LET'S MIMIC: BIOMIMICRY DESIGN AS A SCALABLE MODEL FOR SUSTAINABILITY SKILLS IN VET

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Abstract

Biomimicry, namely the design innovation derived from the study of biological systems, offers an instructive model for sustainability education in Vocational Education and Training (VET). Natural organisms and ecosystems operate on renewable energy, cycle materials without generating net waste, and adapt solutions to local constraints; these operating principles translate directly into the design priorities of a green economy. This paper presents LET'S MIMIC, an Erasmus+ Cooperation Partnership across six European countries that integrates biomimicry design methodology into VET through a learning model combining Project-Based Learning (PBL), microlearning, and digital collaboration. The project addresses a structural problem: many occupational standards and working practices predate serious engagement with sustainability and continue to embed resource-intensive production methods. LET'S MIMIC responds by developing a competence framework in which learners apply six biomimicry design steps, namely Define, Biologise, Discover, Abstract, Emulate, and Evaluate, to investigate authentic sustainability challenges. The intervention develops green competences (resource efficiency, circular economy principles), digital skills (online collaboration, information handling), and transversal competences (critical thinking, teamwork, communication, self-regulation), supported by a Biomimicry Digital Learning Platform and a set of open educational resources.

Keywords: Biomimicry, innovation, sustainability, VET.

1 INTRODUCTION

Biomimicry, defined as "innovation inspired by nature", proceeds from the observation that biological evolution has produced solutions to many of the resource, transport, food, and waste challenges that human designers now face [4]. Natural systems operate on solar energy, continuously recycle materials, and adapt to local conditions over geological time; these operating principles constitute a well-grounded basis for sustainable design practice.

Biomimicry is well-suited to STEM education: it provides an integrative framework through which biology, materials science, and engineering converge on shared design problems. Rather than treating these as separate disciplines, biomimicry-based pedagogy connects scientific inquiry to practical application, supporting the development of 21st-century competencies across diverse student populations [11]. As environmental and resource constraints intensify, familiarity with nature-inspired design methodology has become increasingly relevant for VET graduates entering engineering, architecture, and production sectors.

VET graduates enter a wide range of regulated sectors in which professional standards define the expected knowledge, skills, and working methods. A significant proportion of those standards were established before sustainability became a policy priority and have not been substantially revised to reflect green economy requirements. In practice, this means that VET programmes may reproduce linear, resource-intensive occupational practices, preparing learners for roles that conflict with the sustainability transitions those same sectors are expected to undergo.

Integrating Education for Sustainable Development (ESD) into VET offers a systemic response to this misalignment. ESD programmes can reorient institutional priorities toward active capacity-building, equipping learners with the knowledge and practical competencies required for participation in the green economy [8]. This involves not only curricular revision but also changes in pedagogical approach, assessment design, and educator preparation.

Combining Biomimicry Process Design with Project-Based Learning constitutes a pedagogically coherent approach to this challenge. PBL situates learning within authentic, open-ended problems, requiring learners to apply and test knowledge rather than reproduce it. When biomimicry serves as the design methodology, the inquiry process is itself structured and scientifically grounded, providing a more rigorous framework than generic creative-thinking instruction.

VET systems are tasked with preparing individuals for both occupational practice and broader social participation, encompassing sector-specific knowledge alongside transferable competences. Among the latter, green competences have gained prominence in policy as climate commitments and the UN Sustainable Development Goals translate into labour-market requirements [9]. A green economy, as UNEP defines it, seeks to improve human well-being and social equity while reducing environmental risk and resource scarcity [10]. VET occupies a direct role in developing the workforce necessary for that transition.

Project LET'S MIMIC responds to these requirements by developing biomimicry design competencies in VET learners: the practical capacity to apply a structured, nature-inspired methodology to real sustainability challenges within their vocational fields.

This paper reports the project's methodological design, its digital platform implementation, and findings from piloting activities conducted across the six partner countries.

2 ANALYSIS OF CURRENT PRACTICES ON BUILDING SUSTAINABILITY SKILLS IN VET

LET'S MIMIC conducted a needs analysis across its six partner countries, namely Greece, Romania, Türkiye, France, Spain, and Portugal, to document the current state of sustainability and biomimicry skills development in VET. The analysis combined desk research with structured questionnaire surveys administered to 201 VET students and 126 VET teachers [1].

