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Procurement Educational Consortium for Innovation-sourcing using Sustainability

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PRocurement Educational Consortium for Innovation sourcing Using Sustainability

Intellectual Output 1

Mapping the landscape - literature - EU projects - consultancy reports - trainings at higher education

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Abstract:	This report outlines the initial phase of a project aimed at mapping the competency literature related to public procurement for sustainable innovations, innovative sustainable SMEs, and environmental engineers. The project conducts literature reviews to gain a comprehensive understanding of the future competency requirements for actors in these three target groups. The data collection process includes scientific literature analysis, outcomes of European projects, consultants' reports, and other stakeholder reports to specify the competency and capability requirements in public procurement and innovative sustainability issues. The report emphasizes the importance of social, meta, functional, and cognitive competences, particularly in relation to public procurement and sustainable innovation, as well as the roles of entrepreneurs and environmental engineers. The report highlights the need for increased leadership, managerial, and strategic capacity in public procurement for sustainable innovation, moving beyond operational processes and legislation. It also addresses barriers faced by SMEs in participating in public procurement and emphasizes the importance of revising the attractiveness of public procurement for SMEs. The report is divided into five main chapters, each focusing on specific areas such as competency requirements for public procurement leaders, competency requirements for environmental engineers, and competency requirements for entrepreneurs. The report concludes with a general summary of the findings.

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List of Abbreviations

Abbreviation	Meaning
IO	Intellectual Output
D	Deliverable
PSM	Purchasing and Supply Management
SPSM	Sustainable Purchasing Supply Management
GDP	Gross Domestic Product
SME	Small and Medium Enteprises
EU	European Union
SDG	Sustainable Development Goals
NGOs	Non-Governmental Organisations
IEA	International Engineering Alliance
EEA	European Environment Agency

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Introduction

In the project's initial phase, the competency literature on public procurement for sustainable innovations, innovative sustainable SMEs, and environmental engineers, as well as their combination in literature, is mapped. Therefore, literature reviews are conducted to gain a comprehensive overview of the future competence requirements of actors in the three target groups/communities. In addition to scientific literature analysis, other more practice-oriented sources, such as outcomes of European projects, consultants' reports, and other stakeholder reports, are included in the data collection of public procurement and innovative sustainability issues. This is done to specify today's competence and capability requirements for both sides in public procurement transactions. The focus is on the competences, which are a construct of social, meta, functional, and cognition-oriented competences needed in combination with a high involvement in public procurement and innovative sustainability issues and the role of entrepreneurs and environmental engineers.

The Intellectual Output (IO1) has an exploratory character, where we aim to understand the three communities through systematic reviews of scientific literature, consultancy reports, European projects, and other publicly available sources. Public procurement of sustainable innovation sourcing needs to increase leadership, managerial, and strategic capacity in this domain instead of only emphasising operational procurement processes and legislation. Effective public procurement of sustainable innovation involves interaction and dialogue with the other two communities. The attractiveness of public procurement for SMEs needs to be revised due to barriers mentioned by SMEs, such as perceived complicated public procurement laws and regulations.

This report is divided into five main chapters. In Chapter 1, i.e., deliverable 1 (D1), we present a systematic literature review on the necessary competencies of public procurement leaders and public procurers for sustainable innovations. The assessment includes European projects, NGOs and consultant reports. The following chapter presents systematic research results on European higher education institutions and practitioners' organisations' available courses and training materials for public procurement within sustainable innovations. Existing learning resources will be identified and assessed for their usefulness for further use or research.

In the second Chapter, i.e., D2, we present a systematic literature review on the necessary competencies and skills for environmental engineers. The assessment includes European projects, NGO and consultant reports, and an overview of bachelor's and master's degree programs and courses for environmental engineers in Europe's ICIU universities. In Chapter 3, i.e., D3, we present a systematic literature review on the necessary competencies of entrepreneurs. The assessment includes European projects, NGOs, and consultant reports. In Chapter 4, i.e., D4, we present the combined results of all three frameworks. In the final chapter, we present a general conclusion.

D1 Public procurement

Public procurement is an important domain that has the power to bring more innovative and sustainable products and services to society (OECD, 2019). According to the Organization for Economic Co-operation and Development (OECD) report of 2019 (OECD, 2019), public procurement is "the purchase of goods and services by the public sector, at all levels of government." This paper refers to public procurement as national and local authorities like provinces, municipalities, water boards, and semi-public institutions (hospitals or universities).

Each year, the European Union spends around 2 trillion euros on public procurement (national and local authorities, like provinces and municipalities), meaning governments produce 14% of the GDP of all the products and services (OECD, 2019). Because of the high GDP percentage, public procurement can play a crucial role in fostering green production in the market (OECD, 2019).

In this case, competences are a crucial factor for businesses and organisations to grow to success (Bowersox et al., 2000). Competence is an underlying characteristic of an employee (a motive, trait, skill, aspect of one's self-image, social role, or body of knowledge) that results in superior performance (Le Deist & Winterton, 2005). This paper also refers to competence as skill(s). However, there is a need to identify and develop more strategic competences in the public procurement sector to acquire sustainable, innovative products and services from the market (Bals et al., 2019).

Public procurement officers must gain the knowledge and skills to stimulate innovations that contribute to the sustainability of products and services (Bals et al., 2019). The world has been changing dramatically in demography and technology, requiring new skills and competences related to innovation and sustainability (Viale et al., 2022). Thus, public procurement leaders must have the right competences to make innovative sustainable purchases since they are essential to introducing more sustainable and innovative scenarios in society. Therefore, this paper prosses the following research question: Which competences are necessary for public procurement professionals to purchase innovative and sustainable products and services?

Despite the topic's relevance, little research can be found in the literature (Bals et al., 2019; Stek & Schiele, 2021); thus, a clear research gap exists, indicating the necessity of more research on the subject. This paper presents both theoretical and practical contributions. As an academic contribution, this study brings a general panorama of public procurement competences, which can provide valuable insights for practitioners in the public procurement sector aiming to improve their competences. Regarding the practical implication, this paper can help public procurement leaders and individuals seek the right competences within the public procurement sector. As for implementing this research, this paper can help develop relevant training sessions and identify competency gaps. This paper represents the first systematic literature review on sustainable and innovative procurement in the public sector.

D1.1 Systematic literature review on the necessary competencies and capabilities of public procurement leaders

This review aims to provide a state-of-the-art of the existing competences for sustainable and innovative procurement in the public sector. This review uses the following filters:

1. Scopus was used in the literature search to capture published peer-reviewed scientific journals to enhance the quality of our research.
2. Next, no time restrictions were applied, and articles in English were selected.
3. This literature review uses two sets of search strings to expand the search. The first set of search strings includes "purchasing competences." The second set of search strings includes "innovative sustainable purchasing competence." Afterwards, the articles were imported into EndNote. This program detected duplicate articles in both sets and removed them from the selected articles.
4. The fourth filter looks at the initial screening process and checks whether the keywords in the previous filter were key subject terms in the title, abstract, and keywords.
5. Afterwards, the authors used the same key terms to screen the entire paper selected in the previous filter.
6. The final stage consisted of reading the entire paper, where the goal was to capture innovative and sustainable purchasing competences in the public procurement sector.

Conducting the review

This review distinguished between two key search terms to expand the search. The first set uses the search strings "purchasing AND innovat* AND skills OR competenc*." The second set uses the search strings "purchasing AND green OR sust* AND skills OR competenc*. The search was modified to competenc* to capture "competences," "competences," and "competency" and "sust*" to capture "sustainable," and "sustainability." Furthermore, the search process also considered operators such as AND and OR for competences since in literature, skills are referred to competences as well. The same holds for the search string "green" and "sust*." Figure 1 provides the process of how the articles were selected. Entering both sets of search strings in Scopus yielded 224 articles in total. This review removed conference journals, book sections, and serials from the selected articles. Thus, this research only considered peer-reviewed journals, which gave us 191 articles (filters 1-2). Filter 3 removed all duplicate articles in both sets. So, this step removed 15 duplicate reports. Filter 4 removed 94 articles, meaning that 82 articles were left to screen the entire article. In the final stage of reading the whole article, the total number of publications selected was 11 English peer-reviewed articles (published between 1998 and 2022).

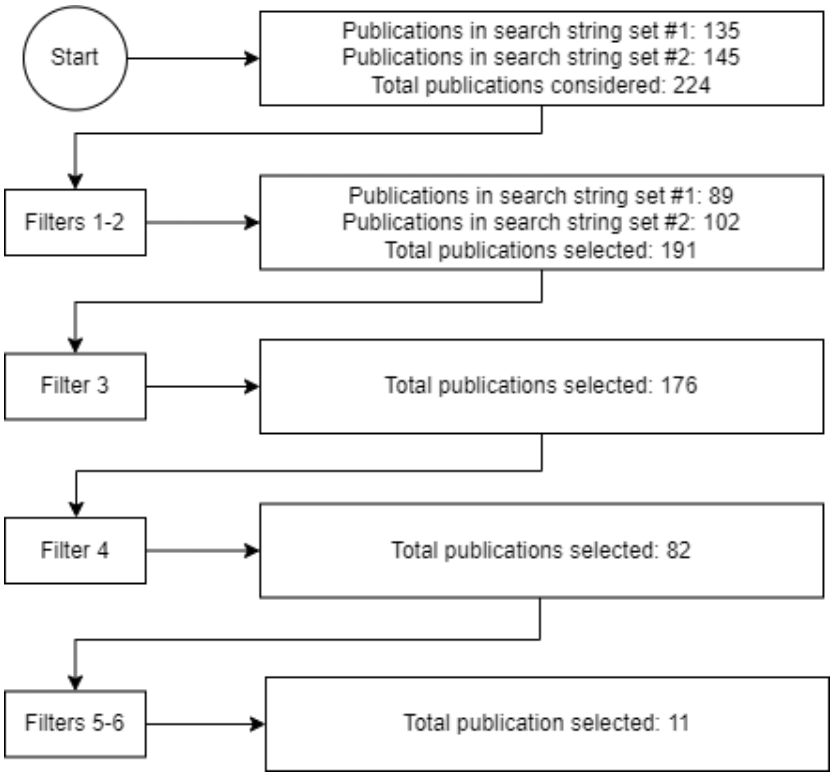

Figure 1 - Publication retrieval process.

This literature review differentiates between three order codes. The coding process involved aggregating four first-order codes (i.e., purchasing and supply management (PSM) competences, sustainable purchasing supply management (SPSM) competences, innovation procurement competences, public procurement competences), four second-order codes (i.e., social, meta, functional, and cognitive competences), and third-order codes. The third-order codes were performed by aggregating the competences found in the literature regarding sustainability, innovation, and public procurement. This research uses an Excel spreadsheet to support the coding process (Gioia et al., 2013).

D1.1.1 Research framework

First-order codes: level of analysis

This paper aims to look for the skills that public procurement professionals need to purchase innovative and sustainable products and services from the market. The level of analysis distinguishes four levels, i.e., purchasing and supply (PSM) competences, sustainable purchasing and supply management (SPSM) competences, innovation procurement competences, and public procurement competences. These levels were determined based on the context of each of the twelve papers. Table 1 provides a summary of the level of analysis.

Two papers (Bals et al., 2019; Stek & Schiele, 2021) primarily determined the skills necessary for a much larger group, i.e., for (PSM) professionals. However, the paper by Stek determined some competences essential for innovation and sustainability, i.e., sellership, imagination, contracting skills, supplier relationship management, and organisational insight &

governance. The authors described the relevance of these skills based on factor analysis (Stek & Schiele, 2021). In five papers (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022), the authors discussed the competences necessary for SPSM. Two papers (Bals et al., 2019; Coderre-Ball et al., 2021) describe the competences essential to consider innovation procurement. However, their research could have been more extensive and considered innovative competences a small part of their research. Next, three papers described the skills necessary for public procurement professionals (Coderre-Ball et al., 2021; Diedrichs, 1998; Steinfeld, 2022). Furthermore, Steinfeld (Steinfeld, 2022) is the first author who did extensive research on the necessary skills for public procurement professionals. This research distinguishes between innovative and sustainable competences since Steinfeld (2022) and any other author did not research this in their research article.

Table 1 - Overview of first-order codes: level of analysis.

	Author	PSM competences	SPSM competences	Innovation procurement competences	Public procurement competences
1	Schulze et al. (2022)		x		
2	Steinfeld (2022)				x
3	Viale et al. (2022)			x	
4	Schulze et al. (2021a)		x		
5	Schulze et al. (2021b)		x		
6	Stek & Schiele (2021)	x	x	x	
7	Schulze & Bals (2020)		x		
8	Coderre-Ball et al. (2020)			x	x
9	Schulze et al. (2019)		x		
10	Bals et al. (2019)	x			
11	Diedrichs (1998)				x

Second-order codes: the content of analysis

The second-order codes look at the content of the analysis. First, the second-order codes examine the type of competences used in each of the twelve papers. Stek & Schiele categorised PSM competences into professional and knowledge skills (Stek & Schiele, 2021). Bals categorised the skills into the following: technical skills, interpersonal skills, internal/external enterprise skills, and strategic business skills (Bals et al., 2019).

Regarding SPSM competences, several authors proposed a classification according to social, meta, functional, and cognition-oriented competences (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2022). This classification was done based on the model by Le Deist &

Winterton (Le Deist & Winterton, 2005). Social-oriented competences are related to interaction and the ability to experience and shape relationships, and these competences are necessary when interacting with someone else. Meta-oriented competences are on a personal level, which are competence between an individual and himself, such as dealing with uncertainty, reflection, and learning. Functional-oriented competences are technical competences that are related to an occupational context, and these are also called "know-how" skills. Cognition-oriented competences are knowledge competences related to a conceptual and systematic way of thinking. These competences are also known as "know-that" and "know-why" skills.

Schulze classified the competences into generic skills (communication skills, systems thinking competence, basic sustainability knowledge, cross-functional teamworking, and commitment to change) and skills related to the PSM process (supplier relationship management (application of tools), stakeholder management (communication), SRM (cooperative attitude), demand management – category strategy, and sustainability/compliance (Schulze et al., 2021a). The same author generically classified the competences in another paper as, i.e., supplier relationship management (application of tools), sustainability/ compliance, basic individual knowledge of PSM, basic sustainability knowledge, commitment to change, and self-reflection (Schulze et al., 2021b).

Regarding public procurement competences, Steinfeld is the first author to determine skills and abilities in the public procurement sector. The author categorised the skills into six categories for skills, i.e., strategy (e.g., building trust and credibility), planning and analysis (e.g., effective communication), leadership (e.g., trustworthiness), sourcing and solicitation (e.g., problem-solving), contract administration, and business principles such as budget analysis (Steinfeld, 2022). Diedrichs determined necessary skills for acquisition librarians in Canada, which falls under the public sector (Diedrichs, 1998). The author categorised the skills into three main categories: managerial, business, and personal skills. Viale distinguished between five skills groups: technical, interpersonal, internal, external, and strategic business (Viale et al., 2022). Coderre-Ball mainly discussed that being open-minded to change is crucial in innovation procurement. Furthermore, these competences are also skills necessary for the public procurement sector (Coderre-Ball et al., 2021).

This research uses the Le Deist & Winterton model to categorise the skills (Le Deist & Winterton, 2005). Several authors have used the same classification method. Next, a similar classification method was used in two SPSM papers, making it less complicated for us to classify the skills (Schulze et al., 2021a, 2021b). The rest of the skills are organised by looking at how Schulze managed specific skills (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2022) and using the holistic model of competence (Le Deist & Winterton, 2005).

Third-order codes: Competence framework

This step fills out the competences found in the literature in the competence framework (see Appendix 1). This framework merged several competences since they fall under the exact competence phrase. The following four sections explain the merged competences. Besides the unmerged skills, the competence framework in Appendix 1 considered the skills mentioned in italic letters in the four sections below.

Social competences

Cross-functional teamwork is crucial when considering sustainable purchasing (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022). This competence was mentioned in several other papers and determined as follows:

1. Cross-functional cooperation with other departments such as R&D, logistics, and finance (Bals et al., 2019).
2. Cooperation with the marketing and legal department (Stek & Schiele, 2021).
3. Teamworking/ team ability skills (Stek & Schiele, 2021).
4. Application of business principles in the marketing department (Steinfeld, 2022).

Cultural awareness (Bals et al., 2019), primarily a skill PSM professionals use, is also called cross-cultural understanding in the paper by Stek & Schiele (2021). *Customer focus* (Bals et al., 2019) is referred to as customer-oriented (Stek & Schiele, 2021) and the anticipation of internal customers' needs (Viale et al., 2022). Network management and development of an internal network (Viale et al., 2022), and the capacity to be empathetic, have social manners, be loyal, and be honest (Stek & Schiele, 2021) were all merged under the competence of *networking* (Bals et al., 2019). Stek & Schiele refers to *conflict resolution* as the ability to resolve conflicts (Stek & Schiele, 2021). This skill is named *conflict resolution* in the competence framework (Bals et al., 2019).

Managing change processes (Stek & Schiele, 2021) was added to the competence *change management* (Bals et al., 2019). Interpersonal communication (Bals et al., 2019) and sourcing and solicitation communications (Steinfeld, 2022) were merged under *communication skills* as mentioned in the papers by Schulze (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022). Detecting weak signals from the environment (Viale et al., 2022) was merged under *problem management* (Diedrichs, 1998).

