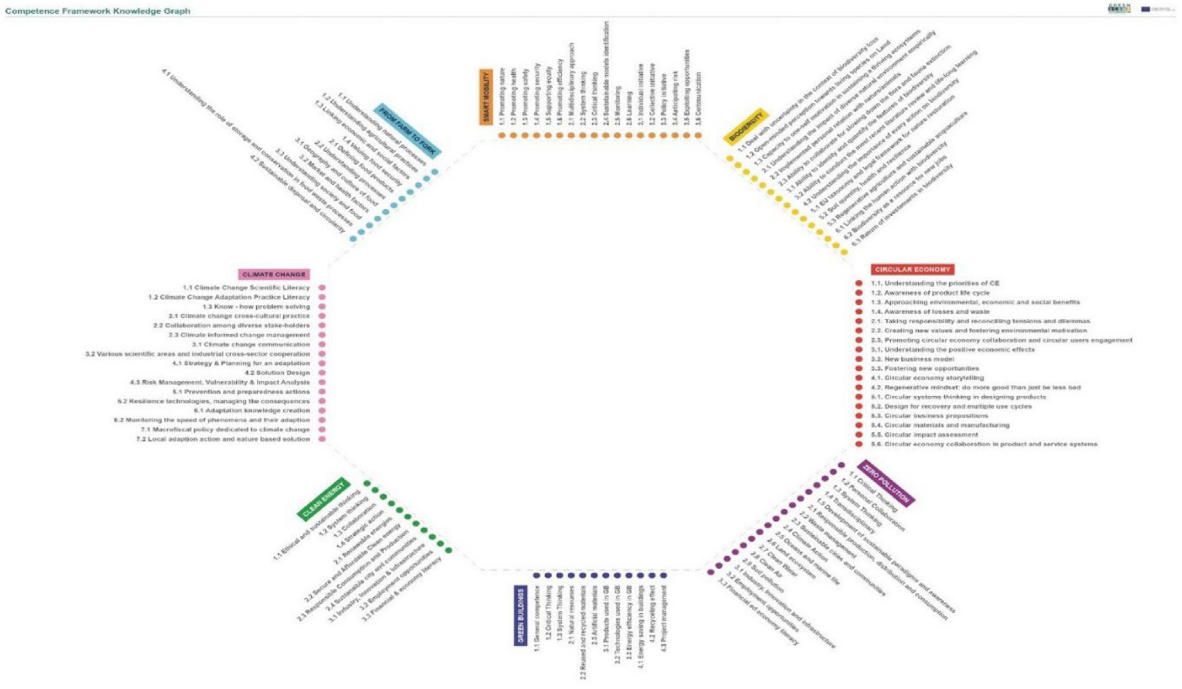

Fig. 5. Competence octagon used as a template for the workshops of the in-presence meeting in Rome, the consultation with the External Advisory Board and the interaction with Youth Design Assemblies.

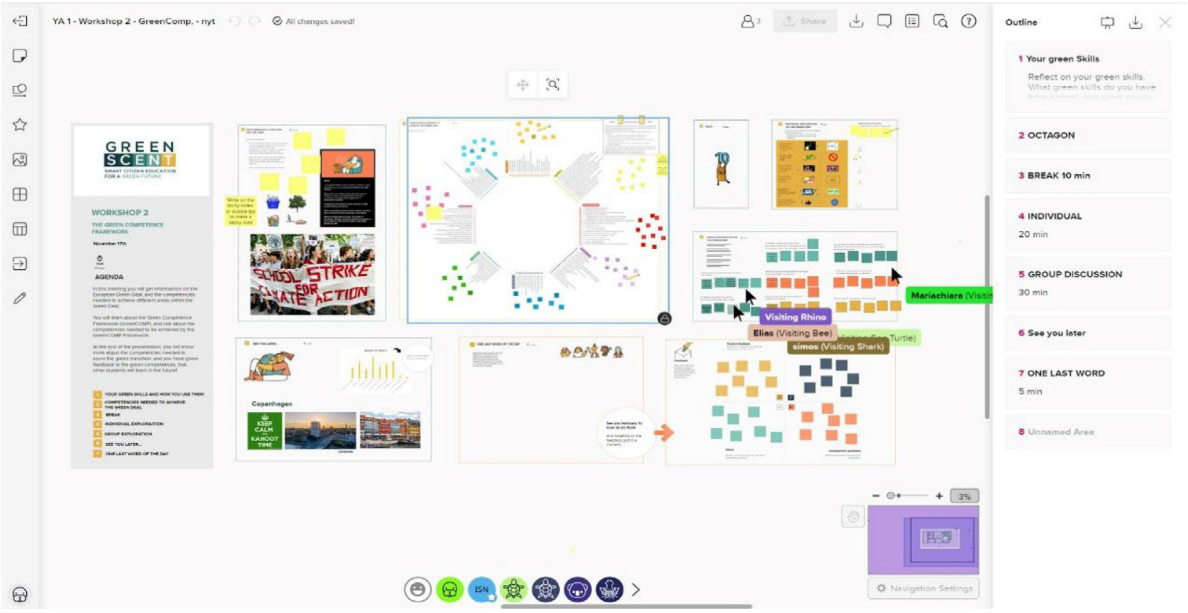

Fig. 6. Collected considerations about the knowledge graph on the Mural board during the co-design workshop with the Youth Design Assembly.

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