



Biomimicry Design for Sustainability Skills in VET

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D3.3 Handbook for Teacher's Use



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1. Introduction

Biomimicry, or “nature-inspired innovation,” is rooted in the idea that nature has already developed solutions to many human challenges, including energy, transportation, and waste management (Benyus, 2014). By following nature’s core principles—such as renewable energy use, efficient resource management, and recycling—biomimicry plays a crucial role in promoting sustainability. Emphasizing interdisciplinary collaboration, biomimicry contributes to 21st-century sustainable design. It also complements STEM education by providing opportunities to teach STEM subjects and environmental sciences while fostering creativity and problem-solving skills (Biomimicry Institute, 2017). As the world confronts increasing environmental and societal challenges, biomimicry enables designers and engineers to develop efficient, sustainable, and resilient solutions. Integrating biomimicry into education helps cultivate environmentally conscious students while strengthening their appreciation for nature’s wisdom.

Project LET’s MIMIC introduces an innovative learning framework that integrates biomimicry with problem-based learning to build innovation and sustainability skills in VET students and beyond.

The project develops digital learning services for student collaboration in biomimicry activities. It further develops digital learning content for students structured on biomimicry steps, such as define, biologize, discover, abstract, emulate, and evaluate. In addition, the project builds educators' capacity to design biomimicry learning activities and introduce them into the classroom. To this end, LET’s MIMIC develops educator support content.

This document constitutes a handbook that supports VET educators in designing and delivering biomimicry learning activities in the classroom. The document presents a methodological learning design that integrates biomimicry with problem-based learning and other active learning methodologies, such as experiential and inquiry-based. It presents steps for educators to design,



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deliver, and evaluate the positive impact of biomimicry activities on students. Finally, the document presents biomimicry learning resources and tools, including external services and networks and the LET's MIMIC self-regulated learning kit, training modules, and digital learning platform.



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2. Objectives of the handbook

The primary aim of this handbook is to provide VET teachers with the tools and resources needed to incorporate biomimicry into their teaching practices. The objectives are as follows:

- **Introduce biomimicry concepts:** Explain biomimicry and its application in various contexts.
- **Offer practical teaching strategies:** Equip teachers with practical methodologies, including problem-based learning (PBL) approaches, to integrate biomimicry into their lessons.
- **Develop critical competencies:** Focus on developing learners' critical thinking, creativity, and problem-solving skills through biomimicry-inspired projects.
- **Promote sustainability:** Encourage adopting sustainable practices in VET education by emphasising nature-inspired solutions.
- **Facilitate collaboration:** Support collaborative learning and interdisciplinary approaches, fostering teamwork and innovation.

Through this handbook, VET teachers will gain the knowledge and confidence to guide their students in exploring biomimicry and applying it to real-world challenges, preparing them for careers prioritising sustainability and innovation.



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3. Introduction to biomimicry

Biomimicry, a term derived from the Greek words “bios” (life) and “mimesis” (imitation), refers to the practice of learning from and emulating nature’s designs, systems, and processes to solve human challenges. By observing how organisms adapt to their environments and perform essential functions, innovators can create sustainable, efficient, and resilient solutions across various disciplines. Biomimicry offers a paradigm shift in design thinking, emphasising sustainability and harmony with the natural world.

In this part, we will explore the foundational concepts of biomimicry, its relevance in vocational education and training (VET), and the goals of this handbook in promoting biomimicry as a teaching and learning tool.

3.1 What is biomimicry?

Biomimicry is the practice of drawing inspiration from nature to develop solutions to human challenges. It involves understanding the strategies living organisms use to thrive and applying them in various fields such as engineering, architecture, product design, and resource management (Benyus, 1997).

Nature has evolved over billions of years, resulting in highly efficient, adaptable, and sustainable solutions. For instance:

- **The design of Velcro®** was inspired by the way burrs stick to animal fur through tiny hooks.
- **Energy-efficient buildings** often mimic termite mounds, maintaining a stable internal temperature.
- **Wind turbines** have been designed based on the shape of humpback whale fins for improved efficiency.



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Biomimicry is not just about copying nature but understanding the underlying principles and applying them to human challenges in a way that aligns with sustainability and ethical practices.

3.2 Importance of biomimicry in VET education

Vocational education and training (VET) is focused on equipping learners with practical skills that can be applied in the workforce. Integrating biomimicry into VET education offers several key benefits (Oguntona and Aigbavboa, 2023):

- **Innovative problem-solving skills:** Biomimicry encourages learners to think critically and creatively by observing and learning from nature. This can lead to innovative solutions that are both effective and sustainable.
- **Sustainability focus:** In a world facing environmental challenges, teaching learners to design solutions that align with ecological principles is essential. Biomimicry fosters a mindset that values resource efficiency, waste reduction, and harmony with nature.
- **Interdisciplinary learning:** Biomimicry bridges disciplines such as biology, design, engineering, and environmental science. VET learners can develop a broad skill set that prepares them for diverse career paths.
- **Engagement and motivation:** Learning from nature can spark curiosity and enthusiasm, making education more engaging and relevant to real-world challenges.