The research examined how sustainability competences are developed and integrated into VET curricula in each country, what national strategies and policy instruments are in place, and the extent to which biomimicry and PBL are incorporated into vocational programmes. All partner countries have national policies aligned with EU frameworks, including the European Green Deal and the European Skills Agenda, that reference green skills development. Biomimicry, as a specific design and pedagogical approach, is, however, largely absent from formal VET curricula across all six countries, notwithstanding its alignment with sustainability and green economy objectives. This absence constitutes the specific gap the project is designed to address.

Desk research identified consistent patterns across the partner countries. In Greece, VET reforms under Law 4763/2020 have introduced occupational profiles oriented toward the green economy, and the National Skills Strategy identifies sustainability competences as a development priority. Romania embeds ESD through its National Strategy for Sustainable Development 2030, with VET curricula organised across three profiles, including technical, natural resources and environmental protection, and services, though the depth of sustainability integration varies by specialisation. In Türkiye, sustainability content is present and growing in technical VET schools, but biomimicry and nature-inspired design remain absent from mainstream curricula. France and Spain integrate sustainability competences primarily through EU frameworks and national green economy strategies; French VET has an established tradition of interdisciplinary, project-oriented learning. Portugal has incorporated ESD into the National Citizenship and Development curriculum, with some VET institutions piloting project-based environmental activities. Across all six countries, the consistent finding was that, where

PBL is applied, it addresses sustainability at a general thematic level rather than through a structured, methodology-driven approach such as biomimicry [1].

The student questionnaire collected data on prior knowledge, self-assessed skills across five dimensions (creativity and innovation, problem-solving, technical drawing, scientific research, and team collaboration), motivation, and problem-solving approaches. Most respondents had limited prior exposure to biomimicry, though many had encountered sustainability topics in past activities. Areas of expressed interest included architecture, sustainable urban design, clean water systems, and environmental preservation. The teacher questionnaire assessed current curriculum practices, confidence in teaching biomimicry and PBL, and professional development requirements. Teachers rated their confidence in applying biomimicry to practical design projects as low to moderate; the most frequently identified needs were ready-to-use materials, worked case studies, and structured professional development. Survey outcomes were synthesised into a Learning Outcomes Matrix for Sustainability Skills in VET, which constitutes the competence framework on which the project's educational design is based [1].

The Learning Outcomes Matrix organises competences into three clusters. The first covers green competences: understanding of ecological systems, resource efficiency, circular-economy principles, and the capacity to evaluate design solutions against sustainability criteria. The second covers innovation and design competencies: translating biological strategies into engineering and design concepts, applying an iterative structured design process, and developing and evaluating nature-inspired solutions to open-ended problems. The third covers transversal and digital competences: critical thinking, teamwork, communication, self-regulation, and the use of digital collaboration tools. The three-cluster structure reflects the project's objective of developing both sector-relevant green competences and the broader transferable competences that support ongoing professional adaptation [5, 6].

3 METHODOLOGY

LET'S MIMIC develops a biomimicry competence framework for VET and implements it through a learning model combining PBL, microlearning, and digital collaboration. Learners apply six design steps, namely Define, Biologise, Discover, Abstract, Emulate, and Evaluate, to authentic sustainability challenges, developing green competences (resource efficiency, circular economy principles), digital skills (online collaboration, information handling, resource evaluation), and transversal competences (critical thinking, teamwork, communication, self-regulation). Educator capacity is supported through facilitation guidance, inclusive learning design principles, and structured assessment frameworks.

The six steps of the LET'S MIMIC Biomimicry Design Process give the framework its structure. In **Step 1 - Define**, learners identify and articulate a sustainability challenge as a design question, establishing context and constraints. **Step 2 - Biologise** translates that challenge into a biological question, shifting the frame of reference to natural systems. **Step 3 - Discover** involves researching organisms and ecosystems that have already solved the equivalent challenge through evolution. **Step 4 - Abstract** extracts the underlying principles and mechanisms from the natural model, separating biological form from functional strategy. **Step 5 - Emulate** applies those abstracted principles to develop a human design concept. **Step 6 - Evaluate** assesses the solution against sustainability criteria and Life's Principles. The process is iterative; in the platform, each step has a distinct colour code, embedded guidance notes, a worked real-world example, and assessment tasks that structure learner progression [1].