Meta-competences

Solving problems in the sourcing and solicitation context (Steinfeld, 2022) was merged into the *ability to solve problems* competence (Stek & Schiele, 2021). *Self-leadership* is the ability to have a good attitude, use power effectively, foster creativity, asses one's performance, and manage stress (Diedrichs, 1998).

Result orientation is a competence necessary for PSM professionals and innovation procurement. This competence includes self-assurance, proactivity, action-taking, willingness to take risks, and poise (Stek & Schiele, 2021). Next, driving for results and proactivity mentioned in the paper by Bals and Viale were also merged under *result orientation (Bals et al., 2019; Viale et al., 2022)*. Creativity, willingness to learn and inventiveness were appended to *imagination* competence (Stek & Schiele, 2021). Competence creativity was also found in the paper by Coderre-Ball, Steinfeld, Bals, and Viale (Bals et al., 2019; Coderre-Ball et al., 2021; Steinfeld, 2022; Viale et al., 2022) and merged under *imagination* as well. Competence *sellership* consists of sub-competences such as entrepreneurial development, salesperson skills (Stek & Schiele, 2021), and entrepreneurship (Viale et al., 2022).

Functional competences

The competence framework distinguished between *innovation sourcing* and *innovation sourcing approaches* (Bals et al., 2019). *Innovation sourcing* is finding and integrating innovations into the organisation (Viale et al., 2022). Innovation implementation, category strategy development, pooling planning & demand, and supply market analysis (Stek & Schiele, 2021) are also components of *innovation sourcing* (Bals et al., 2019; Viale et al., 2022). *Innovation sourcing approaches* include digitisation, supplier selection (Viale et al., 2022), and finding ways to foster innovation (Diedrichs, 1998).

The competence *policy* is the skill to understand the legislative impact and conduct a draft and legislative analysis (Steinfeld, 2022). Technical knowledge of products, commodities, domains, and production systems, technology planning, i.e., knowledge of the company's technological requirements (Stek & Schiele, 2021) are merged under *technical skills* (Diedrichs, 1998). *Contracting skills* involve contract management (Bals et al., 2019; Steinfeld, 2022; Stek & Schiele, 2021), developing supply specifications, designing contracts, claims management, evaluating offers & supplier selection (Stek & Schiele, 2021). *Analytics* involves setting KPIs, conducting performance measurement and follow-up, the ability to do statistical analyses, and portfolio analysis support (Stek & Schiele, 2021). Next, it includes big data analytics (Bals et al., 2019; Steinfeld, 2022; Stek & Schiele, 2021) and KPI reporting design (Bals et al., 2019).

Procurement IT systems or e-procurement applications (Stek & Schiele, 2021) and advanced technical competences in products/services (Viale et al., 2022) are merged under *automation* (Bals et al., 2019; Diedrichs, 1998). *Cost-focus* competence includes global sourcing, making cost analyses, soliciting offers, cost reduction techniques, purchasing knowledge (Stek & Schiele, 2021), and cost savings (Bals et al., 2019). *Forecasting skills* are the ability to forecast demand, Enterprise Resource Planning (ERP), supply chain analysis (Stek & Schiele, 2021), and forecasting in the planning and analysis context (Steinfeld, 2022). *Leadership and personnel management* (Stek & Schiele, 2021) consists of a personnel integration and development plan, purchasing roles and job profiles, a personnel selection process, performance measurement, training, and personnel management.

Cognitive competences

Systems thinking competence is primarily considered an SPSM competence (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022) and consists of the following components, namely: the ability to think beyond one's nose, apply the strategic context of the organisation, understand the supply network, understand the sustainability business case, and understand circular economy models (Schulze & Bals, 2020).

Gathering information to understand an issue better, asking for background information, and critically reviewing processes and approaches (Schulze & Bals, 2020) is merged under *critical thinking* (Bals et al., 2019; Coderre-Ball et al., 2021; Schulze et al., 2019). *Critical thinking* also includes essential sense (Viale et al., 2022) and critical thinking in the planning and analysis context (Steinfeld, 2022). The *ability to make decisions* consists of decision-making (Bals et al., 2019; Schulze et al., 2019). Agility in a strategy context also involves learning agility(Bals et al., 2019; Steinfeld, 2022).

Supplier relationship (Viale et al., 2022), supplier relationship management (SRM), supply risk management, early supplier involvement, supplier evaluation, and strategic business partner (Stek & Schiele, 2021) are components merged under the competence *supplier relationship management – a holistic view*. A holistic view in a strategy context (Viale et al., 2022) combines *holistic thinking* (Stek & Schiele, 2021). Understanding corporate governance, how to add value to the organisation, and the position of purchasing in organisational project management are components merged under *organisational insight and governance* (Stek & Schiele, 2021).

Aggregation process

The initial competence framework detected over 200 competences on all four levels of analysis. However, after aggregating specific competences as explained above, the competence framework caught 134 PSM, SPMS, innovation procurement, and public procurement competences (see Appendix 1). The third-order codes selected competences that included the following level of analysis SPSM, innovation procurement, and public procurement. This process detected four competences that had all these elements, namely: *communication skills* (Bals et al., 2019; Coderre-Ball et al., 2021; Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022; Steinfeld, 2022; Viale et al., 2022), *negotiation skills* (Bals et al., 2019; Coderre-Ball et al., 2021; Diedrichs, 1998; Schulze et al., 2019; Stek & Schiele, 2021), c*ross-functional teamwork* (Bals et al., 2019; Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022; Steinfeld, 2022; Stek & Schiele, 2021) and *critical thinking* (Bals et al., 2019; Coderre-Ball et al., 2021; Schulze & Bals, 2020; Schulze et al., 2019; Steinfeld, 2022; Viale et al., 2022).

Communications skills are skills where the public procurement professional knows how to converse openly and interact with their surroundings. Furthermore, they know how to adapt to a target group and use appropriate communication channels (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022). Several papers by Schulze defined cross-functional team working as "encompassing the interaction with the internal interfaces within an organisation to foster SPSM (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2022)." Diedrichs defines negotiation skill as "the discussion that brings about a result or agreement, especially where some element of bargaining is involved (Diedrichs, 1998)." Critical thinking is the ability to gather information to understand an issue better and know how to ask for background information. Next, the individual critically reviews processes and approaches (Schulze & Bals, 2020; Schulze et al., 2019).

When it comes to SPSM and public procurement skills, these are as follows *communication skills* (Coderre-Ball et al., 2021; Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022; Steinfeld, 2022), *cross-functional team working/ cooperation* (Schulze & Bals, 2020; Schulze et al., 2019; Schulze et al., 2021a, 2021b, 2022; Steinfeld, 2022), *contracting skills* (Steinfeld, 2022; Stek & Schiele, 2021), *negotiation* (Coderre-Ball et al., 2021; Diedrichs, 1998; Schulze et al., 2019), performance management (Schulze et al., 2019; Steinfeld, 2022), and *critical thinking* (Coderre-Ball et al., 2021; Schulze & Bals, 2020; Schulze et al., 2019; Steinfeld, 2022). Communication skills and cross-functional team working/cooperation are social competences, negotiation, and performance management are functional, and critical thinking is a cognitive competence. Note that this filtering process does include meta competences for sustainable public

procurement. The competence framework determines that these skills also apply to PSM professionals, except for performance management skills.

For innovative public procurement skills, there are several skills identified. The skills belonging to the category of social competence are *communication skills* (Coderre-Ball et al., 2021; Steinfeld, 2022; Viale et al., 2022), *building trust* (Steinfeld, 2022; Viale et al., 2022), leadership (Diedrichs, 1998; Viale et al., 2022), *cross-functional team working/ cooperation* (Steinfeld, 2022; Stek & Schiele, 2021), *leadership* (Diedrichs, 1998; Viale et al., 2022), *networkin*g (Steinfeld, 2022; Viale et al., 2022), *openness/open-minded* (Coderre-Ball et al., 2021; Viale et al., 2022), and *problem management* (Diedrichs, 1998; Viale et al., 2022). *Imagination* (Coderre-Ball et al., 2021; Steinfeld, 2022; Stek & Schiele, 2021; Viale et al., 2022) belongs to the categorisation group meta competence. The skills in the category of functional competences are *automation* (Diedrichs, 1998; Viale et al., 2022), *innovative thinking* (Coderre-Ball et al., 2021; Diedrichs, 1998), and *negotiation* (Coderre-Ball et al., 2021; Diedrichs, 1998). As mentioned, critical thinking (Coderre-Ball et al., 2021; Steinfeld, 2022; Viale et al., 2022) belongs to cognitive competences and is considered innovation procurement and public procurement. The competence framework detected that these skills also apply to PSM professionals, except for building trust and innovative thinking.

D1.1.2 Conclusions on competences of the public procurement sector in literature

This literature review differentiates between three order codes, i.e., the level of analysis, the content of analysis, and the aggregation process. The competence framework detected 134 skills categorised under social, meta, functional, and cognition competences. Furthermore, this review distinguished between PSM, SPSM, innovation procurement, and public procurement competences. The four most common skill that contains all these elements are communication (i.e., social competence), cross-functional team working (i.e. social competence), negotiation (i.e., functional competence), and critical thinking skill (i.e., cognitive competence). Besides these four skills, the competence framework identified several other skills for innovative public procurement: building trust, leadership, networking, openness/open-mindedness, problem management, imagination, automation, and innovative thinking. Furthermore, the competence framework identified contracting skills, performance management for SPSM and public procurement.

This review only considered Scopus. However, it is best to use other sources, such as Web of Science and Science Direct, for further research to cover the whole scope. This research only identified four skills necessary for the SPSM, innovation and public procurement. Thus, testing the rest of the skills identified in the competence framework in practice is recommended. This way, more (and new) innovative and sustainable public procurement skills can be detected and analysed.

D1.2 Assessment of European projects (EU-funded project reports) & NGO and consultant reports

The grey literature study, which examined European projects, focused on EU publications on public procurement competences in the context of sustainable innovations. The EU Publications Office search engine was used for the search.

In the first phase, the publication was selected from the search results if the competence, innovation, sustainability, environment, skills or capabilities term appeared with the term "public procurement" in the title OR description OR subjects column. The search results were combined, and duplicates were removed, ending with a long list of 26 publications.

Next, the long list was turned into a shortlist. The abstract/executive summary of each publication in the long list was read and used to decide whether to add the publication to the shortlist or reject it. The main reason for rejection was that the abstract/executive summary should have shown the researcher that the publication was related to public procurement and competencies. One publication was rejected because it could no longer be found. A total of nine publications were shortlisted and retained for further review.

During the review, three more publications were rejected because the publications needed to have input into public procurement competences. However, two more publications were added to the list by Snowball. The final list included eight publications.

All eight publications were reviewed, and the competences found were added to an Excel file. Six publications did not have a competence list but interpreted the necessary competences through tasks or extracted individual competence-related mentions. Two publications6,8 included comprehensive information on the competences required in public procurement (in different proficiency levels). These two publications also included sections on sustainable and innovation procurement. Other EU publications reviewed needed to provide clear lists of competences. However, the reports address public procurement in the EU, and the competences identified are relevant to the study.

The ProcurComp6 and Hankinta-Suomi8 reports and competency matrices contained clearly expressed competency needs for different proficiency levels of procurement. Hankinta-Suomi report is a national (Finland) self-assessment tool for procurement competences based on the ProcurComp6 framework. Based on the precise categorization of competence requirements and the context of public procurement, the ProcurComp6 report is the most useful for the literature review regarding EU publications.

ProcurComp6 identifies sustainable and innovation procurement as competences and defines the related skills required at different proficiency levels. It is essential to note that ProcurComp's6 competence categorization follows a different structure than this white paper. For example, the social and meta competences related to public procurement are mainly reflected in

the ProcurComp6 competence matrix in categories other than sustainable and innovation procurement.

All findings of the grey literature study were categorised according to Le Deist & Winterton (2005): social, meta-competences, cognitive, and functional. The quality of the categorisation was verified by feedback from several researchers.

The reviewed publications identify several social competences that are essential for the public procurement of sustainable innovations. These social competences are presented in Table 2. In ProcurComp6, sustainable innovation procurement identifies SME participation and discusses networking, promotion and engagement.

Table 2 - Social competences: findings of EU publications.

	Competences	References
Social competences	Aim for effectiveness	6
	Conflict management and prevention	6, 8
	Co-creation of trust	1, 6, 8
	Communication	1, 2, 3, 6, 8
	Support	6
	Corruption prevention	5
	Demonstrate positive mindset	6
	Discrimination avoidance	3
	Dispute handling	6, 8
	Emotional intelligence	6, 8
	Encourage a professionalisation culture	6
	Engagement with suppliers	1, 6
	Ethical behaviour, compliance mindset	6, 8
	Expert/consultant collaboration	3, 6, 8
	Goal-oriented leadership	6, 8
	Interaction with users (e.g. citizens)	1
	Networking	8
	Relationship management	1, 8
	Driving change	8
	Implementation of changes	1, 5

[1] Hoekstra, Marissa, Chideock, Cass, Bodea, Gabriela, Bharosa, Nitesh, Cave, Jonathan, Kokkeler, Ben, Oomens, Ivette, Berg, Annelieke van den, Veenstra, Anne Fleur van, Alleweldt, Frank. The digital single market and the digitalisation of the public sector : GovTech and other innovations in public procurement. URL: https://op.europa.eu//publication-detail/-/publication/af394a31-f114-11ec-a534-01aa75ed71a1

[2] Luyckx, Olav, Pál-Hegedüs Ortega, Diana. Public procurement of energy-efficient works, supplies and services : support provided to projects under the intelligent energy Europe II programme and Horizon 2020 energy efficiency. URL: https://op.europa.eu//publication-detail/-/publication/a9902ce6-8a1f-11ec-8c40-01aa75ed71a1

[3] Bovis, Christopher. Innovation and better strategies of public procurement with other policies : in-depth analysis. https://op.europa.eu//publication-detail/-/publication/ef4b6220-27b9-11eb-9d7e-01aa75ed71a1

	Promoting collaborative culture	8
	Promoting diversity	6, 8
	Promoting procurement function	6
	Sharing knowledge	1, 6
	Ability to consider suppliers' proposals	1
	Promoting innovation/innovativeness orientation	6, 8
	Promoting sustainability orientation	6, 8

The meta competences identified in the EU publications are mainly related to attitudes, willingness and proactivity. All identified meta competences are presented in Table 3. None of the publications examined directly listed meta competences. Thus, the meta-competence findings in all publications, including the ProcurComp[6], are interpreted from any context.

Table 3 - Meta competences: findings of EU publications.

	Competences	References
Meta competences	Ability to change	6, 8
	Acceptance of room for failure	1
	Adaptability	6, 8
	Commitment	6, 8
	Flexibility	2
	Proactivity	1, 6
	Providing and receiving feedback	1, 6, 8
	Willingness to learn	2, 6
	Problem-solving skills	6
	Prioritisation skills	8
	Openness to development	3, 6
	Openness to new procurement procedures	1, 6
	Cooperative attitude	6
	Solution orientation	6

The cognitive competences related to the procurement of sustainable innovations highlight knowledge of procurement procedures, regulation and law, the ability to manage large entities and strategic competences. The cognitive competence findings are presented in Table 4. In ProcurComp6, sustainable innovation procurement specifically identifies procedural knowledge, knowledge of emerging technologies, and understanding of green/sustainable procurement.

Table 4 - Cognitive competences: findings of EU publications.

	Competences	References
	Green/sustainable procurement	2, 6

Cognitive competences	Identification of business conditions	5
	Identifying opportunities	6
	Risk management	6, 8
	Setting procurement vision and strategy	6
	Supply chain management	6
	Understanding the importance of the preparation phase	1
	Strategic public procurement	1, 2
	Value for money -mindset	3, 6
	Strategic thinking	6, 8
	Defining requirements	1
	Substance knowledge	5
	Legal knowledge	2, 4, 5, 6
	Knowledge of contract models	8
	Financial knowledge	5
	Market understanding	1
	Understanding of trends	4
	Knowledge of procurement procedures	1, 3, 6, 8
	Knowledge of public procurement regulation	6, 8
	Knowledge about emerging technologies	4, 6

Functional competences are the most identified in the EU publications. Public procurement is function-oriented, and it is evident that professional competences and know-how emerge most strongly. All functional competences identified are presented in Table 5. Here a broad range of competences, from defining needs to monitoring the achievement of objectives and implementing a sustainable/innovation procurement strategy to life cycle management, are needed to execute sustainable and innovative public procurement.

Table 5 - Functional competences: findings of EU publications.

