MODEL STUDENT CURRICULUM

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Deliverable | D 3.3

Leading partner | COFAC

WP | 3- Designing the Green Transition

Type | Demonstrator

Dissemination level | Public

Due Date | Nov. 2024

Version | Version 2

Project | Co-Creating Greener Futures: Developing and Transferring Innovative Bio-Design Modules for Education to Accelerate the Green Transition.
Agreement No 101087204
Acronym | CoCoon

"Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor the granting authority can be held responsible for them."

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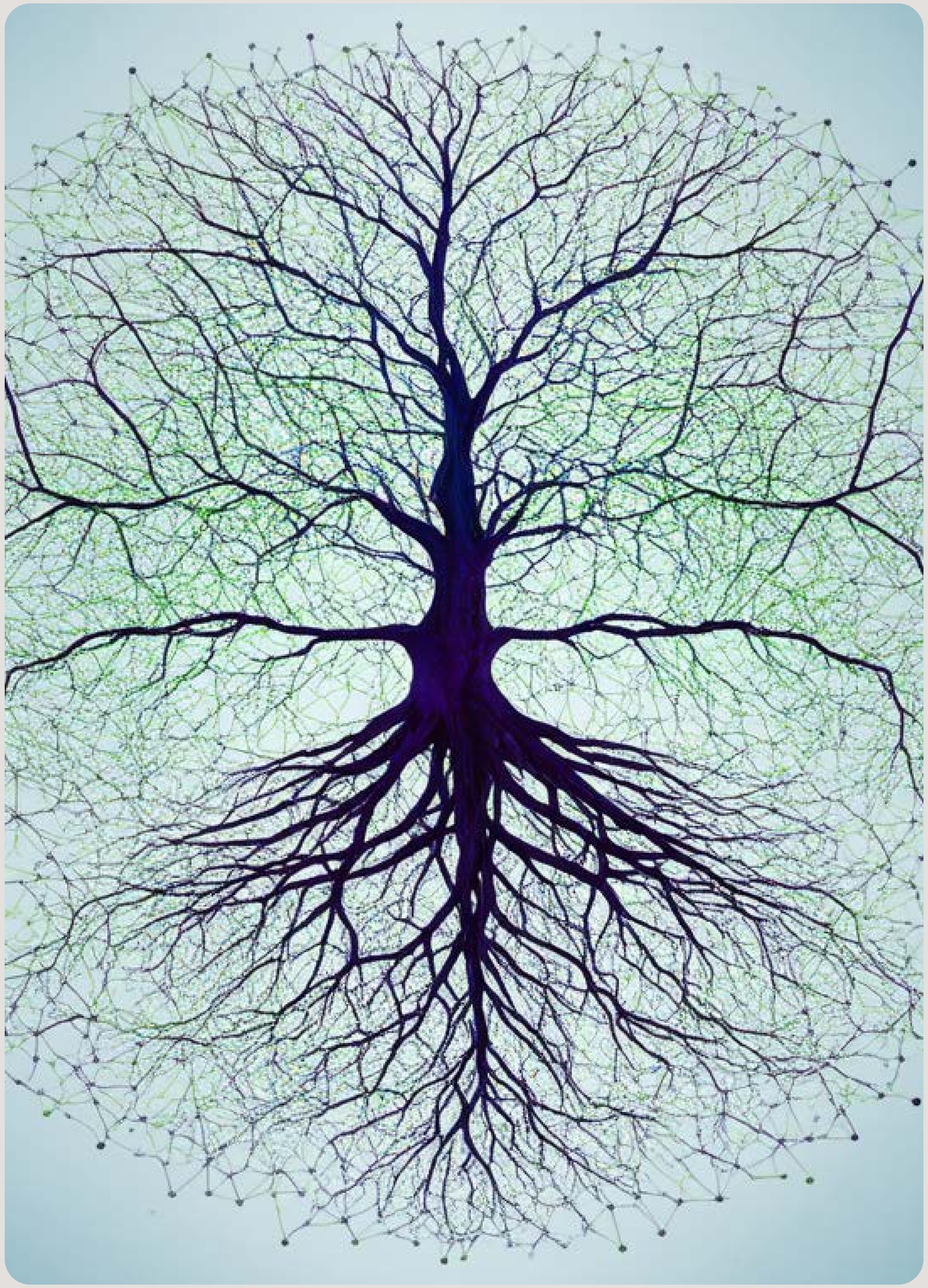
INDEX



FRAMING - BIODESIGN BACKBONE | HISTORICAL EVOLUTION

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Cocoon Bio-Making

For the things we have to learn before we can do, we learn by doing. [1]

The aim
Replacing unsustainable materials and production methods through the experimenting, learning, and disseminating of natural-based materials and processes, aiming the development and production of sustainably designed artifacts.

