Constructionism as a Key to Interdisciplinary Competences

Combining Computational Thinking, Entrepreneurship, and Green Skills

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Abstract

One of the biggest challenges in education today is equipping learners with future-oriented skills that take into account technological advances, environmental sustainability and entrepreneurial innovation. As part of the Erasmus+ "ComeThinkAgain" project, this paper presents a consolidated list of competences and teaching methods aimed at promoting computational thinking (CT), entrepreneurship education (EE) and innovation as well as green skills (GS) and social responsibility. Based on an in-depth literature review, existing frameworks, and a curriculum analysis, this research synthesizes a cross-country competence list. This list was validated and refined through nine co-creation workshops across the partner countries, in which various stakeholders discussed the list of competences and teaching methods to ensure relevance to practice. Central to this effort is the application of constructionism, which serves as a unifying approach to developing these competences. By emphasising learning by doing and active exploration, constructionism provides a practical basis for the cross-curricular integration of CT, EE and GS and thus promotes systems thinking, environmental responsibility and strategic innovation. This approach allows for the design of modular learning systems for both vocational education and training (VET) and higher education (HE), creating comprehensive micro-modules for sustainable and interdisciplinary skills development.

Keywords and Phrases: Computational thinking, Entrepreneurship education, Green skills, Constructionism, Transversal Competences

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1. Introduction

In a rapidly changing world, it is essential to prepare future generations to address the diverse challenges, such as digitalisation and climate change, by equipping them with the necessary skills and competences. With respect to this, interdisciplinarity and multifaceted competences are key in the 21st century also when addressing the challenges of tomorrow's professions (OECD, 2019). Three competence areas, in particular, can be considered of high value for tackling such challenges: computational thinking (CT), entrepreneurship education (EE) and innovation as well as green skills (GS) and social responsibility. However, while these competences are often treated as separate domains, there is a lack of coherent frameworks that leverage their natural synergies. A constructionist approach can be the key to integrate and foster CT, EE and GS skills by providing a learning environment where abstract concepts become tangible through hands-on activities (Kayii & Akpomi, 2022). Following the combination of theoretical knowledge and practical implementation, learners can be engaged by dealing with real-world problems, therefore allowing to foster systems thinking, innovation capabilities, but also environmental awareness. Furthermore, the interdisciplinary nature of sustainability challenges, where solutions require technical competence as well as an entrepreneurship mindset highlights the importance of a constructionist approach (Huang et al., 2020). The focus on learning by doing and active exploration complements the hands-on characteristics of entrepreneurship and the problem-solving focus in CT, enabling learners to understand principles through direct experience rather than passive learning.

Supporting teachers trained at higher education (HE) and vocational education and training (VET) institutions is crucial, as they educate the future workforce and are responsible for promoting the synergetic development of CT, EE and GS in their students. Thus, we established ComeThinkAgain, a multi-national Erasmus+ research project that aims to develop and implement a cross-sectoral, standardised training and certification system for teachers and trainers, which builds on three interwoven competence pillars of CT, EE and GS.

Therefore, the research question underlying this paper is as follows: *How can a constructionist approach facilitate the integration and teaching of computational thinking (CT), entrepreneurship education (EE), and green skills (GS) through hands-on, project-based learning methods?*

This paper analyses current approaches to defining and teaching competences in CT, EE and GS – the three core pillars of our project. It reviews key European frameworks (Section 2), outlines the co-creation methodology with 9 stakeholder workshops (Section 3), and presents a structured literature review (Section 4) leading to a preliminary competence list. Section 5 synthesises theory and practice, while the final section discusses findings and next steps.

2. European Competence Frameworks

With our focus on European competence frameworks we identified three that align with the objectives of our project and define a conceptual background that connects the projects aims with established European standards for competence development: the Digital Competence Framework (DigComp), the Entrepreneurship Competence Framework (EntreComp), and the Sustainability Competence Framework (GreenComp). The following sections provide a brief overview of each framework, outlining their structure and key competences.