Figure 1. Inspiration by nature to solve today's complex sustainability challenges.



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By incorporating biomimicry, VET education can produce skilled professionals who are job-ready and capable of contributing to sustainable innovation in their industries.

3.3 Biomimicry in practice

In this section, we explore how the principles of biomimicry are applied in real-world contexts. From understanding the core principles that guide biomimetic design to examining case studies across various industries, this part highlights how nature's ingenuity can inspire innovative and sustainable solutions. We will also delve into the challenges faced when applying biomimicry and how nature-inspired strategies can overcome them.

3.3.1 Key principles of biomimicry

Biomimicry is guided by core principles that help designers and innovators harness nature's wisdom. These principles ensure innovative solutions are sustainable and aligned with ecological systems (Benyus, 1997; Vincent et al., 2006). The following are some of the key tenets of biomimicry:

- **Emulate nature's forms, processes, and systems:** Biomimicry involves observing and imitating nature's shapes, materials, and methods to create functional and efficient solutions. For example, a kingfisher's streamlined body inspired the design of high-speed trains (Benyus, 1997; Bhushan, 2009).
- **Adapt to local conditions:** Just as organisms evolve to thrive in their specific environments, biomimicry creates solutions that fit local conditions and resources (El-Zeiny, 2012).
- **Use life-friendly chemistry:** Nature's processes rely on non-toxic, renewable resources. Biomimicry promotes using environmentally friendly materials and manufacturing methods (Kennedy et al., 2015).



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- **Optimize rather than maximise:** Nature's solutions are efficient, using only what is needed. This principle encourages minimising resource use while maximising performance (Vincent et al., 2006).
- **Evolve to survive:** Nature constantly evolves through adaptation and resilience. Biomimetic solutions should be flexible and capable of evolving to meet changing conditions (Benyus, 1997; Pawlyn, 2011).
- **Integrate development with growth:** In nature, systems grow in harmony with their surroundings, balancing individual needs with the ecosystem's health (Benyus, 1997).

By adhering to these principles, biomimicry fosters sustainable innovation that addresses human needs and respects ecological limits.

3.3.2 Case studies and examples in various fields

Biomimicry has been applied across various industries, from architecture and design to technology and healthcare. Below are some notable examples of biomimicry in practice:

- **Architecture and construction:**
 - The **Eastgate Centre** in Zimbabwe is a building mimicking termite mounds' natural ventilation systems to maintain a stable internal temperature and reduce energy consumption.
 - The **Eden Project** in the UK features biomes inspired by the structure of soap bubbles, optimizing space and strength.
- **Engineering and technology:**
 - **Velcro®** was invented after a Swiss engineer noticed how burrs stuck to his dog's fur. The hook-and-loop design became a revolutionary fastening system.
 - The **Shinkansen Bullet Train** in Japan was redesigned to reduce noise and improve efficiency. Its beak mimics a kingfisher's, allowing it to move smoothly through the air.



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- **Healthcare and medicine:**
 - The **gecko's adhesive feet** inspired the development of new medical adhesives and bandages that stick without causing damage to the skin.
 - **Shark skin patterns** have influenced the design of anti-bacterial surfaces, reducing the spread of infections in hospitals.
- **Energy and resource management:**
 - **Solar panels** inspired by the sunflower's ability to track the sun maximize energy capture throughout the day.
 - **Wind turbines** have been enhanced by mimicking the serrated edges of humpback whale fins, improving efficiency and reducing noise.

These examples demonstrate how biomimicry can lead to innovative, sustainable solutions that address complex human challenges.

3.3.3 Challenges and solutions inspired by nature

While biomimicry offers immense potential, its application is not without challenges. Understanding these challenges and drawing inspiration from nature to overcome them is a key aspect of biomimetic design (Oguntona and Aigbavboa, 2023).



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Figure 2. Examples of biomimicry activities across the world.

Challenges in applying biomimicry:

- **Complexity of natural systems:** Nature's solutions are often intricate and require a deep understanding of biological processes. Translating these into human designs can be difficult.
- **Cost and feasibility:** Biomimetic designs may involve specialized materials or processes that are initially costly or difficult to scale.
- **Interdisciplinary collaboration:** Biomimicry often requires collaboration between biologists, engineers, designers, and other specialists, which can be challenging to coordinate.
- **Regulatory and market barriers:** New, innovative products may face hurdles in gaining regulatory approval or market acceptance.

Biomimicry itself is a source of inspiration for addressing the above challenges. Some examples of nature-inspired solutions to applying biomimicry for innovation include:

- **Adaptive designs:** Nature teaches us to adapt to changing environments. Products that are flexible and can evolve are more likely to succeed.
- **Efficiency and resource use:** Biomimetic solutions can reduce costs and environmental impact by optimising resource use, as seen in nature.