Biomaterials
A material[2] derived from, or produced by, biological organisms such as plants, animals, bacteria, fungi, and other life forms. These are also called biologically derived materials. It is also a material used for a biological purpose, such as a biomedical[3] application like treating an injury or growing biological cells.

Biodesign
For the purpose of this research, we can adopt two distinct interpretations of the term "biodesign":

The first one refers to applications in health : initially adopted by the Stanford Program in Biodesign[4], launched in 2001 as a unit of the interdisciplinary biosciences or "Bio-X" initiative at Stanford. The program grew out of the Stanford Medical Device Network, which had been formed a few years earlier to promote education and mentoring in the area of biomedical technology innovation. The name "Biodesign" was suggested by students, with the idea that this would align with the Bio-X nomenclature and emphasize the design aspects of the program.

The second one, described by Myers[5] on his book "BIODESIGN - Nature Science and Creativity"; according to him, the term biodesign goes further than other biology-inspired approaches to design and fabrication; refers specifically to the incorporation of living organisms as essential components, enhancing the function of the finished work and also used to highlight experiments that replace industrial or mechanical systems with biological process.

[1] *Aristotle, The Nicomachean Ethics*
[2] *https://aese.psu.edu/teachag/curriculum/modules/biomaterials/what-is-a-biomaterial*
[3] *....The first historical use of biomaterials dates to antiquity, when ancient Egyptians used sutures made from animal sinew (ligaments or tendons). The modern field of biomaterials combines medicine, biology, physics, and chemistry, and more recent influences from tissue engineering and materials science. (https://www.nibib.nih.gov/science-education/science-topics/biomaterials)*
[4] *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3759560/*
[5] *https://www.biology-design.com/*

Natural materials to produce artifacts

In terms of archeology, civilization has evolved through the development of artifacts, from ancient times, by using natural materials such as clay, wood, stone, and glass. Also, fabrics[6] such as bamboo, cotton, silk, and linen have been used for centuries, from ancient Egypt to China and India where fabrics were naturally sourced and dyed.

Figure: Ancient linen from ancient Egypt - radiocarbon testing at the University of Oxford about 3482 BC over-5,000-year-old linen dress, recently confirmed as the world's oldest woven garment. The Tarkhan Dress, named for the Tarkhan cemetery south of Cairo in Egypt[7]

Historians have regarded materials as such an important aspect of civilizations that entire periods of time have been defined by the predominant material used (Stone Age, Bronze Age, Iron Age).
In terms of chronology, only recently, on the 20th century, with[8] major achievements in materials science theory and practice, the range of materials expanded through the development and combination of diverse materials. Synthetic, composites, alloys, hybrid, superconductors, semiconductors, nano materials and other terms are combinations that can be found nowadays in mass industrial production, moving away from natural materials as we understand.

[6] *https://blog.patra.com/2018/06/07/natural-fabrics-and-the-fashioned-from-nature-exhibition-at-the-va/*
[7] *https://www.quora.com/What-is-the-oldest-known-textile-artifact*
[8] *https://energosteel.com/en/the-material-science-historical-information-on-the-materials-science-development/*

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Making three-dimensional objects

The method of transmitting information by making three-dimensional physical models is ancient. In its earliest form, it was used to create personifications of deities and effigies. Interesting examples of these can be found in caves in various locations, dating from around 230,000 BC.

The first evidence of representative or illustrative models, particularly for the purposes of projects, to give form to an idea and show what something will look like, appeared in ancient Egyptian architecture and sculpture around 3,500 BC.