	Competences	References
Functional competences	Advising	8
	Applying appropriate procedure	3
	Applying exclusion ground	3
	Assessing the innovative quality of tenders	1
	Auditing value for money	1
	Award criteria setting	3
	Capacity building	2, 5
	Claim management	6, 8

	Commercialisation	4
	Contract modifications	6
	Contract specifications	3, 6
	Cost monitoring	6, 8
	Cost reductions	5
	Cost-benefit analysis	56, 8
	Data collection	5, 6, 8
	Defining KPIs	6
	Definition of needs/outcomes	6, 8
	Demonstrating value for money	1
	Dialogue	1, 4
	Exploring market opportunities	1, 4
	Facilitating an environment for win-win solutions	6
	eProcurement	2, 4, 5
	Implementation of strategic procurement policies	2, 6
	Implementation of sustainable/innovative procurement strategy or another outcome/benefit-based strategy	6, 8
	Implementing sustainability/innovativeness into the contract clauses	6, 8
	Implementing sustainability/innovativeness into the specifications and criteria	6, 8
	Identification of targeted outcomes	1
	An inclusive approach to attracting additional suppliers	1
	Integrating the good practices of sustainable/innovative procurement into the organisation's activities	6, 8
	Involving SMEs	1
	Joint/cross-border procurement	1, 2, 3, 8
	Life cycle costing	1, 2, 3, 6, 8
	Market analysis	1, 6, 8
	Market research	1, 4, 6, 8
	Market testing	3

[4] Opportunities for public technology procurement in the ICT related sectors in Europe : final report. URL: https://op.europa.eu//publication-detail/-/publication/13c1a0e3-8993-4220-8346-8444edf8a331

[5] Stock-taking of administrative capacity, systems and practices across the EU to ensure the compliance and quality of public procurement involving European Structural and Investment (ESI) Funds : final report. URL: https://op.europa.eu//publication-detail/-/publication/d1082259-0202-11e6-b713-01aa75ed71a1

[6] Blagoeva, Tsvetelina, Campagno, Melissa, Karaki, Karim, Kessler, Brian. ProcurCompEU : study on professionalisation of public procurement in the EU and selected third countries. URL: https://op.europa.eu//publication-detail/-/publication/400d4892-8542-11eb-af5d-01aa75ed71a1

	Monitoring the impact/effectiveness of sustainable/innovativeness procurement	6, 8
	Monitoring KPIs/performance	6
	Needs assessment	1, 6,7, 8[8]
	Negotiation	3, 6, 8
	Negotiation strategy	6
	Partnership creation	6, 8
	Performance-based tendering	1
	Planning	6, 8
	Preparing the business case for innovation/sustainable procurement	6
	Providing incentives to the supplier market to invest in research and development, and commercialisation	8
	Reporting	6
	Short-term and long-term action plans	6
	Stakeholder motivation	6, 8
	Stakeholder/supplier engagement	1, 6, 8
	Supplier prior involvement	3
	Target/goal setting	6, 8
	Technical specifications	3, 6
	Tender documentation creation	5, 6, 8
	Tender evaluation	1, 3, 6, 8
	The utilisation of award criteria	3
	Value in contracts	5
	Supplier management	8
	Analytical thinking	6, 8
	Flexibility in the contract phase	4
	Promote sustainable/innovative procurement	6, 8
	Systems, tools, templates	5, 6, 8
	Strategic management	6, 9
	Project management	6, 8
	Contract dispute resolution skills	8
	Contract management	3, 6, 8
	Balancing price and quality	6
	Budget and payment management	6, 8
	Governance management	2, 5

[7] Procure2innovate.eu website. URL: P2I | European network of competence centres for innovation procurement (procure2innovate.eu).

[8] Hankinta-Suomi (The Finnish Ministry of Finance), a self-assessment tool for procurement skills. URL: Hankintaosaamisen itsearviointi - Valtiokonttori

	IPR rights management	1, 4
	Prioritising impacts/outcomes, economic importance and market impact	8
	Life cycle management	6, 8
	Market management	2, 4
	Ability to consider options	1
	Process structuring	1
	Innovation procurement	1, 2, 6
	R&D capabilities	1
	Guidelines on Sustainable/innovative procurement	8
	Pre-commercial procurement	1
	Partnership management	1
	Balancing cooperation and competition	1
	Data analysis	6, 8
	Risk assessment	6, 8

D1.2.1 Summary on grey literature in the context of public procurment

In summary, EU publications' information on the competence needs for sustainable and innovation procurement relies on the ProcurComp6 report. In other publications, the data needs to be more cohesive and cohesive. The ProcurComp6 report and its competence matrix, available for download in several languages, are valuable tools for practitioners. However, due to their strong focus on functional competences, the ProcurComp6 report should be read as a whole rather than in isolation from the sustainable and innovative procurement section.

D2 Environmental engineering framework

Environmental engineering is crucial in transforming the European Union (EU) into a modern, resource-efficient, competitive economy. With rapid technological advancements and evolving business needs, environmental engineers require specific knowledge, broad skills, and competences to drive sustainable innovations. A comprehensive search was conducted using various combinations of keywords and criteria to identify the key competencies needed by environmental engineers. The search included Scopus, focusing on articles and reviews published in English journals.

This chapter integrates the identified competencies into a competence framework, categorized into social, meta, cognitive, and functional competencies. Additionally, European projects funded by the EU, such as Horizon 2020, have actively supported the development of environmental engineering skills and competencies to address climate change, energy security, and sustainable transportation challenges. These projects have provided opportunities for environmental engineers to acquire new skills and competences in energy modelling, life cycle assessment, and sustainability assessment.

Furthermore, the role of non-governmental organizations (NGOs) in environmental protection and sustainability is highlighted. Collaboration between NGOs and environmental engineers is essential in identifying and implementing solutions to environmental problems. Reports from credible sources like the International Engineering Alliance, European Environment Agency, UNESCO, and European Accreditation Board for Engineering Education shed light on the skills and competencies required for environmental engineers. These reports emphasize technical and non-technical skills, including knowledge of environmental regulations, design principles, communication, problem-solving, leadership, and collaboration.

The report also examines the competences addressed in European higher education institutions, particularly those within the European Consortium of Innovative Universities (ECIU). A systematic search was conducted to identify courses and training programs related to environmental engineering and sustainable innovations. The competences prioritized in these courses and curricula provide insights into the skills and knowledge imparted to future environmental engineers.

By analyzing the findings from Scopus searches, European projects, NGO and consultant reports, and higher education institutions, this report aims to provide a comprehensive understanding of the competences required for environmental engineers to address environmental challenges, promote sustainable development, and contribute to the achievement of the United Nations' Sustainable Development Goals (SDGs).

D2.1 Systematic literature review on the necessary competencies and capabilities of (environmental) engineers

A Scopus search was performed considering different combination of key words and criteria:

1. key words "innovation" and "sustain*" and "environmental" and "engineering", "competenc*", limited to Document type "article" or "review" and Source type "Journals" and language "English", resulted in 17 articles
2. key words "innovation" and "sustain*" and "environmental" and "engineering", "skills", limited to Document type "article" or "review" and Source type "Journals" and language "English", resulted in 12 articles
3. key words "sustainable innovation" and "environmental" and "engineering", limited to All Open Acess and Source type "Journals", resulted in 4 articles
4. key words "sustainable innovation" and "environmental" and "engineering" and "skills" or "competences", resulted in 1 article
5. key words "eco-innovation" and "environmental" and "engineering", limited to All Open Acess and Source type Journals and language English, resulted in 11 articles
6. key words "eco-innovation" and "environmental" and "engineering", and "skills" or "competences", resulted in 2 articles

In a second step, duplicate articles have been removed as well as those that, based on the abstract reading, the content was considered not relevant to the research. As a result, 8 articles were selected as the final papers to be analysed for the identification of competences (see Table 6).

Table 6 - Final list of papers analysed for competences in the context of environmental engineers.

	Title	Authors	Year	Source	DOI
1	A competence-based approach to sustainable innovation teaching: Experiences within a new engineering program	McAloone, T.C.	2007	Journal of Mechanical Design, Transactions of the ASME, 129 (7), pp. 769-778	10.1115/1.2723806
2	The influence of KIBS-client interactions on absorptive capacity-building for environmental innovation	Pace, L.A., Miles, I.	2022	European Journal of Innovation Management, 23 (4), pp. 553-580	10.1108/EJIM-01-2019-0026
3	Green technology innovation: Anatomy of exploration processes from a learning perspective	Wicki, S., Hansen, E.G.	2019	Business Strategy and the Environment, 28 (6), pp. 970-988.	10.1002/bse.2295

4	Inclusion of education for sustainable development in environmental engineering. A systematic review	Acosta Castellanos, P.M., Queiruga-Dios, A., Álvarez, L.G.	2021	Sustainability (Switzerland), 13 (18), art. no. 10180	10.3390/su131810180
5	Roadmapping towards sustainability proficiency in engineering education	Rodriguez-Andara, A., Río-Belver, R.M., Rodríguez-Salvador, M., Lezama-Nicolás, R.	2018	International Journal of Sustainability in Higher Education	10.1108/IJSHE-06-2017-0079
6	The Grandest Challenge of All: The Role of Environmental Engineering to Achieve Sustainability in the World's Developing Regions	Mihelcic, J.R., Naughton, C.C., Verbyla, M.E., Zhang, Q., Schweitzer, R.W., Oakley, S.M., Wells, E.C., Whiteford, L.M.	2017	Environmental Engineering Science, 34 (1), pp. 16-41	10.1089/ees.2015.0334
7	Engineering sustainable complex systems	Ahram, T.Z., Karwowski, W.	2013	Management and Production Engineering Review, 4 (4), pp. 4-14	10.2478/mper-2013-0032
8	Challenges and benefits of open-ended sustainable design in first-year engineering	Ayer, S.K., Messner, J.I., Anumba, C.J.	2014	Journal of Professional Issues in Engineering Education and Practice, 140 (2), art. no. 04013017	10.1061/(ASCE)EI.1943-5541.0000192

D.2.1.1. Competence framework

This step integrates the competences found in the literature in the competence framework. The framework represents a pile of several competences that fall under the exact competence category. The following four sections explain the competences in a specific way.

Table 7- Social competences of environmental engineers in literature.

Competences	References list from Table 6

Social competences	Communication	1,2,3,4,5,6,7,8
	Leadership	1,2,3,5
	Conflict management	1,4
	Judgement	1,2,3,5,7
	Resilient	5,7
	Mobility	4
	Passion	2
	Language and cultural skills	1,3,4,6
	Sharing	1,3
	Politeness	2,6
	Networking	2,4,8
	Relationship management	1,2,3,5
	Compatibility	2
	Influencing	2,3,8
	Interdisciplinarity	3,4,8
	Teamwork	1,2,3,4,5,6,7,8

Table 8 – Meta competences of environmental engineers in literature.

	Competences	**References list from Table 6**
Meta competences	Explorative	1,2,3,7,8
	Assimilative	1,2,7
	Transformative	1,2,4,7
	Exploitative	2,7
	Absorptive capacity	1,2,4,5,7
	Designing	1,2,7,8
	Calculative	1,4,7,8
	Sponteneous presence	4,7
	Result oriented	7,8
	Farsighted	5,7
	Influencing	2,5,7
	Confidence	3,7
	Perseverance	2,4,7
	Diagonistic	3,5,7,8
	Collaborative	7
	Delivering	7
	Informative	2,7
	Motivating	3,4,7
	Creative	2,3,7,8

	Anticipated self-knowledge	7,8
	Professional and ethical Responsibility	7,8
	Problem solving	1,3,4,5,7,8

Table 9 – Functional competences of environmental engineers in literature.

	Competences	References list from Table 6
Functional competences	Professional and ethical planning skills	1,2,3,4,5,6,7,8
	Analytic	2,3,5,7
	Computer applications	1,2,3,4,5,6,7,8
	Data mamangement	1,7
	International business ideas	1,3,5,6
	Traininer	1,2
	Mesurement capacity	1,5,7
	Process management	1,7
	Innovation sourcing	1,2,7
	Cost benefit analysis	1,3
	Sustainability analysis	1,2,5
	Basic sustainability knowledge	1,2,4,6,7,8
	Design capabilities of ethical-environmental systems	1,3,7,8

Table 10 – Cognitive competences of environmental engineers in literature.

	Competences	References list from Table 6
Cognitive competences	Critical thinking	1,2,3,4,5,6,7,8
	Strategic management	1,2,3,4,5,6,7,8
	Reasoning and argumentative	5,7,8
	Professional decision-making	5,7
	Experience-based learning	5,7
	Systems thinking	5,7

D2.2 Assessment of European projects (EU-funded project reports)

Environmental engineers are vital in transforming the EU into a modern, resource-efficient and competitive economy aiming to go beyond efficiency and productivity. The environmental engineering sector faces continuing changes with a rapid evolution of technologies and business needs. As a part of the change, it requires specific knowledge of the sector, familiarity with ongoing innovations, and broad skills and competences to be a generator of sustainable innovations. Environmental engineers must develop skills and competences to carry out the Green Deal objectives and define and maintain sustainable and innovative solutions for innovative suppliers, i.e. privately held firms, primarily small and medium-sized enterprises (SMEs), and adopted by buyers.

Enhancing environmental engineering skills and competencies is crucial to achieving sustainable development goals. Therefore, Horizon 2020 recognises and supports this through various research and innovation programs. The European Union (EU) has actively funded projects to develop environmental engineering skills and competencies to tackle significant climate change, energy security, and sustainable transportation challenges. These projects aim to address the challenges posed by climate change, resource depletion, and environmental degradation, with the following objectives to enhance the skills and competencies of environmental engineers to tackle environmental challenges and promote sustainable development, focusing on future generations and their needs. The Horizon 2020 program funds numerous projects focusing on developing new technologies and solutions to environmental challenges, such as renewable energy systems, smart grids, and low-carbon transport. These projects have provided opportunities for environmental engineers to develop new skills and competencies in energy modelling, life cycle assessment, and sustainability assessment, which includes promoting interdisciplinary collaboration, encouraging innovation, and ensuring that environmental engineers have the technical and scientific knowledge to design and implement effective solutions.

Several European Union-funded projects that cover a broad spectrum of different types of environmental engineers' skills by different categories of environmental engineering were identified and listed. Following the competencies classification approach presented in chapter D1 of this report, environmental engineers' skills, listed as hard and soft, are grouped into social, meta, cognitive, and functional competencies. Identified necessary social competencies for environmental engineers are presented in Table 11.

Table 11 - Social competencies of environmental engineers in EU projects reports.

	Competences	References
Social competences	Ethical	13, 14
	Communication	11, 13, 14
	Teamwork	13, 14
	Cultural aspects consideration	13
	Empathy and emotional intelligence	13
	Personal engagement	13
	Inclusive behaviour	13
	Global thinking	13

	Ability to present and communicate results to a broader audience	13, 14
	Negotiation skills	13

Meta competences should have been addressed in the analysed EU project reports. Using a cognitive approach, they were identified in reports. All identified meta-competences are oriented on problem-solving, creativity, innovation, and leadership, including awareness of eco-responsibility and ecologic issues.

Table 12 - Meta competencies of environmental engineers in EU projects reports.

	Competences	References
Meta competences	Open mindedness	13
	Problem-solving	13
	Collaboration	13
	Creativity	12, 13, 14
	Solution focus	13
	Innovation	13, 14
	Tolerance	13
	Multidisciplinary working	13
	Eco-responsibility	13
	ecologic consciousness	13
	Exploitation	14
	Leadership	13
	Self-knowledge	13

Only a few cognitive competencies were identified in 2 of identified European-funded projects, with a strong focus on stress and knowledge management, entrepreneurship, and understanding of the organisation.

Table 13 - Cognitive competencies of environmental engineers in EU projects reports.

	Competences	References
Cognitive competences	Stress management	13
	Research and organisation	13
	Knowledge management	14
	Entrepreneurship	14

Functional competencies are widely discussed in EU projects where different skills and competencies for environmental engineers are identified. Table 14 presents functional competencies, which can be grouped as technical competencies, such as the ability to apply various methods, calculations, or analysis; economic-related competences with a focus on market needs

and analysis costs planning and taxation; management-related competencies that focus on environmental project management processes, planning, reporting, legal regulations, performance analysis, reputation management.

Table 14 - Functional competences of environmental engineers in EU projects reports.

	Competences	References
Functional competences	Economic knowledge	13
	Technical skills	13
	Updating of random variables	14
	Material and load modelling	14
	Intellectual property	14
	Multi-level Monte Carlo methods	14
	Fault diagnostics methods and structural health monitoring	14
	Safety quantification	14
	Practical reliability engineering	14
	Uncertainty quantification and propagation for sensitivity or reliability purposes	14
	Vulnerability and risk assessment	14
	Life cycle assessment	14
	Reliability analysis	14
	Project management	13, 14
	Methods and techniques integrating sustainability in SMEs	11
	Business performance indicators	11
	Planning	11
	Reputation and image management	11
	Reporting	11
	Environmental taxation	11
	Research plan design	14

The Erasmus + project SME (Small and Medium Enterprises) Green Skills HUB aims to assist and guide small and medium size enterprises to implement Sustainable Development Goals (SDG) by fostering green skills and competencies needed for SMEs integrating SDGs goals. SMEs are recognised as crucial in achieving the SDGs by adding a significant financial portion to the World's economy and employment, promoting innovations and entrepreneurship. The Framework was developed by 5 European countries (Ireland, Italy, Portugal, Turkey and Spain) and identified six units of competencies, including core processes and actions regarding planning, implementation, and monitoring (see Figure 2, source: https://smegreenskillshub.eu/wp-content/uploads/2022/06/SME-GS-Hub_O1_EU_Framework_EN.pdf). These competencies follow a life-cycle project approach as learning outcomes grouped in knowledge, skills, and

attitudes that consultants need to develop to support the implementation of SDGs in SMEs' business practices.

Figure 2 - European framework of competencies to implement the SDGs and SMEs.

Each unit of 6 identified has learning outcomes grouped as generic or specific competencies focusing on the knowledge of SDGs and their role, impact, collaboration and ability to apply best practices in SMEs. The Framework supports sustainable entrepreneurship through technical, social, and personal competencies. Another Erasmus+ project, "Engineers for Europe (E4E)", aims "to foster innovation and resilience of EU engineers through the acquisition of new competences, including skills, knowledge, attitudes and leadership, with a focus on digital, green, resilience and entrepreneurship, geared by the new requirements of the world of work"[9]. The project is still in the initial stage to develop concrete solutions: 1) establish a "European Engineering Profession Skills Council" to build a constructive collaboration between higher education, vocational educational training, industry and professional representatives; 2) build a robust "Monitoring and diagnostic Mechanism" to gauge trends, challenges and opportunities for engineers; 3) Develop evidence-based "Skills Strategies" for the engineering profession in order to design and deliver innovative curricula for upskilling/reskilling engineering professionals on soft skills and transversal competences in digital, entrepreneurial, green and interdisciplinary areas.