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- **Collaboration models:** Nature operates in ecosystems where different species collaborate. Similarly, interdisciplinary teamwork can be fostered through shared goals and mutual benefits.
- **Resilience and redundancy:** Natural systems often have built-in redundancy to ensure resilience. Biomimetic designs can incorporate similar features to improve durability and reliability.

By understanding these challenges and applying nature's strategies, biomimicry can overcome obstacles and deliver innovative, efficient, and sustainable solutions.



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4. Learning methodologies and frameworks

This section delves into the role of innovative learning methodologies in vocational education and training (VET) and how they align with biomimicry. A particular focus is on PBL, a student-centred approach that encourages active problem-solving and discovery. Integrating biomimicry into PBL empowers learners to approach challenges creatively, inspired by nature’s strategies.

4.1 PBL and biomimicry

4.1.1 Comparing PBL and biomimicry

In the context of this project, the integration of PBL and biomimicry process design is structured through a **Learning Outcomes Matrix** (LET’s MIMIC project Deliverable 2.1 PART A – Learning Outcomes Matrix for Sustainability Skills, 2025), which establishes clear correspondences between the steps of **PBL** and those of **biomimicry**. This matrix provides a framework to facilitate the incorporation of biomimicry into PBL-based learning activities and supports educators in effectively making this connection. Both PBL and biomimicry are iterative processes. Project LET’s MIMIC introduces a methodology for integrating biomimicry processes into broader PBL activities (LET’s MIMIC technical report D2.1 PART B – Project-Based Learning Framework for Biomimicry Process Design, 2025). The iterative nature of both methods is reflected in the following key steps:

PBL Steps	Biomimicry Process Design Steps
Define: Identify the problem and establish criteria for success.	Define: Clearly articulate the impact the design should have and define the challenge.



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Biologize: Understand the problem in biological terms.	Biologize: Analyse the essential functions and context of the challenge in nature.
Discover: Research natural models that address the same functions.	Discover: Identify biological strategies and patterns that solve similar challenges.
Abstract: Extract key biological principles and restate them in non-biological terms.	Abstract: Study the essential features or mechanisms behind biological strategies and translate them into design strategies.
Emulate: Develop solutions inspired by natural strategies.	Emulate: Apply biomimicry principles to generate innovative solutions.
Evaluate: Test and refine solutions based on feasibility and impact.	Evaluate: Assess how well the biomimetic design meets sustainability criteria and constraints.

Table 1. Aligning PBL and biomimicry processes (LET's MIMIC technical report D2.1 PART B - Biomimicry Process Design for Sustainability Skills, 2025).

This matrix guides educators and learners, ensuring that biomimicry principles are seamlessly integrated into **PBL-based** activities. By leveraging existing competencies in PBL, educators can facilitate the structured adoption of biomimicry as a design framework, enhancing the application of nature-inspired solutions in vocational education and training (VET).

This integrated approach mirrors workplace dynamics in VET settings, preparing students to address complex, multifaceted challenges relevant to their professional development.



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4.1.2 Integrating biomimicry into PBL

Integrating biomimicry into PBL enhances problem-solving by encouraging learners to draw inspiration from natural systems. Biomimicry emphasises learning from nature’s time-tested strategies to address human challenges sustainably and efficiently.

The following are strategies for integration of biomimicry into PBL (LET’s MIMIC technical report D2.1 PART B – Project-Based Learning Framework for Biomimicry Process Design, 2025):

- **Nature-Inspired problem statements:** Design problem scenarios that explicitly encourage students to seek solutions inspired by biological processes or organisms. For example, energy efficiency, water conservation, or structural design challenges can be framed in biomimetic terms.
- **Biological exploration:** Facilitate opportunities for students to explore and study natural environments, either physically or through virtual resources, to observe patterns, structures, and functions in nature.
- **Interdisciplinary collaboration:** Encourage cross-disciplinary collaboration involving insights from biology, engineering, design, and sustainability. This mirrors the real-world application of biomimicry, which often requires diverse expertise.
- **Prototype development:** Guide students in developing and testing prototypes of their biomimetic solutions, fostering iterative learning and innovation.
- **Reflection on sustainability:** Emphasize the importance of sustainable solutions, drawing parallels between natural efficiency and human design challenges.

Biomimicry in PBL fosters creativity and instils a mindset focused on sustainability and innovation, aligning with global goals for environmental stewardship.



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4.1.3 Facilitating collaborative learning

Collaboration is critical in biomimicry projects, mirroring the interdisciplinary approach to solving complex problems.