According to the Egyptologist Nadja Tomoum, three-dimensional physical models were used in ancient Egypt for the purposes of showing a client, such as the King or a high-ranking official, the plans for an architectural project or a monumental sculpture or as a visual illustration of paintings or reliefs for the walls of graves or temples, before the work was started on the actual commission.[9]

[9] *Tomoum, N. The sculptor's models of the late and Ptolemaic periods – A study of the type and function of a group of ancient Egyptian artifacts, (Cairo: National Center for Documentation of Cultural and Natural Heritage and The Supreme Council of Antiquities, 2003, p. 25).*

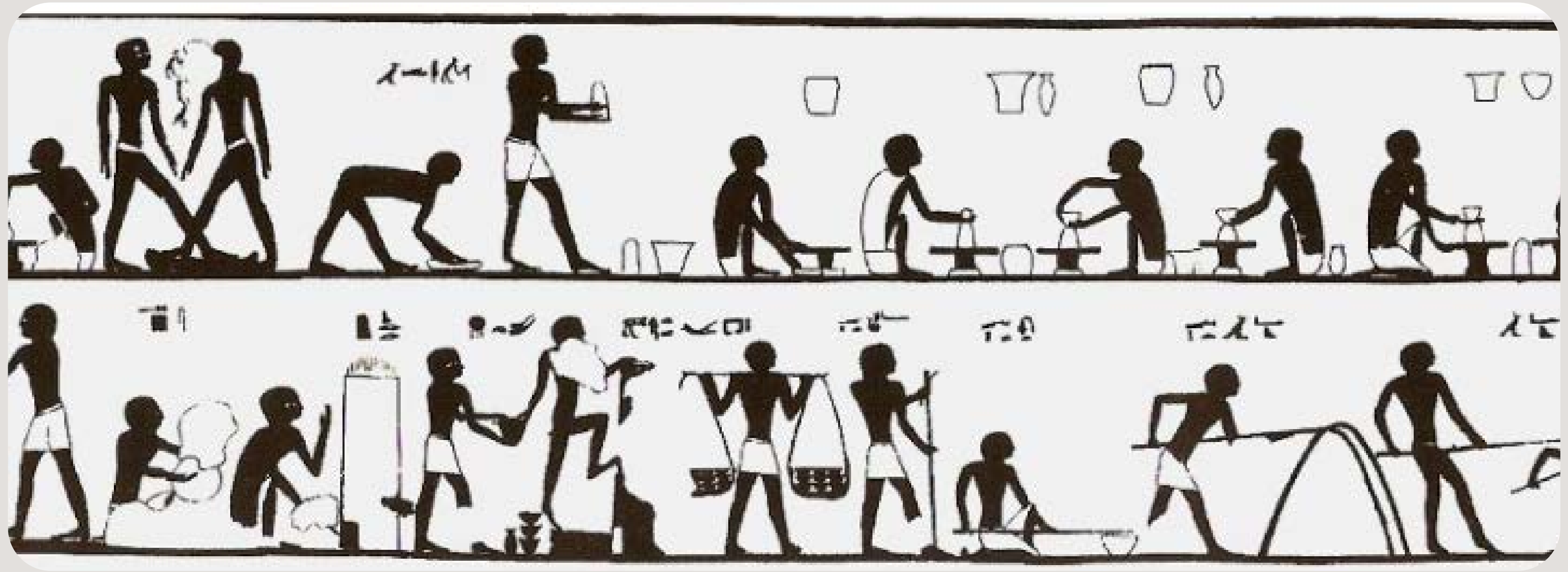

Figure: clay modeling. Wall in the tomb of Baqt, Egypt c. 1970 BC
Source: The British Museum, London.