[9] E4E Project Summary. Webpage: https://engineers4europe.eu/sites/default/files/2022-11/E4E%20Project%20Summary.pdf (accessed on 10 April 2023).

Another Erasmus + project, A-STEP 2030,[10] conducted a Focus Group with engineering academia, engineering students and engineering employees in Ireland, France, Denmark and Finland to identify Sustainable development goals related to skills and competence requirements for future engineers. Members of the focus group identified 18 skills and competencies needed for environmental engineers to achieve the SDGs (see Table 15).

Table 15 - Frequency of highly mentioned skills and competences.

Frequency of use	Term used	Frequency of used	Term used
14	Communication	4	Collaboration
11	Technical skills	4	Innovation
6	Critical Thinking	4	Creativity
6	Ethical	4	Solutions
5	Project Management	4	Cultural
5	Open Mindeness	4	Teamwork
4	Problem-Solving		

Conducted analysis of discussed skills and competences in Focus Group needed for engineers tackling environmental issues and SDGs in each country helped to identify additional skills set not included in the table but discussed by members: leadership, research and organisation, empathy and emotional intelligence, presentation, multidisciplinary working, stress management, economic knowledge, personal engagement, ecologic consciousness, negotiation skills, global thinking, self-knowledge, tolerance, and eco-responsibility.

Horizon 2020 project "Training in Reducing Uncertainty in Structural Safety – TRUSS",[11] completed in 2018, focused on a training programme created for engineer's doctorates to graduate with a business, entrepreneurship, communication, project management and other transferrable skills. The project report identifies key training modules for engineering students to develop and strengthen their skills and competencies. During the project, several workshops and trainings were organised with:

1. Core modules such as safety quantification, reliability analysis, life cycle assessment, vulnerability and risk assessment, uncertainty quantification and propagation for sensitivity or reliability purposes, and practical reliability engineering;

[10] A-STEP 2030: Attracting diverse talent to the engineering professions of 2030. Project report R2 "Engineering skills and competence requirements for sustainable development and achieving the SDGS – outcomes of focus groups held in Ireland, France, Denmark and Finland as part of A-STEP 2030 project activity 1: task 2". Webpage: https://www.astep2030.eu/sites/sub_site_astep2030/files/2021-12/UPDATED%20A-STEP%202030%20-%20REPORT%20R2%20-%20ENGINEERING%20SKILLS%20REQUIREMENTS%20FOR%20SUSTAINABLE%20DEVELOPMENT%20AND%20ACHIEVING%20THE%20SDGS.pdf (accessed on 16 April 2023).

[11] TRUSS (2018). Training in Reducing Uncertainty in Structural Safety. D3.11 Final Report. WP3 – Structured Training. Website: https://cordis.europa.eu/project/id/642453/results (accessed on 17 April 2023).

2. Specialist modules: updating of random variables, material and load modelling; fault diagnostics methods and structural health monitoring, multi-level Monte Carlo methods, intellectual property;
3. Soft skills: communication, presentation, research plan, knowledge management, project management, creativity, innovation, entrepreneurship, ethics, exploitation, and teamwork.

D2.3 Assessment of NGO and consultant reports

Environmental engineers require technical and non-technical skills to succeed, understand environmental principles, and effectively address environmental challenges. Non-governmental organisations (NGOs) are essential actors in environmental protection and sustainability. Furthermore, they can shape and impact the governance framework. NGOs often collaborate with environmental engineers to identify and implement solutions to environmental problems and can identify critical skills and competencies different sectors expect from environmental engineers.

Reviewing NGOs and consultant reports finds several typical thematic related to environmental engineers' skills and competencies. Founded reports emphasise the importance of both technical and non-technical skills for environmental engineers, where technical skills include knowledge of environmental regulations, design principles, and technologies. In contrast, non-technical skills include communication, problem-solving, leadership, and collaboration. The reports were selected based on their relevance to the topic and the source's credibility. The reports reviewed were the International Engineering Alliance (IEA), European Environment Agency (EEA), UNESCO reports, and European Accreditation Board for Engineering Education publication. The recommendations provided in each report were analysed and categorised into themes related to environmental engineers' skills and competences. Completed environmental engineers' skills and competencies analysis is presented in Table 16.

Table 16 - Summary of environmental engineers: hard technical competencies in NGOs report.

	Competences	References
Social competences	Communication	13, 15, 16
	Ability to work in multicultural environments	15
	Ethic	13, 16
	Equality	15
	Teamwork	15, 16
	Collaboration	13, 15, 16
	Society focus	13, 15
	Conflict resolution	15
Meta competences	Responsibility for decisions	13
	Continues professional development and life-long learning	13, 15
	Motivation	15
	Imagination	15
	Discernment	15

	Rapid understanding/learning	15
Cognitive competences	Universal and local knowledge	13, 14
	Ability to perform	15
	Management	13
	Language proficiency	16
	Analytical and problem-solving methodology	15
	Judgement/Critical thinking	13, 15
	Innovative thinking	15
	Identify and solve applied science problems	15
	Awareness of sustainable development issues	16
	Commercial awareness	12, 15
	Problem-solving and analysis	13, 15
	Flexibility to adapt to changing conditions	15
	Leadership under pressure	15
Functional competences	Waste, water and natural disaster management	12
	Knowledge of up-to-date regulations	12, 13
	New technologies and IT	12, 15
	Design and development of solutions	13
	Impact assessment	13, 15
	Foresight methods	14, 15
	Modelling grounded in assumptions of mainstream economics	14, 15
	Integrated assessment modelling	14
	Design and drawing skills – computer-aided design (CAD)	15
	Pollution control and evaluation	15
	Project management	15
	Mathematics	16
	Marketing	12
	Customer service/management	12, 15

One of the first reports found on environmental engineers' competencies was published in 2012 by the European Centre for the Development of Vocational Training,[12] where current gaps in environmental engineers' competencies were discussed. Identified competencies gaps among environmental engineers include waste, water and natural disaster management, up-to-date regulations, energy sector certification and procedures, and knowledge gaps on new technologies and IT. In addition, some needed generic skills were identified – commercial awareness, customer service, and marketing.

[12] European Centre for the Development of Vocational Training (2012). Green skills and environmental awareness in vocational education and training. Synthesis report. Website: https://www.cedefop.europa.eu/files/5524_en.pdf (accessed on 11 April 2023).

The International Engineering Alliance in the Graduate Attributes & professional competencies engineering activities divide into several roles: engineer, engineering technologist and engineering technician. These roles are defined by "their distinctive competencies and level of responsibility to the public"[13]. The development of engineering qualification is an ongoing process in the following stages: 1) accredited education qualification which can be obtained as a Bachelor's or Master's degree in the University. It helps to build a knowledge base and attributes for continuous learning and develop competencies required for independent practice. 2) professional registration, where competencies for independent practice are required. 3) international register held by various jurisdictions. In addition, it is expected to maintain and enhance competence throughout the entire time. The document defines professional competence profiles for each role of engineer following different characteristics divided into 13 groups: universal and local knowledge, problem analysis, design and development of solutions, evaluation, protection of society, regal, regulatory and cultural, ethnics, able to manage engineering activities, communication and collaboration, continuing professional development and lifelong learning, judgment, responsibility for decisions. A summary of all professional competencies for each role is presented in Table 17.

Table 17 - Professional competence profiles for engineers (IEA, 2021).

Differentiating Characteristic	Professional Engineer	Engineering Technologist	Engineering Technician
Comprehend and apply universal knowledge.	Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice	Comprehend and apply the knowledge embodied in widely accepted and used procedures, processes, systems or methodologies	Comprehend and apply knowledge embodied in standardised practices
Comprehend and apply local knowledge	Comprehend and apply advanced understanding of the widely-applied principles underpinning good practice specific to the jurisdiction of practice	Comprehend and use the knowledge embodied procedures, processes, systems or methodologies that are specific to the jurisdiction of practice	Comprehend and apply knowledge embodied in standardised methods particular to the jurisdiction of practice.
Problem analysis	Define, investigate and analyse complex problems using data and information technologies where applicable	Identify, clarify, and analyse broadly-defined problems using the support of computing and information technologies where applicable	Identify, state and analyse well-defined problems using the support of computing and information technologies where applicable.
Design and development of solutions	Design or develop solutions to complex problems considering a variety of perspectives and	Design or develop solutions to broadly defined problems	Design or develop solutions to well-defined problems

[13] The International Engineering Alliance (2021). Graduate attributes & professional competencies. Webpage: https://www.ieagreements.org/assets/Uploads/Documents/IEA-Graduate-Attributes-and-Professional-Competencies-2021.1-Sept-2021.pdf (accessed on 10 April 2023).

	taking account of stakeholder views	considering a variety of perspectives.	
Evaluation	Evaluate the outcomes and impacts of complex activities	Evaluate the outcomes and impacts of broadly defined activities	Evaluate the outcomes and impacts of well-defined activities
Protection of society	Recognise the foreseeable economic, social, and environmental effects of complex activities and seek to achieve sustainable outcomes*	Recognise the foreseeable economic, social, and environmental impacts of broadly-defined activities and strive to achieve sustainable results*	Recognise the foreseeable economic, social, and environmental effects of well-defined activities and seek to achieve sustainable results*
Legal, regulatory and cultural	Meet all legal, regulatory, and cultural requirements and protect public health and safety during all activities.	Meet all legal, regulatory, and cultural requirements and protect public health and safety during all activities.	Meet all legal, regulatory, and cultural requirements and protect public health and safety during all activities.
Ethics	Conduct activities ethically	Conduct activities ethically	Conduct activities ethically
Manage engineering activities	Manage part or all of one or more complex activities	Manage part or all of one or more broadly-defined activities	Manage part or all of one or more well-defined activities
Communication and collaboration	Communicate and collaborate using multiple media clearly and inclusively with various stakeholders during all activities.	Communicate and collaborate using multiple media clearly and inclusively with various stakeholders during all activities.	Communicate and collaborate using multiple media clearly and inclusively with various stakeholders during all activities.
Continuing professional development and lifelong learning	Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.	Undertake CPD activities to preserve and develop competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work	Undertake CPD activities to maintain and develop competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.
Judgement	Recognise complexity and assess alternatives in light of competing requirements and incomplete knowledge. Exercise sound judgement in the course of all complex activities.	Choose appropriate technologies to deal with broadly defined problems—exercise sound judgement during all broadly-defined activities.	Choose and apply appropriate technical expertise. Exercise sound judgement in the course of all well-defined activities.
Responsibility for decisions	Be responsible for making decisions on part or all of the complex activities	Be responsible for making decisions on part or all of one or more broadly defined activities	Be responsible for making decisions on part or all of one or more well-defined activities
*Represented by the 17 UN Sustainable Development Goals (UN-SDG)			

Competence profiles for each engineer's role represent the benchmark route or vertical progression to become professional, act and make decisions individually, and be recognised and trusted nationally or internationally. The profile helps navigate the professional path and identify outcomes that need to be achieved for future learning and development.

The EEA report (2020)[14] emphasised the importance of linking knowledge with actions to achieve a sustainability transition where skills, especially technology related, are one of the main components of sustainability transition. It will require a "diverse new knowledge, drawing on multiple disciplines and types of knowledge production". In particular, "evidence about the systems driving environmental pressures, pathways to sustainability, promising initiatives and barriers to change" or specific knowledge and skills sector related. *"Foresight methods", "modelling grounded in assumptions of mainstream economics",* and *"integrated assessment modelling"* are listed as necessary ones for engaging with people and identifying or exploring possible futures, setting out long-term targets, outcomes, the optimal configuration of technologies, and risks or opportunities.

UNESCO's (2010)[15] report highlights the importance of engineers using scientific knowledge and mathematics to create technologies and infrastructure to address human, social, and economic issues. The report presents four skills relevant to engineers: "technical, personal, professional, and managerial (See Table 18).

Table 18 - Attributes of a professional engineer[14].

	Competences
Technical	Ability to think mathematically, sound knowledge of appropriate basic science, a good understanding of a specific discipline, maintenance of current knowledge and practice
Personal	Ability and willingness to learn, appreciation of limits to knowledge, good communication skills, appreciation of international dimensions
Professional	Commitment to high standards, appreciation of personal and ethical responsibilities, ability to handle uncertainty, and ability to communicate effectively.
Managerial	Ability to work in a team, appreciation of management concepts and issues, ability to lead and manage personal, financial and technical resources

The report noted the importance of engineers being well-versed in the latest technological advancements, design and drawing skills – computer-aided design (CAD) and continued professional development (CPD). Engineering education also seeks to develop robust analytical and problem-solving methodology and approach that includes soft social (motivation, ability to

[14] EEA. The European environment – state and outlook 2020. Knowledge for transition to a sustainable Europe. Webpage: https://www.eea.europa.eu/soer/publications/soer-2020 (accessed on 10 April 2023).

[15] UNESCO (2010). Engineering: Issues, Challenges and Opportunities for Development. Webpage: https://unesdoc.unesco.org/ark:/48223/pf0000189753 (accessed on 11 April 2023).

perform, rapid understanding, communication and leadership under pressure) and technical skills in training and mentoring. Social skills are keen for successful communication and effective engagement with others integrating business requirements into design decisions. UNESCO presents 27 engineering branches, of which only a few were further analysed: environmental and sustainable engineering. Environmental engineering focus on environmental protection and enhancement. It includes water engineering and planning and development of water resources and hydrology. Sustainable engineering focus on sustainability and climate change mitigation. The report identifies critical expertise where environmental engineers need to focus: modelling, monitoring, impact assessment, pollution control, evaluation, and collaborative design. Critical knowledge, innovative thinking and imagination as skills are needed to redesign technologies, processes, infrastructure and systems to become efficient, productive and practical with a strong focus on social awareness and equality. Additional skills identified in the report for engineers, which can be applied to environmental engineers as well, are project management, discernment, critical skills, relationship management with customers and users, leadership, the flexibility to adapt to changing conditions, ability to work for the team and in a multicultural environment, ethical and environmental awareness.

European Accreditation Board for Engineering Education[16] recently published the report "Being an engineer tomorrow in Europe", where one of the critical skills for engineers to be developed is proper communication, including language proficiency. Mathematics is another necessary skill for basic engineering. The report strongly focuses on European education and training institutions and how they have to reflect on today's challenges for engineers, which include requirements for collaboration, teamwork, awareness of sustainable development issues and understanding of ethical aspects with a strong focus on cooperation, not competition, to improve engineers' recruitment level and ability to become successful in the current market.

D2.4 A systematic search of available courses and training on environmental engineers within the context of sustainable innovations

The beginning of the search parameter was to select the higher education institutions in Europe providing environment-related courses being closed with engineering. Later, the team chose the European Consortium of Innovative Universities (ECIU) to reduce the process's ambiguity. Out of all the members, more than ninety per cent of consortium universities have facilities for environment-related courses addressing sustainability issues with relevant competences development. Following are the ECIU members that were assessed via the available website.

[16] European Accreditation Board for Engineering Education (2022). Being an engineering tomorrow in Europe. Webpage: https://www.enaee.eu/documents/ (accessed on 16 April 2023).

Table 19 - Member universities of ECIU analysed for the courses.

SN	ECIU member	Website of Member Universities of ECIU	Environment related courses (key words: engineering, environment)
1	Aalborg University	https://www.en.aau.dk/	https://studieordninger.aau.dk/2023/41/4351
2	Dublin City University	https://www.dcu.ie/	https://www.dcu.ie/courses/undergraduate/school-chemical-sciences/environmental-science-and-technology
3	Technical University Hamburg	https://www.tuhh.de/tuhh/en/startpage.html	https://www.tuhh.de/tuhh/studium/vor-dem-studium/studienangebot/bachelorstudiengaenge/green-technologies-energie-wasser-klima.html
4	National Institutes of Science and Technology	https://www.groupe-insa.fr/en	https://www.insa-lyon.fr/en/energetics-and-environmental-engineering
5	Kaunas University of Technology	https://ktu.edu/en/	https://admissions.ktu.edu/programme/d-environmental-engineering/
6	Linköping University	https://liu.se/	https://liu.se/en/education/program/6msus
7	Lodz University of Technology	https://p.lodz.pl/en	https://p.lodz.pl/en/research/research-projects/projects-implemented-faculty-process-and-environmental-engineering
8	Tampere University of Applied Sciences	https://www.tuni.fi/en	https://www.tuni.fi/en/students-guide/curriculum/degree-programmes/otm-4efc0e5e-87ae-4dd9-aa94-05f2d8be8956?
9	Universitat Autònoma de Barcelona (UAB)	https://www.uab.cat/	https://www.uab.cat/web/estudiar/official-master-s-degrees/content/skills/biological-and-environmental-engineering-1204099122867.html?param1=1345664654271
10	University of Aveiro	https://www.ua.pt/	https://www.ua.pt/en/curso/151, https://www.ua.pt/en/curso/498, https://www.ua.pt/en/course/484

11	The University of Stavanger	https://www.uis.no/nb	https://www.uis.no/en/studieprogram-og-emner/environmental-engineering-master-of-science-degree-programme/2022
12	University of Trento	https://www.unitn.it/en	https://international.unitn.it/environmental-engineering/programme-overview
13	University of Twente	https://www.utwente.nl/en/	https://www.utwente.nl/en/education/master/programmes/environmental-energy-management/

Then, a set of competences were collected those prioritized in the course or curriculum. The detailed segregation of the competences is as below on the category social, meta, functional and cognitive competences.