The following are strategies for encouraging student collaboration in biomimicry projects (Hmello, 2004):

- **Team-based projects:** Assign students to diverse teams to work on biomimicry challenges, encouraging them to share knowledge and perspectives.
- **Role-playing exercises:** Students can assume the roles of designers, engineers, or biologists in simulated problem-solving scenarios.
- **Peer feedback:** Students can review and provide feedback on each other's work, fostering a collaborative and supportive learning environment.
- **Cross-disciplinary collaboration:** Encourage partnerships between students from different fields, such as biology, engineering, and art, to develop innovative solutions.
- **Online discussion forums:** Use forums to facilitate ongoing discussions, idea sharing, and peer support.
- **Mentorship opportunities:** Engage experts and professionals in biomimicry to mentor students and provide real-world insights.

4.2 LET's MIMIC practical biomimicry learning framework

This section provides a structured approach to implementing biomimicry in vocational education and training (VET). It focuses on identifying key learning outcomes and competencies, designing engaging learning activities, and developing effective assessment strategies aligned with biomimicry principles.



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4.2.1 Learning outcomes and competencies

To effectively integrate biomimicry into the curriculum, it is essential to define clear learning outcomes and competencies. These outcomes should encompass technical and transferable skills that learners will develop through biomimicry-based education.

Biomimicry in PBL contributes to developing sustainability knowledge, skills, and competencies highly valued by industry and society. It helps develop (Mejia-Villa et al., 2023):

- **Knowledge:** Understanding key concepts, principles, and theories related to sustainability in vocational education and training (VET), informed by desk research and questionnaire findings.
- **Skills:** Developing practical abilities through hands-on learning experiences that apply sustainability principles effectively in VET contexts.
- **Competencies:** Acquiring critical thinking, problem-solving, and decision-making skills for integrating sustainability into vocational education curricula.
- **Soft skills:** Biomimicry also fosters the development of soft green skills, which are highly appreciated in the job market. These include:
 - **Creativity and innovation:** Recognizing the importance of creativity and innovation in personal and professional life, generating original ideas, and applying imaginative approaches to challenges.
 - **Problem-solving:** Developing a structured problem-solving mindset by breaking down complex situations, identifying root causes, and applying logical reasoning to find effective resolutions.
 - **Team Collaboration:** Recognizing the value of teamwork in achieving common goals, developing collaboration strategies, and employing communication techniques to work effectively within a team.



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- **Curiosity and inspiration:** Biomimicry encourages students to explore real-world problems by mimicking nature’s designs and processes, making learning more engaging.
- **Critical thinking and systems thinking:** Encouraging students to analyse how natural systems function and apply these principles to innovative problem-solving.
- **Contextual learning:** Integrating biology, engineering, design, and environmental science to foster interdisciplinary learning experiences.
- **Environmental consciousness and ethical thinking:** Encouraging appreciation for sustainability, ethical considerations, and long-term impacts of design solutions.
- **Design thinking:** Promoting creativity and iterative development processes through biomimicry-based problem-solving.
- **Communication:** Enhancing the ability to present complex ideas effectively through PBL.
- **Resilience and Adaptability:** Learning from nature’s adaptability fosters resilience and persistence in overcoming challenges.
- **Technical skills:** Biomimicry supports the development of core technical skills, including:
 - **Scientific research:** Understanding fundamental research methodologies and developing the ability to investigate natural or social phenomena.
 - **Technical drawing:** Learning the core principles and applications of technical drawing to visually communicate functions and constructions accurately.
- **Sustainability skills:** Biomimicry helps students adopt sustainable habits and behaviours by:
 - **Awareness raising:** Defining sustainability and its key aspects.
 - **Applying sustainability in different contexts:** Comparing and selecting sustainable activities based on specific contexts and across multiple sectors.
 - **Interdisciplinary learning:** Developing interdisciplinary approaches to sustainability.



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- **Communication:** Selecting practical communication tools and outreach methods for promoting sustainability.
- **Active engagement:** Encouraging sustainable choices through education, awareness, and strategic communication.
- **Civic sensibility:** Biomimicry also strengthens civic responsibility by:
 - **Democracy skills:** Understanding democratic principles and the rights and responsibilities of citizens.
 - **Civic engagement:** Applying civic engagement principles to everyday life.
 - **Community impact:** Analysing social, political, and environmental issues impacting communities.
 - **Policy understanding:** Evaluating civic policies considering multiple perspectives and social implications.
 - **Inclusivity:** Cultivating inclusivity and participation in civic life.
 - **Communication in civic engagement:** Developing effective communication techniques for civic engagement and advocacy.
- **Biomimicry-specific skills:** Students engaging in biomimicry-based education will develop specialised competencies such as:
 - **Understanding biological systems:** Understanding biomimicry processes and models.
 - **Understanding core biomimicry principles:** Explaining the core principles of biomimicry and how natural processes inspire human innovations.
 - **Transferring knowledge to the real world:** Applying biomimicry principles to real-world problems and analysing case studies.
 - **Evaluating existing biomimicry solutions:** Identifying strengths, weaknesses, and opportunities for improvement.
 - **Understanding ethical aspects:** Investigating ethical and sustainability considerations in biomimicry applications.