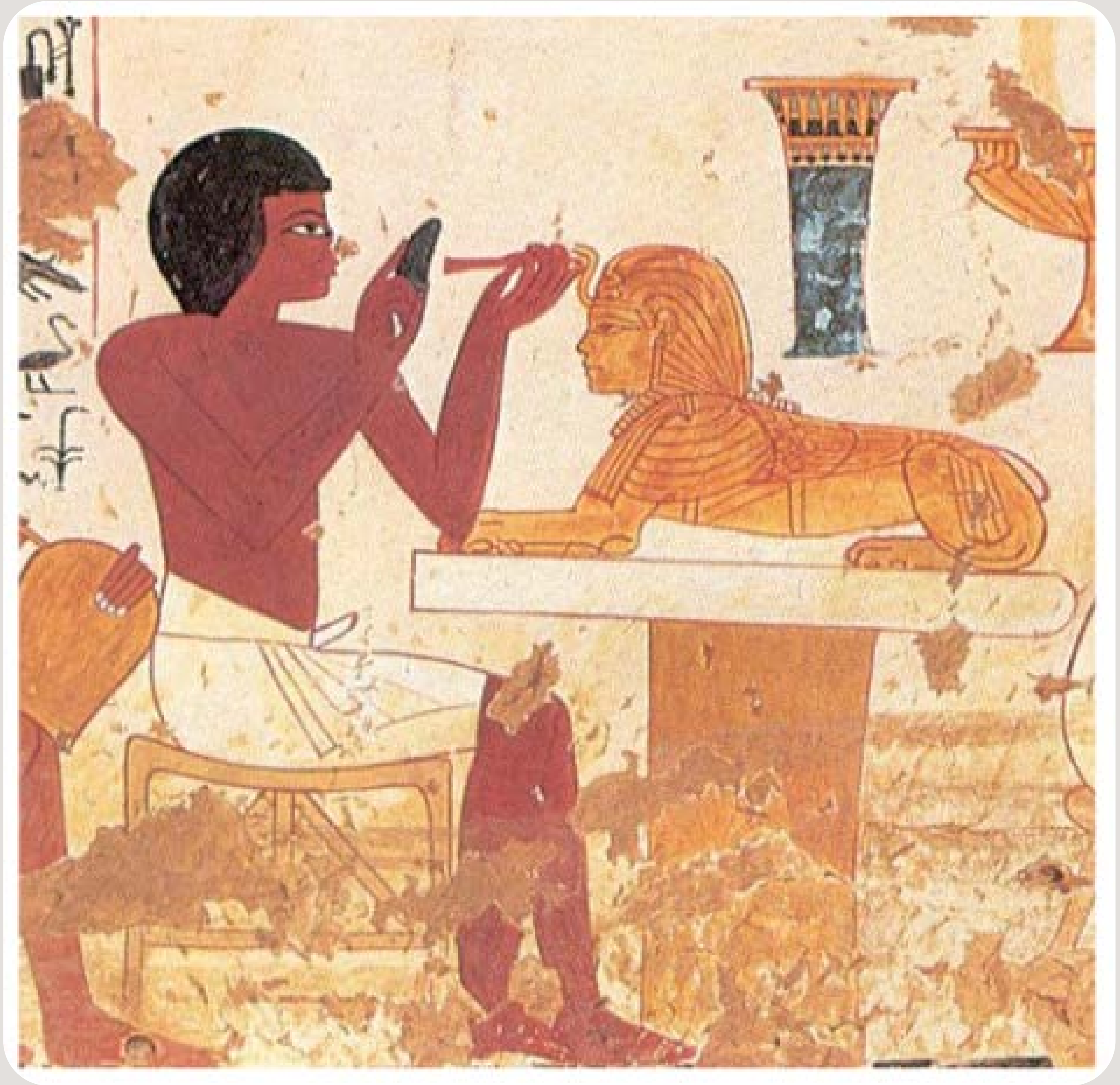

Figure: stone sculpting. Workshop of Nebamun, Egypt, around 1400 BC
Source: The British Museum Library, London

The methods for transforming materials as the direct carving process (wood, stone and even bones) and the adding process (clay), has expanded with the innovation of smelting and casting metals in the Bronze Age which started to change the way that cultures developed and interacted with each other. Melting materials to be poured into molds (such as glass jewelry), and metallic materials as copper, gold, silver, and bronze, also have ancient roots, especially for manufacturing tools (such as axes).

According to Benjamin[10], the Greeks knew only two procedures for technically reproducing works of art: founding and stamping. Bronzes, terra cottas, and coins were the only artworks which they could produce in quantity.

Figure: stone sculpting. Workshop of Nebamun, Egypt, around 1400 BC
Source: The British Museum Library, London

Figure: Casting method. Jeweller's mold for casting glass 14th-13th BC
Source: National Archaeological Museum, Athens.