The Digital Competence Framework for Citizens (DigComp): DigComp provides a common understanding of what digital competence is and displays the following competences (EC. 2022b): *information and data literacy, communication and collaboration, digital content creation, safety,* and *problem-solving*. Of particular importance is the focus on problem-solving, which includes recognizing needs and technological solutions, using digital tools in innovative ways and continuously updating one's digital skills. DigComp provides a clear pathway for assessing and developing these skills at different levels, from the basics to highly specialized skills. It serves as a guide for educational programs, policy decisions and workplace training aimed at improving digital literacy.

The Entrepreneurship Competence Framework (EntreComp): EntreComp aims to promote entrepreneurial competences as one of the 8 key competences for lifelong learning (EC, 2016). The framework covers 15 competences in the three key competence areas: *(i) Ideas & Opportunities (ii) Resources* and *(iii) Into action*. The competences of the EntreComp model encompass a broad spectrum of skills that enable individuals to think and act entrepreneurially and successfully implement innovations. These competences from the three categories form the foundation for the Entrepreneurship part of the *Consolitated Competence List* in section 4.5.

The European Sustainability Competence Framework (GreenComp): GreenComp provides an EU-wide reference framework for learners and educators offering a unified concept of what sustainability competences include. It aims to improve and support the development of skills, knowledge and values needed to live and act sustainably. The framework incorporates 12 competences which are categorized into four thematic areas (EC, 2022a): *embodying sustainability values, embracing complexity in sustainability, envisioning sustainable futures,* and *acting for sustainability*.

3. Methods

The project is based on a comprehensive, systematic literature review of competence frameworks and educational approaches. By analyzing their strengths and limitations, the team identified gaps and challenges in current curricula and teaching practices, informing the development of a consolidated competence list. The methodology also examines how these competences are implemented across primary, secondary, and VET education to assess their alignment with digital and sustainability demands. To ensure practical relevance, co-creation workshops with educators, experts, and stakeholders are conducted across the projects partner countries. These workshops validate and refine the competence list and teaching methods, ensuring adaptability to diverse educational settings. The project outlines four primary methodologies as part of the workshop framework selected for their effectiveness in fostering engagement and promoting creativity: (1) World Café, (2) SOAR Analysis (3) Design Thinking and (4) Plus/Delta Feedback.

4. Results

The results section analyses the three pillars, summarising key insights, skill gaps, training methods, and synergies. It concludes with findings from the co-creation workshops, reflecting stakeholder perspectives.

4.1 Core Findings of Computational Thinking

Papert first introduced the foundational ideas related to CT in his book Mindstorms, emphasizing how children can learn through active engagement with computers, constructing knowledge by creating meaningful artifacts (Papert, 1980). His constructionist approach, deeply rooted in Piaget's constructivist theories, views learning as an iterative and exploratory process, where computers serve as powerful tools for thought. The modern conceptualization of CT can be traced to Wing (2006), who defined it as the thought process used by computer scientists to solve problems. Wing's work expanded CT beyond computer science, positioning it as a fundamental skill for problem-solving across disciplines, sparking extensive research into its educational applications and practical frameworks. This perspective aligns with other definitions, such as Aho's (2012), which frames CT as a problem-solving approach that translates real-world problems into algorithms and computational steps. Initially rooted in computer science, CT has since evolved into a versatile skill set applicable across disciplines, ranging from education and engineering to the social sciences and the arts (Shute et al., 2017). As a result, CT is increasingly recognized as a fundamental competency for the 21st century, fostering critical thinking, creativity, and adaptability in an ever-changing digital landscape. The World Economic Forum (2015) similarly identifies ICT skills, encompassing CT, as fundamental for creating and processing technology-based content. This broad consensus underscores the importance of teaching CT to prepare children for challenges and opportunities of the digital age.