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Integrating these technical, sustainability, civic, and biomimicry-specific skills into the curriculum will give students a well-rounded education that prepares them for the workforce's and society's evolving demands.

4.2.2 LET's MIMIC application of innovative pedagogical approaches

The LET's MIMIC approach to integrating PBL and biomimicry applies **constructivist** and **social learning** theories, allowing students to learn actively through real-world problem-solving. Constructivism is a pedagogical theory that advocates that knowledge is synthesised and not transferred (Papert, 1993). Constructivism is based on the principle that students learn better through active approaches, experimentation, and exploration. LET's MIMIC takes this educational approach a step further, implementing active learning through **biomimicry process design** inspired by nature to address the complex challenges of the modern world.

Other pedagogical approaches integrated into the LET's MIMIC pedagogical design include:

- **Gamification:** Game elements are used in contexts other than entertainment and in learning to promote long-term engagement (Deterding et al., 2011).
- **Microlearning:** Bite-sized learning activities that scaffold student knowledge (Hug, 2005; Buchem et al. 2010).
- **Experiential learning:** Student engagement through direct experiences, such as nature walks or site visits, can help observe biological systems in action. Hands-on projects allow students to apply their learning to real-world challenges following the experiential learning paradigm (Kolb, 1984).
- **Design thinking:** This innovation-building process encourages students to empathise with user needs, define problems, brainstorm solutions, and create prototypes. Design thinking aligns well with biomimicry's problem-solving approach (Brown, 2009).



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- **Inquiry-based learning:** Students explore questions and conduct investigations to find solutions inspired by nature. This method fosters curiosity and independent learning (Pedaste et al., 2015).
- **Project-based learning:** Students work on long-term projects that address real-world problems, integrating biomimicry principles into their solutions (Blumenfeld et al., 1991; Thomas, 2000).
- **Flipped classroom:** By reviewing materials, such as videos and readings, before class, students can use in-class time for discussions, hands-on activities, and deeper exploration of biomimicry concepts (Bergman and Sams, 2012; Bishop and Verleger, 2013).

This integrated learning framework supports the development of self-regulation skills among students, such as:

- Goal setting.
- Internal motivation.
- Self-monitoring.
- Self-instruction.
- Self-reinforcement.

Teachers can apply the LET's MIMIC learning framework to develop active, personalised, and collaborative learning paths, enhancing student engagement and educational outcomes.

4.2.3 Designing learning activities with biomimicry

Practical learning activities are essential for engaging students and fostering a deep understanding of biomimicry concepts. These activities should encourage exploration, creativity, and hands-on application.

Types of learning activities:



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- **Case study analyses:** Present learners with case studies of successful biomimetic innovations, prompting them to analyse the biological inspiration, design process, and outcomes.
- **Field exploration:** Organize visits to natural environments where students can observe and document biological structures and systems.
- **Design challenges:** Assign open-ended design challenges where students must develop a solution to a real-world problem using biomimicry principles.
- **Prototyping workshops:** Conduct workshops where students can create physical or digital prototypes of their biomimetic designs.
- **Collaborative projects:** Encourage teamwork through group projects that require interdisciplinary collaboration and collective problem-solving.
- **Reflection and journaling:** Integrate reflective activities where students document their learning journey, insights from nature, and personal growth.

Following is an example of a learning activity developed through biomimicry-based educational approaches:

Title: Nature-inspired water filtration design.

Objective: Design a water filtration system inspired by natural processes (e.g., mangroves, coral reefs).

Steps:

- Research how plants and ecosystems naturally filter water.
- Develop a conceptual design based on observed biological principles.
- Create a prototype and test its effectiveness.
- Present findings and reflect on the sustainability of the solution.



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4.3.4 Assessment strategies

Assessment in biomimicry-based learning should be holistic, evaluating the final product, the process, and key competencies developed. A combination of formative and summative assessments ensures a comprehensive evaluation of student learning.

Assessment methods may include:

- **Rubrics:** Develop detailed rubrics that assess creativity, problem-solving, teamwork, sustainability considerations, and technical accuracy.
- **Portfolios:** Encourage students to compile a portfolio documenting their research, design process, prototypes, and reflections.
- **Presentations:** Assess students through oral presentations where they explain their biomimetic solutions and justify their design choices.
- **Peer review:** Incorporate peer assessment to foster collaborative learning and provide diverse feedback.
- **Self-assessment:** Allow students to reflect on their performance and learning progress through self-assessment tools.
- **Prototype testing and evaluation:** Evaluate the functionality, feasibility, and sustainability of prototypes developed by students.

The above can be applied in formative or summative assessment contexts, analysed below:

- **Formative assessment:** Provide ongoing feedback through checkpoints, discussions, and draft reviews. This approach allows continuous improvement, enabling students to refine their work based on constructive feedback. By emphasising the learning process rather than solely the outcome, formative assessment fosters more profound understanding and skill development.
- **Summative assessments:** Conduct final evaluations based on the completed project, presentation, and overall portfolio.