Craftsman

Richard Sennett, in his book "The Craftsman"[11] says that "Craftsmanship is poorly understood." One of the earliest celebrations of the craftsman appears in a Homeric hymn to the master god of craftsmen, Hephaestus:
"Sing clear voice Muse, of Hephaestus famed for skill. With bright-eyed Athena, he taught men glorious crafts throughout the world—men who used to dwell in caves in the mountains before, like wild beasts. But now that they have learned crafts through Hephaestus famous for his art, they live a peaceful life in their own houses the whole year round."

More than a technician, the civilizing craftsman has used these tools for a collective good, that of ending humanity's wandering existence as hunter-gatherers or rootless warriors (...).

Figure: jug with Athena as clay sculptress 470 BC - Source: Bluemel, C. Greek sculptors at work (London: Phaidon, 1969).

According to Flusser, another word used in the same context is technology [12]. The greek techne means "art" and is related to tekton, a "carpenter". The basic idea here is that wood (hyle in Greek) is a shapeless material to which the artist, the technician, gives form, thereby causing the form to appear in the first place. In his famous essay "about the word design" , he explains the Latin equivalent of the Greek techne, which is ars. The words design, machine, technology, ars, and art are closely related to one another.

Flusser also remembers Plato's basic objection to art and technology, which was that they betray and distort theoretically intelligible forms (ideas) when they transfer these into the material world. For him, artists and technicians were traitors to ideas and tricksters because they cunningly seduced people into perceiving distorted ideas.

Throughout the Middle Ages[12], most trades (blacksmithing, shoemaking, baking, carpentry, stone masonry, etc.) were controlled and operated by guilds. These guilds also created a community for the tradesmen and often became influential political

[10] Benjamin, Walter. The Work of Art in the Age of Mechanical Reproduction
[11] Sennett, Richard. The Craftsman - chapter 1

[12] Flusser, Villem. The shape of things - a philosophy of design
[13] https://classicalu.com/the-apprenticeship-model/

bodies as well. Typically, a master craftsman (say, a blacksmith) would take on an apprentice (a "learner," from the Latin apprendere, "to lay hold of, grasp") who would study and work under the master in order to learn the trade.

Later, after the Renaissance, the period which sought the skills development in all areas of knowledge, exemplified by the so called "renaissance man" (or "polymath")[14] as Alberti (architect, painter, classicist, poet, scientist, and mathematician) and Leonardo da Vinci (artist, scientist, musician, inventor, and writer), modern bourgeois[15] made a sharp division between the world of the arts and that of technology and machines.

During the 'Scientific Revolution' [16], between 1500 and 1700, a new social group, consisting of engineers, scientists, inventors, artists, and explorers, emerged and became institutionalized. This group confronted traditional natural philosophy with the challenges of practice and experience, but also engaged in self-contained explanations of natural phenomena, expecting that science is a means to master nature.

Adding a different thought on the hands-on process, Rosseau, in 1762, with his Educational treatise "Emile"[17], wrote: "instead of making a child stick to his books, I employ him in a workshop, his hands work to the advantage of his intellect , he becomes a philosopher while he thinks he is simply becoming an artisan."[18]

Interesting thoughts also on Louise St. Pierre article "Design and Nature: A History"[19]: she states that the Scientific Revolution[20], the Enlightenment in the 17th and 18th centuries, and the elevation of scientific and rational thinking combined to diminish society's ability to see mystery and enchantment in the natural world.

This detachment from the so called "natural world" improved with the advent of the Industrial Revolution (Britain in the 18th century) the process of change from an agrarian and handicraft economy to one dominated by industry and machine manufacturing. These technological changes introduced novel ways of working and living and fundamentally transformed society.

Moving to contemporary days, Daniel Charny[21] , curator of the V&A exhibition "Power of Making" says that while for some people making is critical for survival, for others it is a way of learning…yet despite all the value that exists in making, fewer and fewer people know how to make things they use, need, or want; or even how these things are made.This is one of the unfortunate legacies of the industrial revolution that shaped the world we live.