Curricula Implementation of CT: In recent years there has been a strong effort establishing CT skills in compulsory educations curricula. However, this is also accompanied by challenges: competition with other subjects in the curricula, difficulties with assessments or a lack of teachers, who are appropriately qualified to guarantee a successful transfer of CT competences (EC, 2022b). To get an overview of how CT is currently integrated in curricula, we analyzed the curricula of all 9 partner countries of the ComeThinkAgain project in more detail. The curricula review showed that the integration of CT into curricula varies significantly across countries, reflecting diverse educational priorities and structures (EC, 2022b). In many nations, CT is embedded within broader initiatives for digital competence and media literacy, often introduced as part of programming, computer science, or mathematics education. For example, Finland integrates CT across subjects like mathematics and crafts, while in Switzerland, CT is a key component of the "Media&Informatics" module. Other countries, such as Denmark, are in the process of formalizing national strategies for CT, building on pilot projects like "Technology Comprehension." In regions like Spain and Belgium, CT is addressed through cross-curricular approaches or dedicated coding and robotics courses. Despite the differences, there is a common trend towards embedding CT within education initiatives, equipping students with problem-solving and algorithmic thinking skills essential for the future.

Training Methods in CT: Over the last decades researchers have explored diverse educational strategies to enhance student learning in CT. Different approaches emphasize the flexibility and adaptability of CT in promoting critical thinking and problem-solving skills across different domains and age groups. Hsu et al. (2018) presented an overview of teaching methods in CT, highlighting among others: *Problem-based learning, collaborative learning, project-based learning, game-based learning, scaffolding, problem-solving, storytelling,* and *design-based learning*. Other key approaches found in the literature include *programming and robotics* (Lye & Koh, 2014). In addition, *Maker-Education* (Rode et al., 2015) emphasizes hands-on activities that foster creativity, iterative design, and problem-solving through tangible projects. Unplugged activities (Brackmann et al., 2017), such as the Bebras Challenges and CS Unplugged, engage learners in CT without computers, using games and exercises to teach algorithmic thinking. G*ames* and *game development* (Varghese & Renumol, 2024) enhance CT by involving students in system design and interactive problem-solving. A common thread among these approaches is their alignment with *constructionism*, which emphasizes learning by doing, iterative exploration, and the creation of artifacts (Papert & Harel, 1991).

4.2 Core Findings for Entrepreneurship Education

Entrepreneurship is a multi-layered concept with various definitions and perspectives that reflect and emphasise its dynamic nature. According to the EntreComp framework (2016), it is about recognising and exploiting opportunities to create value, be it in financial, social or cultural form. In a report by the EC (2015), entrepreneurship is closely linked to important economic outcomes such as growth through innovation, job creation and productivity gains, often achieved through the reorganisation of activities and the transfer of knowledge and technology. Originally limited to the economic sphere, the concept of entrepreneurship has now been extended to various social and political areas. Gianesini et al. (2018) emphasise that entrepreneurship today consists of creating new opportunities despite challenges and uncertainty, making it an important driver of economic growth, sustainability and social progress. Kuratko et al. (2012) describe an entrepreneur as someone who organises, manages and assumes the risks of a business. Schumpeter (1934) defines entrepreneurship as a pattern of behaviour that mobilises and manages economic resources to create value. Entrepreneurship research is constantly evolving, leading to changing definitions and theoretical foundations. Experts agree that higher levels of entrepreneurial activity generally contribute to more innovation and economic growth. This emphasises the need to improve EE to promote the development of the necessary skills for future entrepreneurs (Sánchez, 2013; Thomas & Mueller, 2000).

Curricula Implementation of EE: In many countries, entrepreneurship is seen as a key competence for promoting innovation, economic growth and employment. The 'Youth Wiki' of the European Commission provides valuable insights into the development of entrepreneurial competences in 34 different European countries. Chapter 3, 'Employment & Entrepreneurship', examines how entrepreneurship is embedded in national education systems. It shows how curricula are designed and implemented to promote entrepreneurial thinking and behaviour. However, the integration of entrepreneurship into the curricula varies significantly between countries. In some countries, a holistic approach is taken that includes both theoretical and practical elements. Here, students not only learn business basics, but also apply them in practical projects. In other countries, entrepreneurship content may only be taught in theory, without practical applications or the necessary support for teachers. In Austria for instance, entrepreneurship is taught in 'Economics' as well as interdisciplinary with practice-orientated projects. In Estonia, EE is promoted through subjects such as 'Entrepreneurial Studies' and 'Business Studies' as well as programmes such as 'Junior Achievement' to provide students with practical entrepreneurial skills (Youth Wiki: Europe's Encyclopedia of National Youth Policies, n.d.).