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Given the emphasis on iterative learning and skill-building in biomimicry education, formative assessments are the preferred approach. This method ensures students receive timely feedback, encouraging reflection, adaptation, and continuous progress throughout the learning journey.

Formative assessment can be supported by digital tools to make feedback interactive and engaging, such as the following:

- **Kahoot®**: Used for quick quizzes to check students' understanding of biomimicry concepts.
- **Mentimeter®**: Used for live polls or word clouds to gather insights on students' learning progress.
- **Padlet®**: Allows students to document and reflect on their ideas collaboratively.
- **Google® Docs** and **Jamboard®**: They facilitate peer reviews and collaborative brainstorming.
- **Flip®** (formerly Flipgrid): Used to encourage students to submit short video reflections on their learning process.



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5. LET's MIMIC approach for designing biomimicry projects for students

This section focuses on the practical steps in developing biomimicry projects, from identifying challenges to generating innovative solutions inspired by nature. It also emphasises the importance of case study development and documentation to enhance learning and knowledge sharing.

5.1 Identifying challenges and problem statements

A well-defined challenge or problem statement is the foundation of any successful biomimicry project. Identifying the proper challenge ensures students can effectively apply biomimicry principles to develop innovative solutions.

Steps for identifying challenges include:

- **Observe and explore:** Encourage students to explore their surroundings and observe areas where human-made systems could be improved through nature-inspired solutions.
- **Engage with stakeholders:** Involve community members, industry experts, or other stakeholders to identify real-world challenges that need solutions.
- **Focus on sustainability:** Prioritize challenges that have environmental, social, or economic impacts and require sustainable solutions.
- **Frame the problem statement:** Guide students in framing clear, concise problem statements that define the issue and set the context for biomimicry-based solutions. For example, “How can we design energy-efficient buildings that regulate temperature naturally, inspired by biological systems such as termite mounds?”



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5.2 Generating biomimicry-inspired solutions

Once a challenge is identified, the next step is to generate solutions inspired by nature. This process involves research, ideation, and application of biomimicry principles (Deldin and Schuknecht, 2014).

Steps for generating a solution include:

- **Research biological models:** Students should research how nature addresses similar challenges. For example, studying how leaves optimise light capture for solar panel design.
- **Brainstorm and ideate:** Facilitate brainstorming sessions where students propose multiple solutions based on their biological research.
- **Select and refine:** Provide students with iterative feedback to help them select the most feasible and impactful solution and refine their ideas.
- **Prototype and test:** Encourage students to build prototypes, test their solutions, and adjust based on performance and feedback. During prototyping, students can draw inspiration from examples in nature, such as:
 - **Velcro®:** Inspired by burr seeds that stick to animal fur.
 - **Self-cleaning surfaces:** Inspired by the lotus leaf, which repels water and dirt.
 - **Energy-efficient ventilation:** Inspired by termite mounds that regulate internal temperature.

5.3 Developing and documenting case studies

Documenting biomimicry projects as case studies is crucial for learning, reflection, and sharing knowledge with a broader audience. A well-documented case study highlights the entire process, from problem identification to solution implementation and results (Pawlin, 2011).

Key elements of a biomimicry case study include:



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- **Introduction and background:** Provide context for the project, including the identified challenge and its significance.
- **Biological inspiration:** Describe the natural systems or organisms that inspired the solution, detailing their relevant characteristics and functions.
- **Design and development process:** Outline the steps to develop the solution, including research, ideation, prototyping, and testing.
- **Results and Impact:** Present the project's outcomes, including the solution's effectiveness and potential impact.
- **Reflections and Learnings:** Reflect on the successes, challenges, and lessons learned throughout the project.
- **Visual Documentation:** Include images, sketches, diagrams, and prototypes to illustrate the project's progression.

Following is an example of a case study developed through biomimicry-based educational approaches:

Title: Nature-inspired water collection system.

Objective: Design a water collection system for arid regions.

Biological inspiration: Study of the Namib Desert beetle, which collects water from fog using its textured shell.

Solution: A fog-harvesting device with a surface mimicking the beetle's shell, optimizing water capture efficiency.

Results: Increased water collection rates in field tests compared to traditional methods.

- **Reflections:** Insights on improving design scalability and exploring additional biological models for enhancement.



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6. Supporting pedagogical resources and tools

Effective teaching in biomimicry requires leveraging innovative methods, digital tools, and strategies that encourage collaborative learning. This section provides educators with practical approaches and resources to enhance student engagement and learning outcomes.

6.1 Mainstream digital resources and tools

Digital tools enhance biomimicry education by providing access to resources, facilitating collaboration, and supporting creative projects.