According to him, the distance between the maker and the user is growing …distance and lack of understanding are also impacting governments and educational institutions, which are failing to see that making is very much part of the future…nor is making the exclusive domain of the creative arts…applied thinking lies at the core of creating new knowledge of all kinds…arts should not be separated from science, technology, engineering and the math…

Transdisciplinarity in arts, design and science

In 1919[22] Walter Gropius, with "The Handicraft Manifest" affirmed that artists, architects, and painters must all return to the crafts. The most influential design school in history, the Bauhaus, was founded more than 100 years ago, and mathematical principles and engineering rigor were applied to fine arts, crafts, and architecture. The school pioneered a splendid amalgamation of science and design.

A broader transdisciplinary way of thinking happened in 1956, when the physicist C.P. Snow published an article in the New Statesman entitled "The Two Cultures," which refers to what Snow called a "gulf of mutual incomprehension" between the sciences and the humanities, making true communication between them very difficult, it was a critical moment for the understanding the benefits of different areas working together.

In 1967 Gyorgy Kepes, a Hungarian-born painter, photographer, designer, educator, and art theorist, immigrated to the U.S. in 1937 to teach design at the New Bauhaus in Chicago. He later accepted an invitation to initiate a program in visual design, a division that later became the Center for Advanced Visual Studies.
As Kepes was in contact with a wide assortment of artists, designers, architects, and scientists, MIT was then one of the first Universities to unite artists, designers and engineers into scientific projects.

Also in 1967, in California, the Experiments in Art and Technology (E.A.T.), a non-profit and tax-exempt organization created by the Bell Labs, was established to develop collaborations between artists and engineers. The group operated by facilitating person-to-person contacts between artists and engineers, rather than defining a formal process for cooperation. E.A.T. initiated and carried out projects that expanded the role of the artist in contemporary society and helped explore the separation of the individual from technological change.

[14] https://www.studentsofhistory.com/what-is-a-renaissance-man
[15] Flusser, Villem. The shape of things - a philosophy of design
[16] Jürgen Renn, Peter Damerow, in International Encyclopedia of the Social & Behavioral Sciences (Second Edition), 2015
[17] Jean Jaques Rosseau treatise "Emile"#chapter III
[18] https://www.britannica.com/topic/Renaissance-man
[19] https://www.researchgate.net/publication/373653278_DESIGN_AND_NATURE_A_HISTORY
[20] https://www.britannica.com/event/Industrial-Revolution
[21] Power of Making, V&A Publishing , 2011
[22] https://www.nature.com/articles/d41586-019-02355-4

Tinkering and DIY
According to Wilkinson and Petrich Historically23, the verb tinkering was first used in the 1300s to describe tinsmiths who would travel around mending various household gadgets. Ronolis[24] defines material tinkering as the art of manipulating the material creatively for discovery and learning purposes….based on a trial-and-error approach.

Attributed to Aristotle, the phrase “For the things we have to learn before we can do, we learn by doing” synthesizes the idea of tinkering, nowadays disseminated in several contemporary and interactive museums such as the “Exploratorium” in California and “Nemo”in Amsterdam, where , specially the children can physically interact with materials and machines to create experiments in order to understand scientific phenomena.

The “Do it yourself” idea, traditionally seen to have its roots in the 1950s and 60s.[25] It is attributed to Joseph Moxon’s book Mechanick Exercises. Published in 1683–5, it described how to be a blacksmith, cast metal, draw, do joinery with wood, engrave, print books, make maps and mathematical instruments. Moxon wrote:…”many Gentlemen in this Nation of good Rank and high Quality are conversant in Handy-Works… How pleasant and healthy this their Diversion is, their Minds and Bodies find”. Gradually, the philosophy of the workplace spread into the home, and ‘productive leisure’ boomed.

Later, doing things for oneself was a necessity rather than a luxury for many; The 19th century saw a population explosion, with huge numbers of extra children. Buying toys was expensive, so they were often made at home instead—the start of a long-lasting trend.
A shorter working week meant people had more time to spend on family life and projects around the home. Home ownership was also on the rise, and better pay and longer holidays contributed to it. This followed from a period during and after the Second World War when many everyday essentials were strictly rationed, and skilled labor to carry out projects had been in short supply. …. The 20th century’s hardships and wars provided fertile ground for DIY. The economic disasters of the 1920s and 30s encouraged many to take up DIY, keeping up appearances while their incomes dwindled.