The combination of biomimicry with PBL is pedagogically grounded. Research indicates that learners engaged with authentic, open-ended problems develop stronger conceptual understanding and collaboration competencies than those receiving direct instruction alone [2]. By anchoring PBL projects in real sustainability challenges and employing biomimicry as the design methodology, LET'S MIMIC provides both the inquiry structure and the scientific knowledge base that rigorous project-based work requires. The LET'S MIMIC Matrix maps each biomimicry step to corresponding PBL phases, maintaining structure without constraining the open-ended character of design inquiry. The Learning Outcomes Matrix, derived from the needs analysis, informed the design of learning resources, assessment criteria, and the platform's feedback mechanisms, ensuring alignment among learning objectives, instructional activities, and evaluation.

Microlearning constitutes the third pedagogical pillar of the LET'S MIMIC learning model, complementing the extended inquiry structure of PBL with a delivery format suited to the time constraints

and heterogeneous prior knowledge characteristic of VET contexts. Microlearning disaggregates instructional content into short, self-contained units each targeting a single, well-defined learning objective [12]. This granularity serves two functions within the LET'S MIMIC framework. First, it maps directly onto the biomimicry pipeline: each of the six design steps is supported by dedicated microlearning resources, informational units, worked examples, and formative assessment tasks that learners can access at the point of need within a design activity rather than in a separate instructional session. Second, it enables self-regulated learning: because units are short, tagged, and independently accessible, learners can select and sequence content according to their current understanding and design requirements, constructing personalised learning paths without dependence on synchronous instruction. Research on microlearning in professional and vocational contexts indicates that the format supports knowledge retention through repeated, spaced engagement and reduces cognitive load by limiting the scope of each learning event [12]. Within LET'S MIMIC, these properties are operationalised through digital activities that provide both teacher-directed and learner-initiated access to microlearning content across all six biomimicry steps.

4 IMPLEMENTATION

4.1 The LET's MIMIC Biomimicry Digital Learning Platform

LET'S MIMIC developed a Biomimicry Digital Learning Platform [7] to support team-based and self-directed work on biomimicry design challenges. The platform structures each phase of the six-step process and delivers content through short learning units suitable for both class-based and independent study.

The platform comprises five integrated modules [3]. The **Microlearning module** provides short content units organised by biomimicry step and subject domain, available through a public Repository searchable by title and tag. The **Self-Regulated Learning module** allows students to mark Repository content as favourites, assembling a personalised Micro Lessons collection through which they progress at their own pace; Self-Regulated Learning Paths (SRL-P) are constructed around individual learning goals and self-assessment. The **Teamwork module** (My Classes) provides collaborative workspaces where teachers assign collections, and students form teams to work through the biomimicry pipeline. An interactive Canvas tool allows teams to post text, images, and videos to a shared whiteboard and visually link ideas. Within collaborative workspaces, students apply the six design steps in sequence, contributing to and developing collective solutions through shared digital tools. The **Gamification module** awards experience points (XP) for platform activity and unlocks rewards at defined thresholds. The **Assessment module** provides progress dashboards for both students and educators to support formative monitoring and feedback.

The platform supports seven languages: English, Greek, Romanian, Turkish, French, Spanish, and Portuguese. Teachers and students use role-specific accounts; teacher accounts include a private workspace for preparing and managing collections prior to publication. Classes are created with a shareable enrolment code; teachers assign collections and configure team structures as required. H5P integration embeds interactive, quiz-based assessment directly within the biomimicry pipeline, enabling formative evaluation at each step without requiring users to navigate away from the learning environment. The platform is freely accessible to VET institutions within and beyond the project partnership.

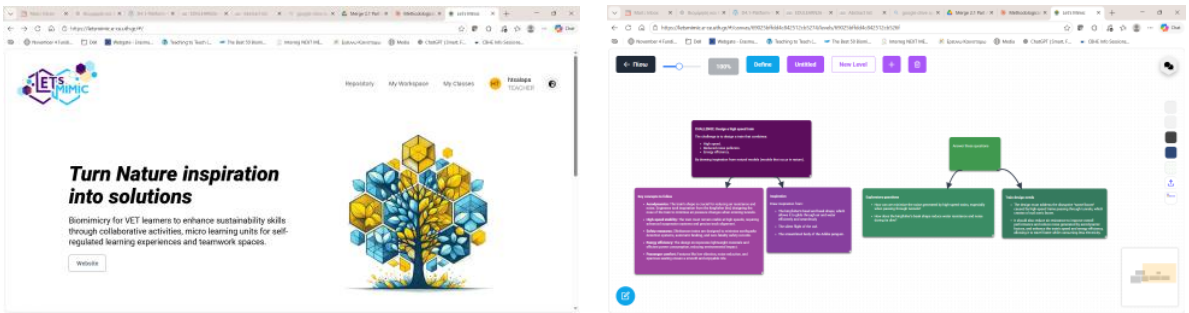


Figure 1. The LET's MIMIC Biomimicry Learning Platform.