Training methods in EE: The field of EE has grown significantly in recent years, providing learners with essential skills, knowledge and the mindset needed to become successful entrepreneurs. Thus, the number and variety of training methods has also increased (Block et al., 2023; O'Brien & Hamburg, 2019; Samuel & Rahman, 2018). The most commonly used categories of existing training methods according to literature and practice are: *Project-based learning, competition-based methods, simulations/games, guest lectures and workshops, design thinking, reflective and theory-based methods*. Many of the approaches mentioned, such as project-based learning, competition-based methods, simulations, reflect constructivist principles by encouraging active, self-directed learning and the application of knowledge.

4.3 Core Findings for Green Skills

As stated in goal number four of the sustainability development goals (UN, 2015), quality education with an explicit focus on sustainable development is of uppermost importance for a sustainable transformation by the year 2030. Also, the European Union's Green Deal relies on well-trained and educated individuals to achieve its aim of making Europe the first climate neutral continent worldwide by 2050. Therefore, sustainability competences are of great significance regardless of age and must be encouraged from early childhood on (EC, 2022a; Vesterinen, 2024). However, there is still lack of agreement on what constitutes sustainability and green skills (Brundiers et al., 2021). According to the GreenComp reference framework

> "sustainability competence[s] empower[s] learners to embody sustainability values, and embrace complex systems, in order to take or request action that restores and maintains eco-system health and enhances justice, generating visions for sustainable futures." (EC, 2022a, p.12).

Curricula Implementation of GS: The idea of educating for a sustainable transition is not yet common sense in education policies across EU countries despite being in relevant focus in recent years (EC, 2021b). Integrating sustainability in curricula remains a difficulty and there is a necessity for research on how to approach teaching, learning and implementing existing competence frameworks in sustainability education (Bianchi, 2020; EC, 2024; Redman & Wiek, 2021). However, it is agreed upon in literature that teaching sustainability requires a pedagogy which encourages an action-oriented, hands-on and learner-centred approach instead of a mere knowledge transfer (EC, 2021b; EC, 2024; Sipos et al., 2008). There exist different strategies in implementing sustainability education in school curricula, the most common ones are cross-curricular (integrating sustainability into all subjects), project-based or as a stand-alone subject. In the work of the EC (2024) school curricula are analysed according to how sustainability education in schools on primary and secondary level in 39 European countries are covered. The overall results reveal that all the examined countries cover sustainability topics in the curriculum which are in most cases incorporated in the subjects of natural sciences, citizenship education and geography. In addition, most education systems treat sustainability competences in a cross-curricular way.

Training Methods in GS: Research shows that in many countries still it is about knowledge transfer when it comes to teaching sustainability, which is not enough to develop sustainable competences and behaviour (EC, 2021b). Also, *outdoor education, including field trips* and *field work*, is a popular teaching method which offers an important learning environment for developing a deeper connection with nature and thus increases sustainable and environmental consciousness and attitudes (Jeronen et al., 2016). Further teaching methods include: Project-based learning, problem-based learning, game-based learning, role-plays and simulations, collaborative approaches (with external partners), case studies, debates and discussions, group work and experiential learning (EC, 2021b; EC, 2022a; Jeronen et al., 2016).