Table 20 – Social competences of environmental engineers in available courses and training.

	Competences	References list from Table 19
Social competences	Communication ideas	1,2,3,4,5,6,7,8,9,10,11,12
	Teamwork	1,3,6,8,9,10,11,12
	Resiliente	1,3,4,5
	Cultural tolerance	5,11
	Leadership	5,6,7,12

Table 21 – Meta competences of environmental engineers in available courses and training.

	Competences	References list from Table 19
Meta competences	Equipment Handle with caution	1,2,4,7,8
	Hazard management	1,2,3,
	Result oriented	1,2,3,4,5,7,8,9,11,12
	Problem solving	1,3,4,5,7,8,9,10,11,12
	Evaluative	1,5,8,10,11
	Planning and synthesizing	1,5,8,9,10,11,12
	Innovative	1,2,4,5,6,7,8,9,10,11,12
	Deliverable	1,5
	Strategic	1,2,3,4,5,6,7,8,9,10,11,12
	Collaborative	1,3
	Relationship building	1,12
	Work ethical	5

Table 22 – Functional competences of environmental engineers in available courses and training.

	Competences	References list from Table 19
Functional competences	Technology friendly	1,3,4,5,6,7,8,10,11,12
	Undesrstanding of Physics, chemistry, biology	1,26,7,8,9,10,11
	Understanding of Pollution control mechanisms	1,2,3,8,9,10,11,12
	Capacity on numerical methods	1,3,4,5,6,7,8,9,11,12
	Capacity on experimental methods	1,5,8,9,10,11,12
	Modeling skill	1,2,4,9,11,12
	Measurement skill	1,5,6,7,8,9,10,11,12
	Process management	1,2,5,8,9,10,11,12
	Data managment	1,3,6,8,9,10,11,12
	Proper documentation	1,2,5,6,9,10,11
	Budget management	3,4,6,7,9,11
	Designing capacity	1,2,3,4,5,6,7,8,9,10,11,12
	Monitoring skills	7,8,10,11
	Basic sustainability knowledge	1,3,4,7,11

Table 23 – Cognitive competences of environmental engineers in available courses and training.

	Competences	References list from Table 19
Cognitive competences	Analytical capacity	1,2,3,4,5,6,7,8,9,10,11,12
	Presence of mind according to situtation	1,4,9
	Risk management	1,2,3,4,5,8,9,10,11
	Critical thinking	1,2,3,4,5,7,8,9,10,11,12
	Professional decision-making	1,5,7,9,11,12

D2.5 Conclusion on environmental engineering

In conclusion, the analysis conducted in this study aimed to identify the competences and skills required for environmental engineers to drive sustainable innovation. A comprehensive search using different combinations of keywords and criteria identified a total of 57 articles. After removing duplicates and irrelevant articles, eight final papers were selected for further analysis.

The competences found in the literature were integrated into a competence framework, which categorized the competences into social, meta, cognitive, and functional competencies. Social competencies highlighted the importance of problem-solving, creativity, innovation, leadership, eco-responsibility, and ecological awareness. Cognitive competencies were identified in two European-funded projects, focusing on stress and knowledge management,

entrepreneurship, and understanding of organizations. Functional competencies encompassed technical, economic, and management-related skills necessary for environmental engineers.

Furthermore, NGO and consultant reports emphasized the significance of technical and non-technical skills for environmental engineers. Technical skills included knowledge of environmental regulations, design principles, and technologies, while non-technical skills encompassed communication, problem-solving, leadership, and collaboration.

Several European Union-funded projects and initiatives, such as the SME Green Skills HUB, Engineers for Europe (E4E), and A-STEP 2030, aimed to enhance environmental engineering skills and competencies to address climate change, resource depletion, and environmental degradation. These projects focused on developing new technologies, interdisciplinary collaboration, and ensuring environmental engineers have the necessary knowledge and skills to design and implement effective solutions.

Additionally, the International Engineering Alliance provided a comprehensive framework for professional competencies in engineering, highlighting the roles of engineers, engineering technologists, and engineering technicians. The framework emphasized the development of engineering qualifications, professional registration, and the maintenance and enhancement of competence throughout an engineer's career.

The reports from the European Environment Agency, UNESCO, and the European Accreditation Board for Engineering Education underscored the importance of linking knowledge with actions, integrating multiple disciplines, and addressing sustainability and environmental issues. These reports identified various skills relevant to engineers, including technical expertise, personal attributes, professional capabilities, and managerial skills.

Finally, a systematic search of available courses and training on environmental engineering within the context of sustainable innovations was conducted. The search focused on European higher education institutions, particularly those affiliated with the European Consortium of Innovative Universities (ECIU). Many ECIU member universities offered environment-related courses that addressed sustainability issues and the development of relevant competences.

In conclusion, this study highlights the diverse set of competences and skills required for environmental engineers to drive sustainable innovation. The findings underscore the importance of technical knowledge, problem-solving abilities, collaboration, leadership, and an understanding of environmental regulations and sustainability principles. The identified competences and skills provide a foundation for developing educational programs, professional training, and policies that can enhance the capabilities of environmental engineers in addressing environmental challenges and promoting sustainable development.

D3 SME framework

Small and medium enterprises (SMEs) are essential drivers of economic growth, innovation, and job creation worldwide. Despite their limited size and resources compared to larger corporations, SMEs possess unique competences that enable them to thrive in dynamic business environments. These competences encompass a diverse range of skills, capabilities, and advantages that contribute to their resilience, adaptability, and success. Understanding and harnessing these competences are crucial for SMEs to navigate challenges, seize opportunities, and establish a competitive edge in the market. This chapter provides a review on the necessary competencies and capabilities of SME entrepreneurs. It explores critical competences such as entrepreneurial spirit, flexibility, communication, financial management, innovation, and customer focus, among others. The review also highlights the importance of continuous learning and staying updated with industry trends for ongoing success in the SME sector.

D3.1 Systematic literature review on the necessary competencies and capabilities of SME entrepreneurs

Small and medium enterprises (SMEs) drive economic growth, innovation, and job creation in many countries worldwide. These enterprises, often characterised by their relatively limited size and resources compared to more giant corporations, possess unique competences that enable them to thrive in dynamic business environments. The competences of SMEs encompass a diverse range of skills, capabilities, and advantages that contribute to their resilience, adaptability, and success. Understanding and harnessing these competences is crucial for SMEs to navigate challenges, seize opportunities, and establish a competitive edge in the market. In this chapter, we will explore some critical competences of small and medium enterprises and highlight their significance in driving sustainable growth and profitability in today's business landscape.

This review aims to provide a state-of-the-art of the existing competences for sustainable and innovative procurement in the SME sector. This review uses the following filters:

1. Web of Science was used in the literature search to capture published peer-reviewed scientific journals to enhance the quality of our research.
2. Next, no time restrictions were applied, and articles in English were selected.
3. This literature review uses two sets of search strings to expand the search. The set of search strings includes "small and medium enterprises competences." Afterwards, the articles were imported into EndNote, and this program detected duplicate articles in both sets and removed them from the selected articles.
4. The fourth filter looks at the initial screening process and checks whether the keywords in the previous filter were vital subject terms in the title, abstract, and keywords.
5. Afterwards, the authors used the same key terms to screen the entire paper selected in the previous filter.
6. The final stage consisted of reading the entire paper, where the goal was to capture innovative and sustainable purchasing competences in the public procurement sector.

Conducting the review

In this review, we used the search strings "purchasing AND innovat* AND skills OR competenc*." The second set uses the search strings "small and medium enterprise* OR SME AND competenc*." The search was modified to competenc* to capture "competences," "competences," and "competency" and "enterprise*" to capture "enterprises" as well. Furthermore, the search process also considered operators such as AND and OR for the term SME. Entering the search strings in Web of Science yielded 2003 articles in total. This review removed conference journals, book sections, and serials from the selected articles to enhance the quality of our search. Thus, this research only considered peer-reviewed journals, which gave us 984 articles (filters 1-2). Filter 3 removed all duplicate articles. However, no duplicates were found. Filter 4 removed 967 articles, meaning that 17 articles were left to screen the entire article. In the final stage of reading the whole article, the total number of publications selected was 5 English peer-reviewed articles (published between 2006 and 2022).

In the dynamic and competitive landscape of the small and medium enterprise (SME) sector, possessing the right skills is crucial for achieving sustainable growth and staying ahead of the curve. SMEs, characterised by their limited resources and lean organisational structures, require individuals who can wear multiple hats, adapt quickly, and navigate diverse challenges. Here are some necessary skills that play a vital role in driving success in the SME sector, along with a brief description of each competence and its potential sources:

1. **Entrepreneurial Spirit and Vision:** SMEs often possess a strong entrepreneurial spirit characterised by a proactive mindset, risk-taking, and a clear vision for their business. This competence stems from the passion and drive of the founders and leaders of the SME (Ashurst et al., 2012; Ismail, 2022; Ng et al., 2020).

2. **Flexibility and Adaptability:** SMEs are typically agile and adaptable, allowing them to respond quickly to changing market conditions, customer demands, and emerging trends. This competence arises from the small organisational structure and the ability to make swift decisions (Ismail, 2022).

3. **Communication and Relationship-Building:** Effective communication is vital for success in the SME sector, both internally and externally. Strong interpersonal skills enable individuals to build relationships with team members, clients, suppliers, and other stakeholders. Clear and concise communication fosters collaboration, builds trust, and facilitates problem-solving, enhancing the overall effectiveness of the organisation (Ashurst et al., 2012; Ismail, 2022; Shee, 2006; Torkkeli et al., 2019)

4. **Financial Management:** Proficiency in financial management is critical for SME professionals. Understanding financial statements, budgeting, cash flow management, and forecasting is essential to making informed business decisions. Sound financial management allows SMEs to allocate resources efficiently, manage growth effectively, and maintain long-term sustainability (Ashurst et al., 2012; Ng et al., 2020).

5. **Innovation and Creativity:** SMEs often have a greater capacity for innovation and creativity, as they are less bound by rigid procedures and can embrace new ideas more readily. This competence is fostered by a culture encouraging experimentation and a

willingness to explore new approaches (Ashurst et al., 2012; Ismail, 2022; Ng et al., 2020; Shee, 2006).

6. **Customer Focus:** SMEs often excel in providing personalised customer experiences, building strong relationships, and delivering tailored solutions. This competence is driven by a close connection to customers and the ability to understand their specific needs and preferences (Ismail, 2022).

7. **Niche Expertise:** SMEs frequently develop specialised knowledge and expertise in specific niches or industries. This competence is built through a deep understanding of their target market, continuous learning, and honing specific skills and capabilities (Ashurst et al., 2012).

8. **Operational Efficiency:** SMEs often optimise their operations to maximise efficiency and productivity. This competence can be sourced from streamlined processes, effective resource allocation, and the ability to do more with limited resources (Ashurst et al., 2012).

9. **Strong Local Networks:** SMEs often have well-established local networks, including connections with suppliers, customers, industry associations, and community organisations. This competence is developed through active participation in local business ecosystems and relationship-building efforts (Ashurst et al., 2012; Ismail, 2022; Torkkeli et al., 2019).

10. **Marketing and Sales:** SMEs often operate with limited marketing budgets, making it vital for professionals to possess skills in marketing and sales, which include understanding target markets, developing effective marketing strategies, utilising digital platforms, and building strong customer relationships. The ability to effectively promote products or services, identify customer needs, and close sales is critical for SMEs to expand their customer base and drive revenue growth (Shee, 2006; Torkkeli et al., 2019)

11. **Problem-Solving and Decision-Making:** SMEs encounter various challenges, and solving problems and making efficient decisions are crucial. Strong problem-solving skills involve critical thinking, analytical reasoning, evaluating options and implementing practical solutions. Making well-informed decisions swiftly enables SMEs to seize opportunities and overcome obstacles (Ashurst et al., 2012; Ismail, 2022; Shee, 2006; Torkkeli et al., 2019).

12. **Leadership and Team Management:** Leadership skills are essential for SME professionals, whether leading a team or working collaboratively. Effective leadership involves setting a clear vision, inspiring and motivating team members, delegating tasks, and fostering a positive work culture. Strong team management skills enable SMEs to leverage the collective abilities of their employees, enhancing productivity and achieving organisational objectives (Ashurst et al., 2012; Ng et al., 2020; Shee, 2006; Torkkeli et al., 2019).

13. **Agility in Decision-Making:** SMEs can make faster decisions due to their smaller size and fewer layers of bureaucracy. This competence allows them to seize opportunities, respond to challenges swiftly, and adapt their strategies as needed (Ashurst et al., 2012; Ismail, 2022).

14. **Employee Empowerment and Engagement:** SMEs often foster a culture of employee empowerment and engagement, where individuals are encouraged to take ownership, contribute ideas, and grow within the organisation. This competence is nurtured through open communication, a supportive work environment, and opportunities for professional development (Ashurst et al., 2012; Ismail, 2022).

15. **Resilience and Resourcefulness:** SMEs possess resilience and resourcefulness in navigating uncertainties, financial constraints, and market fluctuations. This competence stems from the ability to creatively overcome challenges, find alternative solutions, and leverage available resources effectively (Ismail, 2022; Ng et al., 2020).

16. **Digital Literacy and Technology Adoption:** Embracing digital tools and technologies is vital for SMEs to stay competitive in today's digital age. Proficiency in digital literacy and a willingness to adopt new technologies enable individuals to leverage automation, data analytics, online marketing channels, and e-commerce platforms. These skills facilitate operational efficiency, enhance customer experiences, and drive innovation within SMEs (Ashurst et al., 2012; Ismail, 2022; Ng et al., 2020; Shee, 2006).

It is important to note that the presence and significance of these competences may vary across different SMEs, depending on their industry, market context, and individual characteristics. Continuous learning and staying updated with industry trends are crucial for SME professionals to continually develop and refine their skill sets, ensuring ongoing success in the ever-evolving SME sector.

In this chapter, we also use the classification model by Le Deist & Winterton (Le Deist & Winterton, 2005). To repeat, social-oriented competences involve interaction and the ability to establish and nurture relationships, which are essential for interpersonal interactions. Meta-oriented competences, on the other hand, are personal skills involving self-reflection, dealing with uncertainty, and learning. Functional-oriented competences are technical skills specific to a particular job or occupation, often called "know-how" skills. Lastly, cognition-oriented competences refer to knowledge-based skills that involve conceptual and systematic thinking, often called "know-that" and "know-why" skills. The classification of the SME competences is provided in Table 24.

Table 24 - Classification of SME competences.

	Competence	Author
Social competences	Entrepreneurial Spirit and Vision	Ashurst et al. (2012); Ismail (2022); Ng et al. (2020)
	Communication and Relationship-Building	Ashurst et al. (2012); Ismail (2022); Shee (2006); Torkkeli et al. (2019)
	Flexibility and Adaptability	Ismail (2022)
	Customer Focus	Ismail (2022)
	Strong Local Networks	Ashurst et al. (2012); Ismail (2022); Torkkeli et al. (2019)
	Leadership and Team Management	Ashurst et al. (2012); Ng et al. (2020); Shee (2006); Torkkeli et al. (2019)
	Resilience and Resourcefulness	Ismail (2022); Ng et al. (2020)
	Employee Empowerment and Engagement	Ashurst et al. (2012); Ismail (2022)
Meta competences	Creativity	Ashurst et al. (2012); Ismail (2022); Ng et al. (2020); Shee (2006)
	Problem Solving	Ashurst et al. (2012); Ismail (2022); Shee (2006); Torkkeli et al. (2019)
Functional competences	Financial Management	Ashurst et al. (2012); Ng et al. (2020)
	Marketing and Sales	Shee (2006); Torkkeli et al. (2019)
	Niche Expertise	Ashurst et al. (2012)
	Operational Efficiency	Ashurst et al. (2012)
	Digital Literacy and Technology Adoption	Ashurst et al. (2012); Ismail (2022); Ng et al. (2020); Shee (2006)
	Innovation	Ashurst et al. (2012); Ismail (2022); Ng et al. (2020); Shee (2006)
Cognitive competences	Decision-Making	Ashurst et al. (2012); Ismail (2022); Shee (2006); Torkkeli et al. (2019)
	Agility in Decision-Making	Ashurst et al. (2012); Ismail (2022)

D3.2 Assessment of european projects, NGO & consultant reports in the context of SME

First, we provide an overview of various important social competences in the context of small and medium-sized enterprises (SMEs). These competences play a crucial role in the success and growth of businesses. The information is sourced from various publications focusing on social competences in the SME sector. These social competences collectively contribute to SMEs' overall success and sustainability by enhancing communication, collaboration, leadership, and customer relations. The social competences found in the context of SMEs are as follows:

1. Communication Skills: Effectively conveying information, ideas, and messages to stakeholders, clients, and team members.
    - Source: "Effective Communication for SMEs: A Practical Guide" by European Bank for Reconstruction and Development (EBRD)
2. Interpersonal Skills: Building positive relationships, collaborating with others, and resolving conflicts in the business context.
    - Source: "Interpersonal Skills for SME Success" by Small Business Development Corporation (SBDC) Western Australia
3. Leadership Skills: Inspiring and guiding others, providing vision and direction, and fostering a positive work environment.
    - Source: "Leadership Development for SME Owners and Managers" by United Nations Industrial Development Organization (UNIDO)
4. Teamwork and Collaboration: Working effectively in teams, fostering co-operation, and leveraging collective strengths to achieve common goals.
    - Source: "Teamwork and Collaboration: A Handbook for SMEs" by International Trade Centre (ITC)
5. Empathy and Emotional Intelligence: Understanding and empathising with others' perspectives, emotions, and needs and effectively managing interpersonal relationships.
    - Source: "Emotional Intelligence in SMEs: The Essential Toolkit" by Small Business Development Corporation (SBDC) Western Australia
6. Networking and Relationship Building: Cultivating and maintaining professional networks, establishing strategic partnerships, and nurturing client relationships.
    - Source: "Networking Strategies for SMEs: Building Business Relationships" by International Finance Corporation (IFC)
7. Cultural Intelligence: Understanding and appreciating cultural diversity, adapting to cross-cultural business environments, and effectively collaborating with individuals from different cultural backgrounds.
    - Source: "Cultural Intelligence for SMEs: A Practical Guide" by European Bank for Reconstruction and Development (EBRD)
8. Negotiation and Persuasion Skills: Engaging in effective negotiation processes, influencing others, and reaching mutually beneficial agreements.