Essential tools and resources include:

- **Learning management systems (LMS):** Platforms like Google Classroom or Moodle help organise course content, assignments, and discussions.
- **Biomimicry-specific resources:** Websites like AskNature.org offer a database of biological strategies and solutions that can inspire students.
- **3D modelling software:** Tools like Tinkercad® or SketchUp® allow students to create digital prototypes of biomimicry-inspired designs.
- **Collaborative platforms:** Tools like Miro®, Trello®, and Padlet® enable brainstorming, project tracking, and idea sharing.
- **Video and multimedia:** Videos from platforms like YouTube® or TED Talks® can provide visual explanations and real-world examples of biomimicry.

6.2 Biomimicry external databases and networks

Biomimicry is a global movement with numerous resources available for further exploration. The following databases and networks are valuable tools for accessing biomimicry case studies, connecting with experts, and discovering innovations inspired by nature.

Key external biomimicry resources include:



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- **AskNature:** An extensive online resource created by the Biomimicry Institute. It offers a vast database of biological strategies innovators have translated into solutions for design challenges. Teachers and students can search for nature-inspired innovations based on energy, transportation, water, and more themes.
Website: www.asknature.org
- **Biomimicry Global Network:** A network that connects practitioners, educators, and students to exchange ideas and knowledge and collaborate on projects. This network enables people to learn from others and grow the movement globally.
Website: www.biomimicry.org
- **Bioneers Network:** A network promoting the power of nature-based solutions, Bioneers brings together individuals and organisations working at the intersection of ecological and social change.
Website: www.bioneers.org
- **Local biodiversity and ecosystem databases:** Various national and regional biodiversity repositories provide detailed information on local flora and fauna. These resources can inspire students when designing biomimicry projects. Examples include European and national databases like the European Bioinformatics Institute and regional conservation efforts.
- **Biomimicry Institute's Innovation Lab:** This collaborative online space helps innovators and educators connect with nature's solutions to tackle human design challenges. The Institute's resources, webinars, and innovation lab provide direct access to cutting-edge research and projects.
Website: www.biomimicry.org/innovation-lab

6.3 LET's MIMIC portal

The LET's MIMIC portal provides comprehensive information that helps visitors:



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- **Biomimicry concepts:** Understanding the biomimicry steps of
- **LET’ MIMIC methodological learning design:** Technical reports on project implementation, including methodologies.
- **LET’s MIMIC digital learning services and content:** Direct and open access to digital services to support the biomimicry learning process.
- **LET’s MIMIC educator support content:** Supporting material includes a self-regulated learning kit, training modules, a digital learning platform manual, and more.
- **LET’s MIMIC informational material:** Leaflet and newsletters.
- **LET’s MIMIC events and dissemination information:** Events, scientific publications, and dissemination activities, such as internet articles, social media posts, press releases, and more.

Website: letsmimic.eu

6.4 LET’s MIMIC digital learning platform for biomimicry

The **LET’s MIMIC digital learning platform for biomimicry** is a digital space designed to enhance learning through the **LET’s MIMIC biomimicry process design methodology** (LET’s MIMIC technical report D2.1 PART B – Project-Based Learning Framework for Biomimicry Process Design, 2025). The digital platform offers a collaborative environment where VET students and teachers can explore **problem-based** and **self-regulated learning paths (SRL-P)**.

Key features and components of the platform are:

- **Microlearning module:** This module provides short, focused learning units that allow learners to engage in training at their convenience, fostering personalized and flexible learning experiences.
- **Self-Regulated learning module:** This module delivers content tailored to individual goals, enabling students to set their own learning paths through gamified challenges.



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- **Teamwork module:** This module is a collaborative space that encourages interaction, idea-sharing, and higher-order thinking through group activities.
- **Gamification module:** Gamification includes features like points, badges, and leaderboards to motivate and engage students.
- **Assessment module:** This module monitors progress and provides feedback to help students improve performance.

6.5 LET's MIMIC self-regulated learning kit

The development of educational challenges and case studies is a cornerstone of this activity, which is documented in a comprehensive document that introduces a collection of cases addressed through biomimicry and open cases for use in the classroom (LET's MIMIC technical report D3.2 Self-Regulated Learning Kit, 2025). This kit includes:

- **Educational case studies for 21st-century skills:** A comprehensive set of 60 case studies based on real-life problems. These challenges enhance critical competencies, including problem-solving, analytical thinking, creative thinking, ICT literacy, and interdisciplinary approaches to STEM subjects.
- **Resource bank on biomimicry-inspired solutions:** A curated repository of 60 biomimicry-inspired solutions relevant to VET learners' age and knowledge levels. These solutions help students draw parallels between natural systems and human challenges, applying biomimicry to innovate. The solutions address the case studies mentioned above. There is a one-to-one correspondence between the learning challenges and biomimicry-inspired solutions.
- **A collection of open challenges that can be addressed through biomimicry:** The challenges follow a similar format as the case studies but are open, with no solution provided. They are aimed for direct use in the classroom by educators and designed to be



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addressed by students in teams for biomimicry-based innovation. Educators can also use them as a reference for structuring additional student activities.