4.4 Skill Gaps and Challenges in CT, EE, and GS & Key Intersections

The three pillars face similar challenges that limit their effective integration into education. All struggle with insufficient teacher training, a lack of confidence in delivering multidisciplinary content or missing practice-oriented materials. The interdisciplinary nature of these fields adds complexity, as they require connections across curricula, yet often lack clear integration strategies. Additionally, the absence of robust assessment methods, and inconsistent curriculum alignment across countries hinder the development of essential competencies in these areas (EC, 2021a; EC, 2021b; Tagare, 2024; Bianchi, 2020). A particularly effective approach to combine all three pillars is the implementation of interdisciplinary projects (Hinterplattner et al., 2021). In connection with *Making*, projects involve the development of a sustainable products that are optimised with CT and marketed through EE. Students could take on all aspects from the idea to the development and commercialisation themselves and thus acquire a deeper understanding of the connections between technology, the economy and the environment.

4.5 Consolidated Competence List

In our research project, the resulting competence list in Figure 1 constitutes a structured synthesis of thematically coherent elements repeatedly identified across the reviewed literature, with the objective of ensuring both completeness and practical relevance. Importantly, the list is designed as a living document and will undergo further refinement throughout the lifetime of the project. This iterative process will ensure that the competences remains aligned with the latest educational and industry trends, guaranteeing the highest quality learning materials. The goal is to foster a holistic and future-proof set of skills that will equip learners for successful careers and societal contributions in an increasingly interconnected and sustainability-driven world.

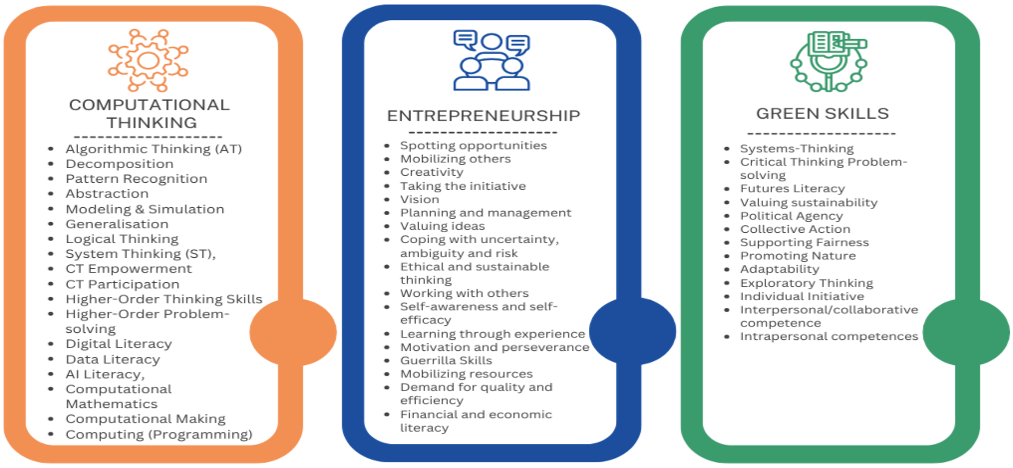

Figure 1: Consolidated Competence List (https://comethinkagain.eu/resources/).

4.6 Findings from the Co-Creation Workshops

We organized nine co-creation workshops across Europe, held both online/onsite and in multiple languages, engaging 97 participants from HEIs, VET providers, the public sector, and the private sector. The participants were invited via targeted emails to ensure a diverse range of perspectives relevant to the three pillars. They came from different professional backgrounds, including university lecturers in education, vocational trainers working with young adults, and practitioners from both public and private sector organizations.

The workshops aimed to refine the consolidated competence list and methods for trainings by fostering collaboration among stakeholders and addressing skill gaps in the three core competence pillars: CT, EE, and GS. Key objectives included mapping stakeholder needs, validating and expanding competences, and mapping curriculum requirements.

List of Competences: The results of the co-creation workshops introduce a practical, application-oriented perspective to the three competences. In CT, they extend beyond foundational concepts to emphasize the integration of advanced tools and techniques, such as AI literacy, blockchain, collaborative platforms (e.g., GitHub), and practical applications in data visualization and automation. In addition, participants found that the competences may be too broad, encompassing both highly specific skills and general concepts. A focus on overarching competences such as problem solving could provide a clearer and more practical framework. For EE, the workshops enrich the framework with actionable skills like business model generation, stakeholder engagement, and entrepreneurial execution. Regarding GS, the outcomes emphasize sustainability in practice, introducing eco-design, resource optimization, renewable energy solutions, and circular economy principles. Furthermore, participants emphasised the need for overarching competencies such as system thinking, adaptability and ethical awareness, which cut across all three pillars.