4.2 LET's MIMIC resources

LET'S MIMIC produced a set of open learning resources for direct use in educational practice. The Self-Regulated Learning Kit contains 60 sustainability challenges paired with 60 biomimicry-based reference solutions, and 60 open-ended sustainability cases for learner investigation. Seven Training Modules provide structured guidance for applying the biomimicry design steps to open challenges and developing nature-inspired solutions. All resources are available on the platform as interactive digital content and in printed form. Worked examples include passive building cooling derived from termite mound ventilation, high-speed train nose design derived from the kingfisher's beak, and water collection systems derived from the Namib desert beetle's surface microstructure.

5 RESULTS

The LET'S MIMIC framework, platform, and resources were piloted across all six partner countries. VET educators integrated the biomimicry methodology and digital platform into classroom practice; learners worked individually and in teams on sustainability challenges using the six-step process. Direct evaluation engaged over 300 students and educators; multiplier events in secondary schools and higher education institutions significantly extended the overall reach.

Learners engaged actively with the Repository, Micro Lessons, and My Classes modules. The self-regulated learning pathway allowed students to assemble personalised collections of microlearning resources aligned with their interests and the relevant biomimicry steps. In collaborative class settings, the Canvas workspace served as a shared design environment where students posted text, images, and videos, linked ideas visually, and developed collective responses to design challenges. The gamification mechanism, including experience points, a progress bar, and unlockable rewards, supported sustained engagement across extended activity sessions.

Educator feedback indicated that the structured pipeline, including colour-coded steps, embedded guidance, and worked examples, reduced the facilitation burden and improved learner orientation within activities. The seven-language interface removed localisation barriers, allowing deployment across all partner countries without adaptation costs. Evaluation data collection is ongoing, drawing on learner progress metrics, educator assessments, and platform analytics to inform quality assurance and iterative resource development.

Quality assurance across all outcomes employed SWOT analyses of implementation progress, partnership and communication quality reports, and work package completion reviews [1]. Key implementation findings included the importance of aligning challenge content with specific VET sector profiles and the need for dedicated educator preparation time prior to piloting sessions. Multiplier events in all six partner countries extended engagement to secondary schools, VET institutions, and community organisations, generating feedback that informed ongoing resource revision. A presentation to the Soroptimist Society of Volos in March 2026 also indicated interest in biomimicry design thinking among audiences outside formal VET.

6 CONCLUSIONS

LET'S MIMIC demonstrates that biomimicry design methodology is a viable basis for sustainability skills development in VET. Embedding a structured six-step inquiry process within project-based learning develops green competences, digital skills, and transversal competences through a single set of learning activities, addressing the breadth of demands associated with participation in the green economy. The approach also provides educators with a structured methodology that lowers the threshold for specialist knowledge required for sustainability-focused teaching.

The Biomimicry Digital Learning Platform delivers the methodology through five modules for microlearning, self-regulated learning, teamwork, gamification, and assessment, supporting both independent and collaborative modes of work. Personalised learning paths accommodate variation in learner pace and background knowledge. The platform's open-access, multi-language design allows adoption by VET institutions outside the project partnership without localisation investment.

The needs analysis confirmed that biomimicry-based sustainability education is largely absent from VET curricula across the six partner countries, despite clear policy impetus in that direction. The project has produced a competence framework, 60 challenge-and-solution pairs, seven training modules, an educator handbook, and a digital platform to address this gap. Piloting results indicate strong learner

engagement and positive educator response, with the structured pipeline and collaborative Canvas workspace identified as particularly effective features in VET delivery contexts. Future work will concentrate on strengthening the assessment evidence base, expanding the challenge-and-solution library, and establishing pathways for sustained platform use and resource dissemination beyond the Erasmus+ funding period.

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