The case studies and challenges have been designed to be integrated into the LET's MIMIC digital learning platform and used in a highly interactive and engaging digital environment. However, they can also be used offline if needed. By engaging in this process, learners acquire sustainability skills and develop a deeper understanding of biomimicry principles and their practical application.

6.6 LET's MIMIC training modules

The LET's MIMIC training modules constitute comprehensive end-to-end activities focusing on each biomimicry step: define, biologize, discover, abstract, emulate, and evaluate. They integrate content from the LET's MIMIC self-regulated learning kit and additional content organised in a manner that educators can use directly in the classroom.

The training modules are an additional learning resource for educators, helping to build student knowledge and skills in biomimicry design.



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7. Implementation recommendations in local contexts

Integrating biomimicry into VET education requires thoughtful implementation strategies, localised adaptations, and robust teacher support. This section outlines practical approaches to help educators effectively deploy the handbook’s content and monitor its impact.

7.1 Adapting the handbook to local contexts

Each educational environment has unique needs, and adapting biomimicry teaching materials to local contexts ensures relevance and effectiveness.

Key adaptation strategies to local contexts include (Maccioni et al., 2024):

- **Understanding local challenges:** Identify regional environmental or societal challenges that can be addressed through biomimicry-inspired projects. For example, water scarcity solutions might be more relevant in arid regions.
- **Incorporating local biodiversity:** Emphasize local flora and fauna in teaching materials, helping students connect with their immediate environment.
- **Language and cultural relevance:** Translate or modify content to reflect local languages, cultural references, and teaching practices.
- **Stakeholder engagement:** Collaborate with local industries, environmental organizations, and community stakeholders to align biomimicry projects with real-world needs.

7.2 Teacher training and support

Teachers need training and ongoing support to deliver biomimicry content and facilitate student engagement confidently (Schunk and Mullen, 2013).

Teacher training and support strategies include:

- **Workshops and seminars:** Conduct training sessions on biomimicry concepts, teaching methods, and project-based learning approaches.



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- **Mentorship programs:** Pair teachers with biomimicry experts or experienced educators who can provide guidance and best practices.
- **Resource libraries:** Develop a repository of teaching materials, lesson plans, and case studies for easy access and reference.
- **Peer learning networks:** Create forums or groups where teachers can share experiences, challenges, and solutions.
- **Ongoing professional development:** Offer continuous learning opportunities through webinars, online courses, and conferences focused on biomimicry and innovative teaching practices.

7.3 Monitoring and evaluation

Monitoring and evaluating the effectiveness of biomimicry education is essential to ensuring that learning objectives are met and identifying areas for improvement (Jituafua, 2024).

Monitoring and evaluation techniques of the effectiveness of a biomimicry learning intervention include:

- **Student assessments:** Formative assessments can help gauge students' understanding and application of biomimicry principles, ensuring continuous feedback and improvement throughout the learning process. Summative assessments can be used selectively to evaluate final projects or presentations.
- **Project outcomes:** Evaluating the quality and impact of student projects, focusing on creativity, innovation, and real-world applicability.
- **Feedback mechanisms:** Collecting feedback from students, teachers, and stakeholders to understand their experiences and identify challenges.
- **Impact studies:** Conduct studies to measure the long-term impact of biomimicry education on students' skills, career choices, and contributions to sustainability.



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- **Continuous improvement:** Use evaluation data to refine teaching materials, methodologies, and support systems, ensuring ongoing relevance and effectiveness.



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8. Further reading and research

For educators, students, and researchers wishing to delve deeper into the field of biomimicry, the following books, articles, and online resources are essential:

Recommended books:

- **Biomimicry: Innovation Inspired by Nature**, by Janine Benyus
This groundbreaking book introduces the principles of biomimicry and showcases how innovation inspired by nature can solve some of the world's most pressing challenges.
Publisher: HarperCollins
- **Design for Life: The Architecture of the Natural World**, by Sim Van der Ryn
Focused on ecological design, this book explores how natural systems and organisms can guide sustainable design in architecture and beyond.
Publisher: Greenleaf Publishing
- **Nature of Technology: What It Is and How It Evolves**, by W. Brian Arthur
An exploration of technological evolution and how nature's processes can be mirrored in technological advancements.
Publisher: Free Press



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Conclusions

This document presented a methodology for supporting educators in designing and integrating into learning biomimicry practices for innovation inspired by nature, with a focus on VET. The document is a handbook that educators can refer to for inspiration on biomimicry learning methodologies and integrating biomimicry into existing active and experiential learning practices, particularly problem- and project-based. The document further provides steps that guide educators in designing biomimicry activities for students. It describes supporting digital resources, both developed by project LET's MIMIC and external, such as biomimicry databases and networks. The document is a valuable resource for enriching VET practices through biomimicry and developing student innovation and sustainability skills.



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