Teaching Methods: The workshops highlighted the importance of interactive and practice-oriented teaching methods. Approaches such as design thinking, project-based learning and simulation games were identified as effective strategies for promoting in-depth learning and competences application. Furthermore, participants emphasised the value of integrating co-creation methods into teaching practice, such as living labs, co-creation hackathons, participatory roadmaps, and innovation jams. These methods enable learners to actively engage with and contribute to their education through collaborative problem-solving, iterative prototyping, and community-driven innovation.

Additionally, a Community of Practice (CoP) emerged from the co-creation workshops, connecting VET institutions, higher education, and businesses into a growing network across Europe.

5. Discussion and Outlook

A closer examination of the competence pillars reveals that they share competences as well as common teaching methods. This highlights the role of constructionism as a central framework for integrating CT, EE and GS into interdisciplinary education. By emphasizing learning by doing and active exploration, constructionism bridges the gap between theory and practice. Common teaching methods across all three areas include *project-based learning, problem-based learning, collaborative learning,* *game-based learning, design thinking, experiential learning,* and *reflective practices*. These approaches foster hands-on engagement, creativity, and critical thinking, enabling learners to develop relevant skills in a meaningful and applied context. In addition, the three pillars also face common challenges including, a lack of trained educators or inconsistent curricular integration. CT, EE, and GS are often taught in isolation rather than being embedded holistically, and assessment methods for these competences remain underdeveloped. Addressing these challenges requires better teacher training, resource allocation, and cross-disciplinary strategies to ensure effective implementation.

During the co-creation workshops, the list of competences was validated and redesigned, with a focus on overarching competences such as problem solving, while incorporating emerging priorities such as AI skills and eco-design. The workshops also revealed a strong alignment between foundational digital, entrepreneurial, and green skills, while highlighting several opportunities to deepen and broaden the competencies for a more comprehensive approach to the evolving demands of the digital and sustainability landscapes. The updated version of the competence list, incorporating insights from the co-creation workshops and aligning with the findings from Deliverable D2.2 on teaching methods, will be *presented by the end of March*.

Lessons Learned – The Role of Constructionism: In alignment with our research question, constructionism has emerged as a key pedagogical framework for integrating computational thinking (CT), entrepreneurship education (EE), and green skills (GS) into interdisciplinary education. By emphasizing learning by doing, iterative exploration, and the creation of meaningful artifacts, constructionist methods effectively address skill development across these domains through hands-on experimentation, iterative problem-solving, and collaborative learning, thereby meeting both theoretical and practical requirements. The synergies between CT, EE, and GS are evident in how computational skills support entrepreneurial innovation, entrepreneurship drives sustainable solutions, and CT enhances environmental initiatives through data analysis and optimisation. However, to ensure comprehensive alignment, the selected competence frameworks must be refined, and consensus must be reached on adaptable training methods that address diverse target groups while covering a broad range of competences, including overlaps.

Outlook: The ComeThinkAgain project is currently advancing two key tasks to support the next development phases. One focus is on developing pedagogical concepts aimed at providing targeted teaching approaches for trainers and educators, ensuring alignment with the defined competences and addressing the diverse needs of educational contexts. Simultaneously, work on learning content and peer reviews continues, emphasizing gender sensitivity, equality, and inclusion. This phase will incorporate practical examples and regionally relevant case studies, leveraging existing open educational resources (OER) to enhance impact and efficiency. The content will undergo peer review within the consortium before pilot implementations take place in various partner countries starting in Autumn 2025, allowing for further refinement. Additionally, efforts are underway to develop the functional and technical specifications for the project's digital teaching platform, ensuring it aligns with educational goals and supports innovative learning experiences.

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