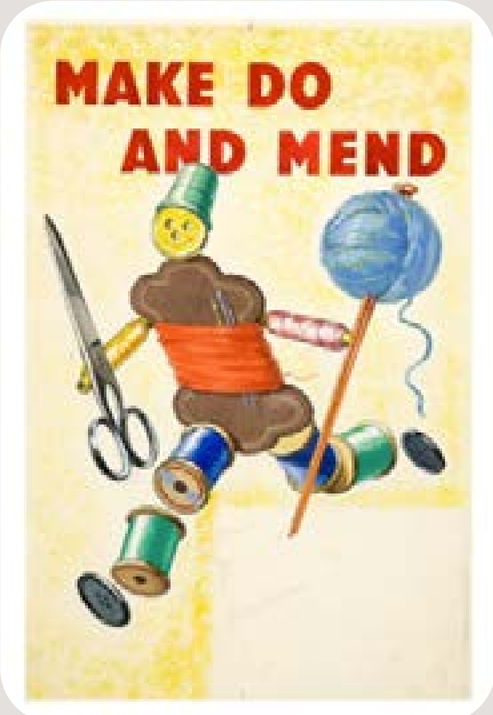

Figure: Ministry of information poster 1939 - 1946
Public domain - Science Museum London

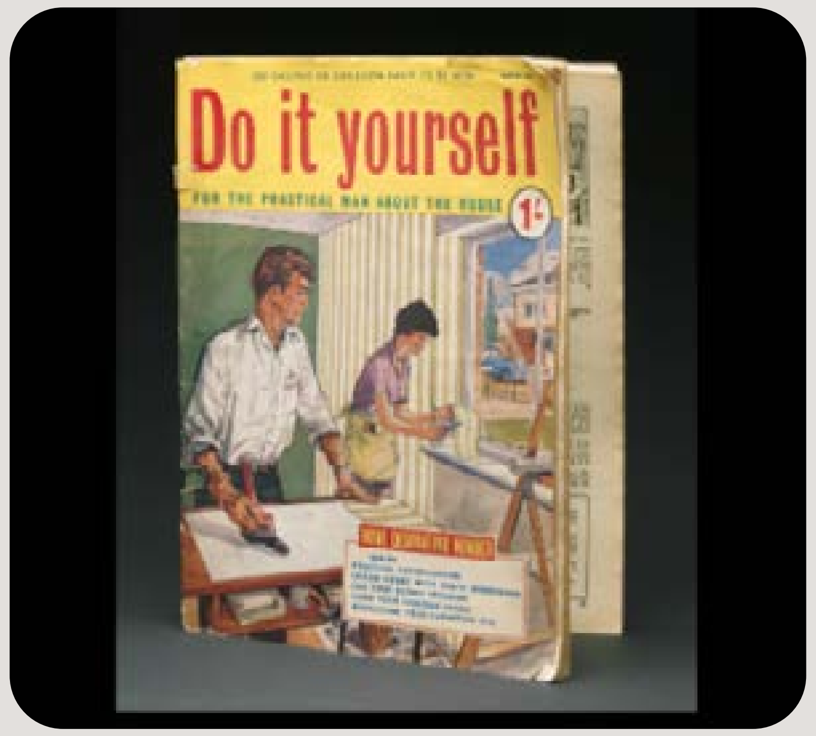

Figure: “Do It Yourself “magazine, March 1962

Maker magazine
In 2005, Dale Dougherty launched Make magazine[26] to serve the growing community, followed by the launch of Maker Faire in 2006. The term, coined by Dougherty, grew into a full-fledged industry based on the growing number of DIYers who want to build something rather than buy it.
“The surge of interest in creating physical items with digital tools and Internet-shared plans and techniques is known as the maker movement” (Burke, 2014, p. 11). A “brief” history of makerspace origins is not easily articulated, as there are a multitude of contributing factors to consider. Therefore, what follows is a condensed version of the history of the maker movement and how it has emerged on educational and library fronts.