- Source: "Negotiation Skills for SMEs: A Practical Handbook" by International Trade Centre (ITC)

9. Conflict Management: Identifying and resolving conflicts constructively, promoting harmony, and maintaining positive working relationships.
    - Source: "Conflict Management in SMEs: Strategies and Techniques" by Small Business Administration (SBA)
10. Customer Focus: Understanding customer needs, delivering exceptional service, and building long-term customer relationships.
    - Source: "Customer Relationship Management for SMEs" by European Commission

Second, we highlight various significant meta-competences in the context of small and medium-sized enterprises (SMEs). Meta-competences are higher-order skills and abilities that enable individuals to manage themselves and their actions within a business setting effectively. These meta-competences collectively contribute to the success and resilience of SMEs by enabling individuals to effectively manage themselves, navigate challenges, and capitalise on opportunities. SMEs can enhance their performance, innovation capabilities, and long-term sustainability by developing and cultivating these meta-competences. The information provided is sourced from publications focusing on different aspects of meta-competences in the SME sector. The meta-competences found in the context of SMEs are:

1. Self-Awareness: Recognising and understanding one's thoughts, emotions, strengths, and weaknesses in the business context.
    - Source: "Developing Leadership Skills: A Sourcebook for SMEs" by International Finance Corporation (IFC)
2. Self-Reflection: Engaging in critically analysing and evaluating one's thinking, actions, and decision-making processes.
    - Source: "Business Coaching: A Guide for SMEs" by European Commission
3. Self-Regulation: Managing and controlling one's cognitive processes, emotions, and behaviours to achieve desired outcomes.
    - Source: "Emotional Intelligence in SMEs: The Essential Toolkit" by Small Business Development Corporation (SBDC) Western Australia
4. Goal Setting and Planning: Setting clear and achievable goals, creating action plans, and monitoring progress towards objectives.
    - Source: "Goal Setting and Planning for SMEs" by Small Business Administration (SBA)
5. Learning Agility: Being open to new ideas, seeking continuous learning opportunities, and adapting knowledge and skills to changing business environments.
    - Source: "Learning Agility: The Key to SME Success" by International Trade Centre (ITC)
6. Problem-Solving: Applying analytical and critical thinking skills to identify, analyse, and solve complex business problems.

- Source: "Problem-Solving Strategies for SMEs" by Small Business Development Corporation (SBDC) Western Australia
- Source: "Problem-Solving Strategies for SMEs" by International Trade Centre (ITC)

7. Adaptability and Flexibility: Embracing change, being open to new perspectives, and adjusting strategies and approaches as needed.
    - Source: "Building Resilience: Strategies for SMEs" by Organisation for Economic Co-operation and Development (OECD)

Third, we highlight various functional competences crucial in the context of small and medium-sized enterprises (SMEs). Functional competences refer to specific skills and capabilities that enable businesses to perform essential functions and achieve their objectives. These functional competences collectively contribute to the success and competitiveness of SMEs by enabling them to perform essential business functions effectively. By developing and enhancing these competences, SMEs can enhance their overall performance, operational efficiency, customer satisfaction, and long-term growth prospects. The information is sourced from publications focusing on different aspects of functional competences in the SME sector. Some functional competences found in the context of SMEs are:

1. Creativity and Innovation: Generating new ideas, thinking outside the box, and fostering a culture of innovation within the SME.
    - Source: "Unlocking Creativity and Innovation in SMEs" by European Bank for Reconstruction and Development (EBRD)
2. Data Analysis and Interpretation: Collecting, analysing, and deriving meaningful insights from data to inform business decisions.
    - Source: "Data Analysis for SMEs: A Practical Guide" by Small Business Development Corporation (SBDC) Western Australia
3. Financial Management: Understanding financial concepts, managing budgets, and making sound financial decisions.
    - Source: "Financial Management for SMEs: A Comprehensive Guide" by International Finance Corporation (IFC)
4. Project Management: Planning, organising, and executing projects effectively, ensuring timely delivery and successful outcomes.
    - Source: "Project Management for SMEs: A Step-by-Step Guide" by Small Business Administration (SBA)
5. Marketing and Sales: Developing marketing strategies, identifying target markets, and effectively promoting products or services.
    - Source: "Marketing and Sales Strategies for SMEs" by International Trade Centre (ITC)
6. Operations Management: Streamlining business processes, optimising resource allocation, and ensuring efficient operations.

- Source: "Operations Management for SMEs: Best Practices and Tools" by European Bank for Reconstruction and Development (EBRD)

7. Technology and Digital Skills: Leveraging technology, adapting to digital advancements, and utilising digital tools for business growth.
    - Source: "Digital Transformation for SMEs: A Practical Handbook" by International Trade Centre (ITC)

Lastly, we explored various cognitive competences valuable in the context of small and medium-sized enterprises (SMEs). Cognitive competences refer to the mental abilities and skills that enable individuals to process information, think critically, and make informed decisions. By developing and strengthening these cognitive competences, SMEs can enhance their problem-solving abilities, improve strategic planning, and optimise decision-making processes. These competences collectively contribute to SMEs' overall success, innovation, and competitiveness. The information provided is sourced from publications focusing on different aspects of cognitive competences in the SME sector. The cognitive competences found in the context of SMEs are:

1. Critical Thinking: Analysing information, evaluating arguments, and making logical and informed decisions.
    - Source: "Critical Thinking Skills for SMEs" by Small Business Development Corporation (SBDC) Western Australia
2. Strategic Thinking: Developing a long-term vision, setting goals, and aligning business activities to achieve strategic objectives.
    - Source: "Strategic Management for SMEs: A Practical Approach" by United Nations Industrial Development Organization (UNIDO)
    - Source: "Strategic Thinking for SMEs: The Key to Success" by European Bank for Reconstruction and Development (EBRD)
3. Decision-Making: Evaluating options, assessing risks, gathering relevant information, and making effective decisions based on logic and evidence.
    - Source: "Effective Decision Making for SMEs" by United Nations Industrial Development Organization (UNIDO)
4. Information Management: Gathering, organising, and analysing relevant data and information to support decision-making and business operations.
    - Source: "Information Management for SMEs: Tools and Techniques" by International Trade Centre (ITC)

D3.2.1 Conclusion on assessment of EU-funded project reports, NGO & consultant reports in the context of SME

In conclusion, the table provides an overview of various competences essential for SME professionals across different domains. The competences are grouped into four categories: social competences, meta-competences, functional competences, and cognitive competences.

Social competences encompass skills related to effective communication, interpersonal relationships, leadership, teamwork, empathy, networking, cultural intelligence, negotiation, conflict management, and customer focus. These competences are crucial for building relationships, managing teams, and delivering exceptional customer experiences.

Meta-competences focus on self-awareness, self-reflection, self-regulation, goal setting, planning, learning agility, problem-solving, information management, and adaptability. These competences emphasise personal growth, self-management, and the ability to learn and adapt in dynamic business environments continuously.

Functional competences encompass specific domain expertise, such as creativity and innovation, data analysis and interpretation, financial management, project management, marketing and sales, technology and digital skills, and operations management. These competences are tailored to the functional areas of an SME and contribute to its operational efficiency and success.

Cognitive competences include decision-making, critical thinking, and strategic thinking. These competences enable SME professionals to analyse complex situations, make informed decisions, and develop long-term strategies to achieve business goals.

By understanding and developing these competences, SME professionals can enhance their effectiveness, contribute to their organisations' growth, and navigate the challenges of the dynamic business landscape. It is important to note that this is not an exhaustive list, and additional competences may be relevant to specific industries or contexts. Nonetheless, this table is a valuable resource for SME professionals seeking to identify and cultivate the competences necessary for personal and professional development.

Table 25 - Summary of competences in EU-funded projects, NGO and consultant reports in the context of SME.

	Competence
Social competences	Communication Skills
	Interpersonal Skills
	Leadership Skills
	Teamwork and Collaboration
	Empathy and Emotional Intelligence
	Networking and Relationship Building
	Cultural Intelligence
	Negotiation and Persuasion Skills

	Conflict Management
	Customer Focus
Meta competences	Self-Awareness
	Self-Reflection
	Self-Regulation
	Goal Setting and Planning
	Learning Agility
	Problem Solving
	Adaptability and Flexibility
Functional competences	Creativity and Innovation
	Data Analysis and Interpretation
	Financial Management
	Project Management
	Marketing and Sales
	Technology and Digital Skills
	Operations Management
Cognitive competences	Decision-Making
	Critical Thinking
	Information Management
	Strategic Thinking

D3.3 Conclusion

In conclusion, small and medium enterprises (SMEs) possess diverse competences essential for success in the dynamic business environment. These competences enable SMEs to thrive despite limited resources, adapt quickly to changing conditions, and establish a competitive edge. The necessary skills in the SME sector encompass various aspects, including an entrepreneurial mindset, flexibility, effective communication, financial management, innovation, customer focus, niche expertise, operational efficiency, strong local networks, marketing and sales acumen, problem-solving and decision-making abilities, leadership and team management skills, agility in decision-making, employee empowerment and engagement, resilience and resourcefulness, and digital literacy and technology adoption.

These competences arise from a combination of factors, including SME founders' and leaders' passion and drive, the organisation's culture, industry-specific knowledge, and the ability to leverage available resources efficiently. While the presence and significance of these competences may vary across different SMEs, continuous learning and staying abreast of industry trends are crucial for SME professionals to develop and refine their skill sets continually.

By recognising and harnessing these competences, SMEs can navigate challenges, seize opportunities, and drive sustainable growth and profitability. The SME sector's unique capabilities contribute to economic growth, innovation, and job creation in many countries worldwide, making it an integral part of the global business landscape. Therefore, nurturing and investing in SMEs' competencies is paramount for fostering a thriving and resilient SME sector.

D4 Competence framework comparison: public procurement, environmental engineering, and SME

This chapter explores the social, meta, functional, and cognitive competences across three communities: public procurement (PP), environmental engineering, and small and medium enterprises (SMEs). It emphasizes the importance of effective communication, leadership, teamwork, conflict management, problem-solving, adaptability, and critical thinking. The report highlights the overlapping competences across these communities, emphasizing their interconnected nature and potential for collaboration. Recognizing and developing these competences can contribute to personal and professional growth in various domains.

D4.1 Social competences

Table 26 highlights the social competences across three different communities: "PP competences," "Env. Eng. Competences," and "SME competences." These competences encompass a range of social and professional skills that are crucial in various contexts. The table showcases the overlapping competences, demonstrating the common areas of focus and importance across the three communities. By identifying these shared competences, individuals and organizations can better understand the essential skills required for effective communication, leadership, teamwork, conflict management, adaptability, and many other aspects vital for personal and professional growth. Table 26 is a valuable resource for recognizing the key competences that cut across different domains and can contribute to individual and organizational success.

Table 26 - Summary of social competences of all three communities.

	PP competences	Env. Eng. Competences	SME competences
Social competences	Communication skills	Communication	Entrepreneurial Spirit and Vision
	Aim for effectiveness	Ethical	Communication and Relationship-Building
	Adaptation	Communication ideas	Flexibility and Adaptability
	Conflict management and prevention	Leadership	Customer Focus
	Advocacy (Leadership)	Ability to work in multicultural environments	Strong Local Networks
	Co-creation of trust	Teamwork	Leadership and Team Management
	Attractiveness regarding internal partners	Conflict management	Resilience and Resourcefulness
	Building trust	Ethic	Employee Empowerment and Engagement
	Capacity to Advice	Resiliente	Interpersonal Skills
	Corruption prevention	Judgement	Empathy and Emotional Intelligence

	Capacity to federate	Cultural aspects consideration	Cultural Intelligence
	Demonstrate positive mindset	Equality	Negotiation and Persuasion Skills
	Change Management	Cultural tolerance	Conflict Management
	Discrimination avoidance	Resilient	
	Comprehension of Complexity	Empathy and emotional intelligence	
	Dispute handling	Collaboration	
	Conflict Resolution	Passion	
	Emotional intelligence	Inclusive behaviour	
	Cross-functional team working/ cooperation	Society focus	
	Encourage a professionalisation culture	Language and cultural skills	
	Cultural awareness	Global thinking	
	Engagement with suppliers	Conflict resolution	
	Customer Focus	Sharing	
	Ethical behaviour, compliance mindset	Ability to present and communicate results to a broader audience	
	Effective questioning techniques	Politeness	
	Expert/consultant collaboration	Negotiation skills	
	Having a vision	Networking	
	Goal-oriented leadership	Relationship management	
	Humility	Compatibility	
	Interaction with users (e.g. citizens)	Influencing	
	Integrity	Interdisciplinarity	
	Networking	Teamwork	
	Interpersonal savvy		
	Relationship management		
	Knowledge sharing		
	Driving change		
	Leadership		
	Implementation of changes		
	Making good first impressions		

	Promoting collaborative culture		
	Mobility		
	Promoting diversity		
	Networking		
	Promoting procurement function		
	Openness, Open-minded		
	Sharing knowledge		
	Organizationally and politically savvy – interaction		
	Passion		
	Promoting innovation/innovativeness orientation		
	Personal credibility within the firm		
	Promoting sustainability orientation		
	Power of Persuasion		
	Problem management		
	Relationship management (strategy)		
	Resilience		
	Setting goals		
	Stakeholder management – communication		
	Stakeholder Relationship Management		
	Structured way of working		
	Supplier Relationship management – communication		
	Talent management (Leadership)		
	Thoughtfulness towards others		

D4.1.1 Conclusion on overlapping social-competences

In this section, we go a step deeper by looking at the competences that overlap all three communities. The result is provided in Table 27. The table presented here showcases the

competences overlapping across three distinct communities. These communities encompass various aspects of social competences, emphasizing the importance of effective communication, conflict management, teamwork, customer focus, leadership, resilience, ethical behaviour, cultural tolerance, and many more. The competences listed in this table demonstrate their relevance and applicability in multiple domains, reflecting the interconnected nature of these essential skills.

Table 27 - Overlap of social competences in all three communities.

	Overlap of competences in all three communities
Social competences	Communication skills
	Communication
	Conflict management and prevention
	Teamwork
	Customer Focus
	Leadership
	Resilience and Resourcefulness
	Ethic
	Equality
	Cultural tolerance
	Resilient
	Empathy and emotional intelligence
	Collaboration
	Passion
	Inclusive behaviour
	Society focus
	Conflict resolution
	Sharing
	Ability to present and communicate results to a broader audience
	Politeness
	Networking
	Relationship management
	Interdisciplinarity

In conclusion, the table highlights the competences that share common ground across three communities. These competences serve as vital pillars in fostering effective communication, collaborative problem-solving, and adaptive behavior. The overlapping competences underscore the universal importance of skills such as empathy, inclusivity, conflict resolution, and interdisciplinarity in diverse settings. By recognizing and developing these competences, individuals and organizations can enhance their ability to navigate complex challenges, build strong relationships, and drive positive change across various communities and industries.

D4.2 Meta competences

A collection of competences across three different domains: public procurement competences, Environmental Engineering competences, and SME competences is showcased in Table 28. These competences are categorized into different types, including meta-competences and cognitive competences, reflecting various skills and abilities that individuals can possess.

In the meta-competences category, we find competences such as the ability to solve problems, ability to change, anticipation of market needs, acceptance of room for failure, attractiveness regarding external partners, adaptability, commitment to change, and more. These competences highlight the overarching skills and traits required to navigate complex challenges and excel in diverse environments.

Moving on to the cognitive competences, we observe a range of skills related to problem-solving, creativity, self-awareness, self-reflection, self-regulation, goal setting and planning, learning agility, and more. These competences emphasize the intellectual and cognitive abilities necessary for effective decision-making, critical thinking, and strategic planning.

Lastly, the table also includes a set of functional competences specific to the SME domain, including financial management, project management, marketing and sales, technology and digital skills, and operations management. These competences highlight the practical and operational skills required to succeed in specific SME-related roles.

By examining the competences presented in this table, individuals and organizations can gain insights into the diverse skill sets needed to excel in project management, environmental engineering, and SME contexts. These competences serve as a valuable resource for individuals seeking to develop and enhance their skills in these areas, as well as for organizations aiming to identify and leverage the key competences of their workforce. Please note that the competences listed in the table represent an overview and are not exhaustive. The specific competences required may vary depending on the context, industry, and organizational needs.

Table 28 - Summary of meta competences of all three communities.

	PP competences	Env. Eng. Competences	SME competences
Meta competences	Ability to Solve Problems	Explorative	Creativity
	Ability to change	Assimilative	Problem-Solving
	Anticipation of market needs	Transformative	Self-Awareness
	Acceptance of room for failure	Exploitative	Self-Reflection
	Attractiveness regarding external partners	Absorptive capacity	Self-Regulation
	Adaptability	Designing	Goal Setting and Planning

	Commitment to change	Calculative	Learning Agility
	Commitment	Sponteneous presence	Adaptability and Flexibility
	Comprehension of Complexity	Result oriented	
	Flexibility	Farsighted	
	Confidence	Influencing	
	Proactivity	Confidence	
	Curiosity	Perseverance	
	Providing and receiving feedback	Diagnostic	
	Deal with ambiguity	Collaborative	
	Willingness to learn	Delivering	
	Imagination	Informative	
	Problem-solving skills	Motivating	
	Organizationally– playful attitude	Creative	
	Prioritisation skills	Anticipated self-knowledge	
	Perseverance	Professional and ethical Responsibility	
	Openness to development	Problem solving	
	Persistence	Open mindedness	
	Openness to new procurement procedures	Responsibility for decisions	
	Politically savvy – playful attitude	Equipment Handle with caution	
	Cooperative attitude	Problem-solving	
	Prioritization	Collaboration	
	Solution orientation	Creativity	
	Result orientation	Solution focus	
	Self-leadership	Innovation	
	Self-awareness	Tolerance	
	Self-confidence	Multidisciplinary working	
	Self-reflection	Leadership	
	Self-reliance	Self-knowledge	
	Sellership	Ecologic consciousness	
	Supplier relationship management – cooperative attitude	Exploitation	
		Influencing	
		Leadership	
		Open-mindedness	

		Continues professional development and life-long learning	
		Motivation	
		Imagination	
		Discernment	
		Rapid understanding/learning	
		Innovative	
		Eco-responsibility	
		Work ethical	
		Relationship building	

D4.2.1 Conclusion on overlapping meta competences

Here we go a step deeper by looking at the meta competences that overlap all three communities. The result is provided in Table 29. The table presents an analysis of competences that overlap across three distinct communities. Specifically, it highlights the shared competences found in the realm of meta-competences. Meta-competences encompass higher-order skills and abilities applicable across various domains and are crucial for personal and professional growth. The identified overlapping competences reflect the commonalities and importance of these skills in fostering creativity, problem-solving, self-awareness, self-reflection, self-regulation, goal setting and planning, learning agility, and adaptability and flexibility. Understanding and developing these competences can profoundly impact individuals' success and their ability to navigate complex challenges in different areas of life.

Table 29 - Overlap of meta competences in all three communities.

	Overlap of competences in all three communities
Meta competences	Creativity
	Problem-Solving
	Self-Awareness
	Self-Reflection
	Self-Regulation
	Goal Setting and Planning
	Learning Agility
	Adaptability and Flexibility

In conclusion, the analysis of competences across the three communities underscores meta-competences' significance in personal and professional development. The identified overlapping competences of creativity, problem-solving, self-awareness, self-reflection, self-regulation, goal-setting and planning, learning agility, adaptability, and flexibility demonstrate their universal relevance and application. These competences serve as the foundation for growth, adaptability, and success across different domains, whether in education, work, or personal relationships.

By recognizing and nurturing these competences, individuals can enhance their creative thinking abilities, effectively address challenges through problem-solving approaches, gain deeper self-awareness, and develop self-regulatory skills. Additionally, the competences of goal setting and planning, learning agility, and adaptability and flexibility enable individuals to adapt to changing circumstances and seize growth opportunities continuously.

The overlap of competences across the three communities emphasizes the interconnectedness of skills and abilities, suggesting that focusing on these meta-competences can transform personal and professional endeavours. By cultivating these competences, individuals can enhance their overall performance, achieve their goals, and navigate complex and dynamic environments with confidence and success.

D4.3 Functional competences

In this section, we will delve into the analysis of functional competences present in each community. Given the extensive list and similar competences in the public and environmental engineering sector, our initial step involves categorising these skills for better organisation and clarity. By doing so, we can establish a systematic framework to explore the skill sets within each community. This categorisation allows us to gain a comprehensive overview of the skills specific to each community, facilitating subsequent analysis of any overlaps or similarities.

The first step is categorising the skills based on their functional domains, enabling us to identify commonalities and patterns among the competences. This categorisation process aids in streamlining the subsequent analysis and ensures a logical presentation of the skills found in each community.

Once the skills are categorised, we will provide an overview of the competences discovered within each community. By presenting a comprehensive snapshot of the skills specific to each community, we can better understand the expertise and proficiencies prevalent in those areas.

Subsequently, we will examine the identified skills across each community to identify potential overlaps or similarities. This comparative analysis allows us to uncover shared competences and highlight areas of synergy among the different communities. By following this structured approach, we aim to provide a detailed exploration and assessment of the functional competences within each community. This analysis will enable us to identify the core proficiencies and expertise required within each domain and identify potential collaboration and knowledge exchange areas among communities.

D4.3.1 Categorisation of public procurement skills

Table 30 categorises various skills from literature, EU-funded project reports, NGO reports, and online training and courses relevant to diverse expertise and professional domains. These skills encompass a broad spectrum of competencies, from analytical and technical proficiencies to

leadership and management abilities. Organising these skills into distinct categories makes it easier to identify and understand the specific capabilities associated with each category.

The categorised skills cover various aspects of business and project management, contract administration, sustainability and corporate social responsibility, data analysis and systems management, innovation and intellectual property, and communication and negotiation skills. The table also highlights the importance of language proficiency and effective communication in professional settings.

This table allows individuals and organisations to gain insights into the diverse skill sets required across different domains. It can be valuable for self-assessment, skills development, talent management, and project planning. Moreover, the categorisation provides a comprehensive understanding of the skills needed to excel in specific areas, facilitating informed decision-making and resource allocation.

Whether one seeks to assess their skill set, identify areas for improvement, or evaluate the skills required for a particular role or project, this categorised table serves as a helpful reference. It helps individuals and entities recognise the breadth and depth of skills required in various professional contexts, enabling them better to navigate the complex landscape of today's professional world.

Table 30 - Categorisation of public procurement skills.

Category	Skills
Analytical Skills	Analytical skills, Analytics, Data analysis, Risk assessment
Advising and Consulting	Advising, Consulting, Strategic management, Project management
Automation and Technology	Automation, Computer Literacy, eProcurement Technology, Tools and Systems Implementation, Systems, tools, templates
Business and Financial Management	Budget analysis and planning (Business principles), Financial and contract administration skills, Forecasting skills, Performance management, Budget and payment management, Governance management
Contract Management	Contracting skills, Contract specifications, Claim management, Implementation - contract management, Contract dispute resolution skills, Contract management
Corporate Social Responsibility and Sustainability	Corporate social responsibility, Basic sustainability knowledge, Sustainability and or compliance, Promote sustainable/innovative procurement, Guidelines on Sustainable/innovative procurement
Data and Systems Management	Data and systems, Spend and demand analysis, Resourcefulness - application of tools, Tools and Systems Implementation
Innovation and Intellectual Property	Assessing the innovative quality of tenders, Innovation sourcing, Innovation sourcing approaches, Innovative thinking, Intellectual Property, IPR rights management, Innovation procurement, R&D capabilities, Pre-commercial procurement

Management and Leadership	Leadership and Personnel management, HR management and training, Stakeholder management - application of tools, Partnership management, Balancing cooperation and competition
Market and Supplier Management	Supplier management, Supplier relationship management - application of tools, Supply market research, Market management
Process and Project Management	Process Management, Process optimization, Project Management, Process structuring, Life cycle management, Prioritizing impacts/outcomes, economic importance, and market impact
Quality Assurance and Compliance	Quality assurance, Sustainability and or compliance
Languages and Communication	Languages, Publishing expertise
Negotiation and Communication	Negotiation, Educating end-users (Sourcing and solicitation), Requisition and approval, Order confirmation, claim management, Ordering, Balancing price and quality
Technical Skills	Technical skills, Basic individual knowledge on PSM, Product knowledge

D4.3.1 Categorisation of environmental engineering skills

Table 31, presented below, categorizes a comprehensive list of skills literature, EU-funded project reports, NGO reports, and online training and courses relevant to various domains and areas of expertise. These skills encompass various professional competencies, knowledge areas, and technical proficiencies. Organizing these skills into categories makes it easier to identify and understand the specific capabilities associated with each category. The table serves as a valuable reference for individuals seeking to assess their skill sets and organizations or professionals involved in talent management, project planning, or skills-based analysis. The categorized skills include planning, economic knowledge, waste and disaster management, technology proficiency, analytics, technical expertise, regulatory understanding, science comprehension, computer applications, data management, etc. By leveraging this table, individuals and entities can gain insights into the diverse skill sets required across various domains and make informed decisions regarding skill development, resource allocation, and team composition.

Table 31 - Categorisation of environmental engineering skills.

Category	Skills
Professional and Ethical Planning Skills	Planning, Project Management, Budget Management, Research Plan Design
Economic Knowledge	Economic Knowledge, Cost Benefit Analysis, Business Performance Indicators
Waste, Water, and Natural Disaster Management	Waste Management, Water Management, Natural Disaster Management, Pollution Control and Evaluation
Technology Friendly	Technology Friendly, Computer Applications, New Technologies and IT, Computer-Aided Design (CAD)
Analytic	Analytic, Analytic Skills, Analytic Methods

Technical Skills	Technical Skills, Technical Knowledge, Technical Expertise
Knowledge of Up-to-Date Regulations	Knowledge of Up-to-Date Regulations, Understanding of Regulations, Regulatory Compliance
Understanding of Physics, Chemistry, Biology	Understanding of Physics, Understanding of Chemistry, Understanding of Biology
Updating of Random Variables	Updating of Random Variables, Probability and Statistics
Data Management	Data Management, Data Handling, Data Analysis
Material and Load Modelling	Material Modelling, Load Modelling
Design and Development of Solutions	Design and Development, Solution Design
Capacity on Numerical Methods	Numerical Methods, Computational Skills
International Business Ideas	International Business, Global Business
Intellectual Property	Intellectual Property, IP Protection
Impact Assessment	Impact Assessment, Environmental Impact Assessment
Trainer	Trainer, Training Skills
Multi-Level Monte Carlo Methods	Multi-Level Monte Carlo Methods, Monte Carlo Simulation
Foresight Methods	Foresight Methods, Future Planning
Modeling Skill	Modeling Skill, Model Development
Measurement Capacity	Measurement Capacity, Measurement Skills
Fault Diagnostics Methods and Structural Health Monitoring	Fault Diagnostics, Structural Health Monitoring
Modeling Grounded in Assumptions of Mainstream Economics	Modeling Grounded in Assumptions of Mainstream Economics, Economic Modeling
Measurement Skill	Measurement Skill, Measurement Techniques
Process Management	Process Management, Process Optimization
Safety Quantification	Safety Quantification, Safety Assessment
Integrated Assessment Modeling	Integrated Assessment Modeling, Integrated Systems Analysis
Innovation Sourcing	Innovation Sourcing, Idea Generation
Practical Reliability Engineering	Practical Reliability Engineering, Reliability Analysis
Proper Documentation	Proper Documentation, Documentation Skills
Sustainability Analysis	Sustainability Analysis, Environmental Analysis
Vulnerability and Risk Assessment	Vulnerability Assessment, Risk Assessment
Designing Capacity	Designing Capacity, Design Skills
Design Capabilities of Ethical-Environmental Systems	Design Capabilities of Ethical-Environmental Systems, Sustainable Design
Marketing	Marketing, Marketing Strategies
Monitoring Skills	Monitoring Skills, Data Monitoring
Customer Service/Management	Customer Service, Customer Management

Methods and Techniques Integrating Sustainability in SMEs	Sustainability Integration in SMEs, Sustainable Business Practices
Reputation and Image Management	Reputation Management, Image Management
Reporting	Reporting, Report Writing
Environmental Taxation	Environmental Taxation, Green Taxes
Research Plan Design	Research Plan Design
Mathematics	Mathematics, Mathematical Skills
Reliability Analysis	Reliability Analysis, Reliability Assessment

D4.3.4 Conclusion on overlapping functional competences

After categorizing the skills in the public procurement and environmental engineering sector, we now have a clear overview of the skills in each community. An overview of the skills in each community is provided in Table 32.

Table 32 - Summary of meta competences in each community.

Functional competences	Analytical Skills	Professional and Ethical Planning Skills	Financial Management
	Advising and Consulting	Economic Knowledge	Creativity and Innovation
	Automation and Technology	Waste, Water, and Natural Disaster Management	Marketing and Sales
	Business and Financial Management	Technology Friendly	Data Analysis and Interpretation
	Contract Management	Analytic	Niche Expertise
	Corporate Social Responsibility and Sustainability	Technical Skills	Operational Efficiency
	Data and Systems Management	Knowledge of Up-to-Date Regulations	Project Management
	Innovation and Intellectual Property	Understanding of Physics, Chemistry, Biology	Digital Literacy and Technology Adoption
	Management and Leadership	Updating of Random Variables	Innovation
	Market and Supplier Management	Data Management	Technology and Digital Skills
	Process and Project Management	Material and Load Modelling	Operations Management
	Quality Assurance and Compliance	Design and Development of Solutions	
	Languages and Communication	Capacity on Numerical Methods	
	Negotiation and Communication	International Business Ideas	

	Technical Skills	Intellectual Property	
		Impact Assessment	
		Trainer	
		Multi-Level Monte Carlo Methods	
		Foresight Methods	
		Modeling Skill	
		Measurement Capacity	
		Fault Diagnostics Methods and Structural Health Monitoring	
		Modeling Grounded in Assumptions of Mainstream Economics	
		Measurement Skill	
		Process Management	
		Safety Quantification	
		Integrated Assessment Modeling	
		Innovation Sourcing	
		Practical Reliability Engineering	
		Proper Documentation	
		Sustainability Analysis	
		Vulnerability and Risk Assessment	
		Designing Capacity	
		Design Capabilities of Ethical-Environmental Systems	
		Marketing	
		Monitoring Skills	
		Customer Service/Management	
		Methods and Techniques Integrating Sustainability in SMEs	
		Reputation and Image Management	
		Reporting	
		Environmental Taxation	
		Research Plan Design	
		Mathematics	
		Reliability Analysis	

After analysing the provided competences in Table 33 of the three communities (PP competences, Env. Eng. Competences, SME competences), we have identified the following overlaps in Table 33.

Table 33 - Overlap of functional competences in all three communities.

	Overlapping Competences
Functional competences	Analytical Skills
	Technical Skills
	Data and Systems Management
	Process and Project Management
	Innovation
	Management and Leadership
	Market and Supplier Management
	Quality Assurance and Compliance
	Automation and Technology

Table 33 highlights the competences in more than one community, indicating areas of shared expertise across the three communities. These competencies are relevant and beneficial to multiple domains and can potentially facilitate community collaboration and knowledge exchange.

D4.4 Cognitive competences

In today's rapidly evolving business landscape, the success of organizations depends on the competences and capabilities of their workforce. Competence frameworks provide a structured approach to identifying and assessing the skills, knowledge, and abilities required for various roles and domains. This introduction compares and contrasts the competencies across three distinct fields: PP (Procurement and Purchasing), Environmental Engineering, and SME (Small and Medium Enterprises). Table 34 highlights the key competences within each field, shedding light on the cognitive skills necessary for professionals to thrive in their respective domains. Let us delve into the competences for each area:

- PP Competences: Procurement and Purchasing professionals play a pivotal role in sourcing goods and services for organizations. Their competences span a range of cognitive abilities, including making informed decisions, critical thinking, and effective decision-making. They also require business acumen, financial knowledge, and strategic thinking skills to navigate the complexities of procurement processes and supplier relationships.
- Env. Eng. Competences: Environmental Engineering professionals possess a unique skill set combining technical expertise and environmental consciousness. In addition to universal and local knowledge, they demonstrate critical thinking and analytical capacity to address environmental challenges. Their competences extend to holistic thinking, research and organization, strategic management and knowledge of sustainable development issues. These professionals also excel in risk management and problem-solving methodologies related to environmental concerns.
- SME Competences: Small and Medium Enterprises face distinct challenges and require competences tailored to their specific needs. SME professionals exhibit cognitive competences such as agility in decision-making, stress management, and information management. They possess entrepreneurial skills, experience-based learning, and commercial awareness. Their competences encompass leadership under pressure, problem-solving and analysis, and flexibility to adapt to changing conditions. SME professionals also have a strong grasp of legal knowledge, market understanding, and the importance of sustainable development.

By comparing these competence frameworks, it becomes evident that while there are some overlaps, each field requires professionals with specialized knowledge and skills. Understanding these competences can assist organizations in identifying suitable candidates, designing training programs, and fostering a workforce capable of meeting the demands of their specific industry.

In conclusion, Table 34 provides a glimpse into the cognitive competences necessary for PP, Environmental Engineering, and SMEs professionals. It serves as a foundation for further exploration and analysis, enabling organizations and individuals to enhance their understanding of the skills required for success in these domains.

Table 34 - Summary of cognitive competences in all three communities.

	PP competences	Env. Eng. Competences	SME competences
Cognitive competences	Ability to make decisions	Critical thinking	Decision-Making
	Advocacy (Strategy)	Stress management	Agility in Decision-Making
	Agility (Strategy)	Universal and local knowledge	Critical Thinking
	Business Acumen	Analytical capacity	Information Management
	Conscientiousness	Strategic management	Strategic Thinking
	Critical thinking	Research and organisation	
	Data analysis (Strategy)	Ability to perform	
	Financial acumen	Presence of mind according to situation	
	Holistic Supply Chain Thinking	Reasoning and argumentative	
	Holistic thinking	Knowledge management	
	Organizational insight and governance	Management	
	PSM Best Practice Intelligence Scouting	Risk management	
	Resourcefulness – creative resource combinations	Professional decision-making	
	Risk management	Entrepreneurship	
	Strategic thinking	Language proficiency	
	Supplier relationship management- holistic view	Experience-based learning	
	Systems thinking competence	Analytical and problem-solving methodology	
	Green/sustainable procurement	Systems thinking	
	Identification of business conditions	Judgement/Critical thinking	
	Identifying opportunities	Innovative thinking	
	Risk management	Identify and solve applied science problems	
	Setting procurement vision and strategy	Awareness of sustainable development issues	
	Supply chain management	Commercial awareness	

	Understanding the importance of the preparation phase	Problem-solving and analysis	
	Strategic public procurement	Flexibility to adapt to changing conditions	
	Value for money - mindset	Leadership under pressure	
	Defining requirements		
	Substance knowledge		
	Legal knowledge		
	Knowledge of contract models		
	Financial knowledge		
	Market understanding		
	Understanding of trends		
	Knowledge of procurement procedures		
	Knowledge of public procurement regulation		
	Knowledge about emerging technologies		

D4.4.1 Conclusion on overlapping cognitive competences

In this analysis, we have examined the competences listed in three different categories: PP competences, Environmental Engineering competences, and SME competences. Our goal was to identify the overlap and similarities between these categories, highlighting the relevant common skills across all three domains. By identifying these shared competences, we can gain insights into the core skills essential in multiple professional contexts. The overlapping competences are found in Table 35.

Table 35 - Overlap of cognitive competences in all three communities.

	Overlapping Competences
Cognitive competences	Ability to make decisions
	Critical thinking
	Risk management
	Strategic thinking
	Systems thinking

We have discovered several areas of overlap and similarity by examining the competences in PP, Environmental Engineering, and SME domains. The identified competences that cut across these categories include the ability to make decisions, critical thinking, risk management, strategic thinking, and systems thinking. These competences demonstrate their universal applicability and

importance in various professional contexts, emphasizing their value and relevance in today's dynamic and complex business environments. By recognizing and developing these shared competences, professionals can enhance their capabilities and adaptability, enabling them to thrive in diverse sectors and contribute effectively to their respective industry

Conclusion

In conclusion, Table 36 outlines the competences required across three communities: public procurement, environmental engineering, and the SME sector. These competences encompass a wide range of skills and qualities essential for individuals working in these fields to succeed and make a meaningful impact.

The social competences listed in the table highlight the significance of effective communication, conflict management, teamwork, and customer focus. These competences enable professionals to build positive relationships, resolve conflicts, collaborate effectively, and meet the needs of their stakeholders. Additionally, resilience, empathy, inclusivity, and ethical behaviour create a harmonious work environment and promote societal well-being.

Meta competences play a crucial role in personal and professional development. Creativity, problem-solving, self-awareness, self-reflection, and goal-setting enhance an individual's ability to think innovatively, adapt to new situations, and continuously grow. These competences foster a mindset of learning agility, enabling individuals to acquire new knowledge and skills in a rapidly evolving landscape.

Functional competences encompass diverse skills related to analytics, technical expertise, data and systems management, project management, innovation, and leadership. These competences are essential for individuals working in public procurement, environmental engineering, and the SME sector to effectively carry out their responsibilities, manage resources, ensure compliance, and drive innovation.

Cognitive competences are critical for decision-making and strategic thinking. The ability to make informed decisions, think critically, manage risks, and employ systems thinking allows professionals to navigate complex challenges and identify opportunities for growth and improvement.

By recognizing and cultivating these necessary competences, individuals can enhance their professional capabilities and contribute effectively to their respective communities. Moreover, integrating social, meta, functional, and cognitive competences fosters a well-rounded and holistic approach to work, enabling individuals to excel in their roles and positively impact public procurement, environmental engineering, and the SME sector.

Table 36 - Necessary competences for all three communities: public procurement, environmental engineering, and SME sector.

	Necessary competences for all three communities: public procurement, environmental engineering, and SME sector.
Social competences	Communication skills
	Communication
	Conflict management and prevention
	Teamwork
	Customer Focus
	Leadership

	Resilience and Resourcefulness
	Ethic
	Equality
	Cultural tolerance
	Resilient
	Empathy and emotional intelligence
	Collaboration
	Passion
	Inclusive behaviour
	Society focus
	Conflict resolution
	Sharing
	Ability to present and communicate results to a broader audience
	Politeness
	Networking
	Relationship management
	Interdisciplinarity
Meta competences	Creativity
	Problem-Solving
	Self-Awareness
	Self-Reflection
	Self-Regulation
	Goal Setting and Planning
	Learning Agility
Functional competences	Analytical Skills
	Technical Skills
	Data and Systems Management
	Process and Project Management
	Innovation
	Management and Leadership
	Market and Supplier Management
	Quality Assurance and Compliance
	Automation and Technology
Cognitive competences	Ability to make decisions
	Critical thinking
	Risk management

	Strategic thinking
	Systems thinking

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Appendix 1: Public procurement competence framework

	Competences	PSM competences	Corresponding Authors	HPM competences	Corresponding Authors	Innovation procurement competences	Corresponding Authors	Public procurement competences	Corresponding Authors
Social competences	Communication skills	x	Reis et al. (2019)	x	Schulze et al. (2019); Schulze & Bals (2020); Schulze et al. (2021a); Schulze et al. (2021b); Schulze et al. (2022)	x	Viale et al. (2022); Codere-Ball et al. (2020)	x	Codere-Ball et al. (2020); Steinfeld (2022)
	Adaptation					x	Viale et al. (2022)		
	Advocacy (Leadership)							x	Steinfeld (2022)
	Attractiveness regarding internal partners					x	Viale et al. (2022)		
	Building trust					x	Viale et al. (2022)	x	Steinfeld (2022)
	Capacity to Advice	x	Stek & Schiele (2021)						
	Capacity to federate					x	Viale et al. (2022)		
	Change Management	x	Reis et al. (2019); Stek & Schiele (2021)					x	Diedrichs (1996)
	Comprehension of Complexity	x	Stek & Schiele (2021)						
	Conflict Resolution	x	Reis et al. (2019); Stek & Schiele (2021)						
	Cross-functional team working/ cooperation	x	Reis et al. (2019); Stek & Schiele (2021)	x	Schulze et al. (2019); Schulze & Bals (2020); Schulze et al. (2021a); Schulze et al. (2021b); Schulze et al. (2022)			x	Steinfeld (2022)
	Cultural awareness	x	Reis et al. (2019); Stek & Schiele (2021)						
	Customer Focus	x	Reis et al. (2019); Stek & Schiele (2021)			x	Viale et al. (2022)		
	Effective questioning techniques	x	Reis et al. (2019)						
	Having a vision							x	Diedrichs (1996)
	Humility	x	Reis et al. (2019)						
	Integrity	x	Reis et al. (2019)						
	Interpersonal savvy			x	Schulze et al. (2022)				
	Knowledge sharing	x	Reis et al. (2019)						
	Leadership	x	Reis et al. (2019); Stek & Schiele (2021)			x	Viale et al. (2022)	x	Diedrichs (1996)
	Making good first impressions							x	Diedrichs (1996)
	Mobility	x	Reis et al. (2019)						
	Networking	x	Reis et al. (2019); Stek & Schiele (2021)			x	Viale et al. (2022)	x	Steinfeld (2022)
	Openness, Open-minded	x	Reis et al. (2019)			x	Viale et al. (2022); Codere-Ball et al. (2020)	x	Codere-Ball et al. (2020)
	Organizationally and politically savvy – interaction			x	Schulze et al. (2019)				
	Passion	x	Reis et al. (2019)						
	Personal credibility within the firm					x	Viale et al. (2022)		
	Power of Persuasion	x	Stek & Schiele (2021)						
	Problem management					x	Viale et al. (2022)	x	Diedrichs (1996)
	Relationship management (strategy)	x	Stek & Schiele (2021)					x	Steinfeld (2022)
	Resilience	x	Reis et al. (2019)					x	
	Setting goals							x	Diedrichs (1996)
	Stakeholder management – communication			x	Schulze et al. (2019); Schulze et al. (2021a); Schulze et al. (2021b); Schulze et al. (2022)				
	Stakeholder Relationship Management	x	Reis et al. (2019); Stek & Schiele (2021)						
	Structured way of working	x	Reis et al. (2019)						
	Supplier Relationship management – communication			x	Schulze et al. (2019);Schulze et al. (2021b); Schulze et al. (2022)				
	Talent management (Leadership)							x	Steinfeld (2022)
	Thoughtfulness towards others			x	Schulze & Bals (2020); Schulze et al. (2022)				
Meta-competences	Ability to Solve Problems	x	Stek & Schiele (2021)					x	Steinfeld (2022)
	Anticipation of market needs					x	Viale et al. (2022)		
	Attractiveness regarding external partners					x	Viale et al. (2022)		
	Commitment to change			x	Schulze et al. (2019); Schulze & Bals (2020); Schulze et al. (2021a); Schulze et al. (2021b); Schulze et al. (2022)				
	Comprehension of Complexity	x	Stek & Schiele (2021)						
	Confidence			x	Schulze et al. (2022)				
	Curiosity	x	Reis et al. (2019)	x	Schulze & Bals (2020)	x	Viale et al. (2022)		
	Deal with ambiguity	x	Reis et al. (2019)			x	Viale et al. (2022)		
	Imagination	x	Reis et al. (2019);Stek & Schiele (2021)			x	Viale et al. (2022); Codere-Ball et al. (2020)	x	Codere-Ball et al. (2020); Steinfeld (2022)
	Organizationally- playful attitude			x	Schulze et al. (2019); Schulze et al. (2022)				
	Perseverance					x	Viale et al. (2022)		
	Persistence			x	Schulze & Bals (2020); Schulze et al. (2022)				
	Politically savvy - playful attitude			x	Schulze et al. (2019); Schulze & Bals (2020); Schulze et al. (2022)				
	Prioritization	x	Reis et al. (2019)						
	Result orientation	x	Reis et al. (2019); Stek & Schiele (2021)			x	Viale et al. (2022)		
	Self leadership							x	Diedrichs (1996)
	Self-awareness			x	Schulze & Bals (2020); Schulze et al. (2022)				
	Self-confidence	x	Reis et al. (2019)						
	Self-reflection	x	Reis et al. (2019)	x	Schulze et al. (2019); Schulze et al. (2021b)				
	Self-reliance	x	Reis et al. (2019)						
	Selfership	x	Stek & Schiele (2021)			x	Viale et al. (2022)		
	Supplier relationship management – cooperative attitude			x	Schulze et al. (2019); Schulze et al. (2021a); Schulze et al. (2022)				
Functional competences	Analytical skills	x	Reis et al. (2019)						
	Analytics	x	Reis et al. (2019); Stek & Schiele (2021)					x	Steinfeld (2022)
	Automation	x	Reis et al. (2019); Stek & Schiele (2021)			x	Viale et al. (2022)	x	Diedrichs (1996)
	Basic individual knowledge on PSM	x	Reis et al. (2019)	x	Schulze et al. (2019); Schulze & Bals (2020); Schulze et al. (2021b); Schulze et al. (2022)				
	Basic sustainability knowledge			x	Schulze et al. (2019); Schulze & Bals (2020); Schulze et al. (2021a); Schulze et al. (2021b); Schulze et al. (2022)				
	Budget analysis and planning (Business principles)							x	Steinfeld (2022)
	Computer Literacy	x	Reis et al. (2019)						
	Contracting skills	x	Reis et al. (2019); Stek & Schiele (2021)	x				x	Steinfeld (2022)
	Corporate social responsibility		Stek & Schiele (2021)	x					
	Cost focus	x	Reis et al. (2019); Stek & Schiele (2021)	x					
	Data and systems			x	Schulze et al. (2019)				
	Demand management – category strategy			x	Schulze et al. (2019); Schulze et al. (2021a); Schulze et al. (2021b); Schulze et al. (2022)				
	Demand management – tender analysis			x	Schulze et al. (2019)				
	Design thinking					x	Codere-Ball et al. (2020)		
	Development of tools/Participation in peer initiative			x	Schulze et al. (2022)				
	Educating end-users (Sourcing and solicitation)							x	Steinfeld (2022)
	eProcurement Technology	x	Reis et al. (2019)						
	Financial and contract administration skills							x	Diedrichs (1996)
	Forecasting skills	x	Stek & Schiele (2021)					x	Steinfeld (2022)
	HR management and training			x	Schulze et al. (2019)				
	Implementation – contract management			x	Schulze et al. (2019); Schulze et al. (2022)				
	Implementation – reporting and measurement			x	Schulze et al. (2019); Schulze et al. (2022)				
	Innovation sourcing	x	Reis et al. (2019); Stek & Schiele (2021)			x	Viale et al. (2022)		
	Innovation sourcing approaches	x	Reis et al. (2019)			x	Viale et al. (2022)		
	Innovative thinking					x	Codere-Ball et al. (2020)	x	Diedrichs (1996)
	Intellectual Property	x	Reis et al. (2019)						
	Invoice, payment			x	Schulze et al. (2019)				
	Languages	x	Reis et al. (2019)						
	Leadership and Personnel management	x	Stek & Schiele (2021)						
	Management of innovation projects					x	Viale et al. (2022)		
	Negotiation	x	Reis et al. (2019); Stek & Schiele (2021)	x	Schulze et al. (2019)	x	Codere-Ball et al. (2020)	x	Codere-Ball et al. (2020); Diedrichs (1996)
	Optimisation of Purchasing Processes	x	Stek & Schiele (2021)						
	Order confirmation, claim management			x	Schulze et al. (2019)				
	Ordering			x	Schulze et al. (2019)				
	Performance management			x	Schulze et al. (2019)			x	Steinfeld (2022)
	Policy							x	Steinfeld (2022)
	Process Management	x	Stek & Schiele (2021)						
	Process optimization	x	Reis et al. (2019)						
	Product knowledge	x	Reis et al. (2019)						
	Project Management	x	Reis et al. (2019)						
	Publishing expertise							x	Diedrichs (1996)
	Purchasing specifications (NEW)			x	Schulze et al. (2022)				
	Quality assurance	x	Reis et al. (2019)						
	Remote Virtual Working	x	Reis et al. (2019)						
	Requisition and approval			x	Schulze et al. (2019)				
	Resourcefulness – application of tools			x	Schulze et al. (2019); Schulze et al. (2022)				
	Spend and demand analysis			x	Schulze et al. (2019)				
	Stakeholder management – application of tools			x	Schulze et al. (2019); Schulze et al. (2022)				
	Strategic positioning (NEW)			x	Schulze et al. (2022)				
	Strategic sourcing	x	Reis et al. (2019)						
	Supplier management	x	Reis et al. (2019)						
	Supplier relationship management – application of tools			x	Schulze et al. (2019); Schulze et al. (2021b); Schulze et al. (2022)				
	Supply market research (NEW)			x	Schulze et al. (2022)				
	Sustainability and or compliance	x	Reis et al. (2019); Stek & Schiele (2021)	x	Schulze et al. (2019); Schulze et al. (2021a); Schulze et al. (2021b); Schulze et al. (2022)	x	Viale et al. (2022)		
	Technical skills	x	Stek & Schiele (2021)					x	Diedrichs (1996)
	Tools and Systems implementation	x	Reis et al. (2019)						
Cognitive competences	Ability to make decision	x	Reis et al. (2019)	x	Schulze et al. (2019)				
	Advocacy (Strategy)	x	Reis et al. (2019)					x	Steinfeld (2022)
	Agility (Strategy)	x	Reis et al. (2019)					x	Steinfeld (2022)
	Business Acumen	x	Reis et al. (2019)						
	Conscientiousness	x	Stek & Schiele (2021)	x	Schulze et al. (2022)			x	
	Critical thinking	x	Reis et al. (2019)	x	Schulze et al. (2019); Schulze & Bals (2020)	x	Viale et al. (2022); Codere-Ball et al. (2020)	x	Codere-Ball et al. (2020); Steinfeld (2022)
	Data analysis (Strategy)							x	Steinfeld (2022)
	Financial acumen	x	Reis et al. (2019)						
	Holistic Supply Chain Thinking	x	Reis et al. (2019)						
	Holistic thinking	x	Stek & Schiele (2021)			x	Viale et al. (2022)		
	Organizational insight and governance	x	Stek & Schiele (2021)						
	PSM Best Practice Intelligence Scouting	x	Reis et al. (2019)						
	Resourcefulness – creative resource combinations			x	Schulze et al. (2019); Schulze et al. (2022)				
	Risk management	x	Reis et al. (2019)			x	Viale et al. (2022)		
	Strategic thinking	x	Reis et al. (2019)						
	Supplier relationship management- holistic view	x	Stek & Schiele (2021)	x	Schulze et al. (2019); Schulze et al. (2022)	x	Viale et al. (2022)		
	Systems thinking competence			x	Schulze et al. (2019); Schulze & Bals (2020); Schulze et al. (2021a); Schulze et al. (2021b); Schulze et al. (2022)	x	Codere-Ball et al. (2020)		