Figure: February 2005 , first edition of the make magazine

[23] https://web.media.mit.edu/~mres/download/Art-of-Tinkering.pdf
[24] https://re.public.polimi.it/bitstream/11311/1164648/1/Rognoli%201_MaDe-Book.pdf
[25] https://www.sciencemuseum.org.uk/objects-and-stories/everyday-wonders/brief-history-diy
[26] https://www.medicalrepublic.com.au/hacking-into-a-bio-community-revolution/41

Maker movement

As some would argue, making and makerspaces[27] have always existed. It is an inherent part of human nature to ideate, plan, and create things with our hands and with tools.
Anderson[28] reports that a further catalyst for the growth and surge of the maker movement occurred when Make: magazine devised “maker faires” as “a series of venues for makers to express themselves” and share their creations .

One driver of this increased interest in makerspaces within the U.S. was President Obama’s (2009) “Educate to Innovate” campaign, in which he promoted the value of making experiences.

In 2014, Taiwanese documentarist Mu-Ming Tsai produced Maker[29] (Tsai, 2014), a film exploring the ideas, tools and people who are leading the “maker movement”. The film discusses how makers are reshaping the economy through “do it yourself” and “do it together” in what is already being called the Third Industrial Revolution. Innovative concepts such as open source, digital fabrication, crowdfunding and local manufacturing are helping to overcome the stereotype of “geeks” and hobbyists. Since then, the maker movement has been boosted by the popularization of the home versions of 3D printing equipment. A low-cost extrusion printer, or a basic 3d scanner, are each available today for less than 200€. Last generation smartphones can also be used for 3d scanning using LIDAR, a mapping technology available in many smartphones that uses the camera to measure the distance to a target surface.

MIT’s Fab Labs
Neil Gershenfeld of MIT’s Center for Bits and Atoms is an originator of the Fab Lab[30], which has had a significant influence on makerspaces (Burke, 2014). Fab Labs, are designed to fabricate things and “consist of digital equipment for designing products and the digitally driven tools to create them” (Burke, 2014, p. 12). In their book, Invent to Learn, Martinez and Stager (2013), share some powerful stories about the learning environment and collaborative culture that emerged from Gershenfeld’s MIT course, “How to Make Almost Anything”. These “Fab Lab” stories very much reflect the dynamic that occurs in today’s makerspaces. There are now hundreds of fab labs throughout the world as the concept has gained popularity, “all of which operate with a common minimum equipment requirement and a shared mission” (Burke, 2014, p.12).

[27] https://curiositycommons.wordpress.com/a-brief-history-of-makerspaces/
[28] https://historyoftheuser.wordpress.com/wp-content/uploads/2013/10/makers_-the-new-industrial-revolution-chris-anderson.pdf
[29] Tsai, Mu-Ming (Director). (2014). Maker [Film]. Muris LLC.
[30] https://curiositycommons.wordpress.com/a-brief-history-of-makerspaces/

STEAM – Science, Technology, Engineering, Arts and Maths
In 2010, Rhode Island School of Design (RISD) has long valued the symbiosis between the arts and sciences, began the addition of art and design to the national agenda of STEM (science, technology, engineering, math) education and research to develop STEAM—a comprehensive educational model that would better prepare future generations to compete in the 21st-century innovation economy.

By 2012, the United States National Research Council proposed STEAM (Science, Technology, Engineering, Arts and Mathematics) as a new method of teaching.
STEAM occupations began growing at double the rate of all other occupations. Furthermore, people with STEM-related degrees earned higher incomes, even in non-STEM-related careers. As the economy continues to evolve, STEM workers have played a critical role in the sustained growth and stability of the U.S. economy — and have become a key component to helping various industries win the future.

Designers and nature

Louise St. Pierre[31] highlights the movement led by William Morris and a number of artists, designers, and philosophers in the mid-late 19th century, who advocated a return to nature and mysticism. Known as the Arts and Crafts Movement, they rejected mechanical production and the mechanistic thinking of the Industrial Revolution.
According to her, while Bauhaus leaders lived in London, they engaged in interdisciplinary conversations with biologists (Anker, 2010). These biologists supported scientific technocracy,viewing ecosystems as machine-like systems that could be controlled and managed by humans (Kallipoliti, 2018). As a result, mastery and mechanism permeated the Bauhaus’ early engagement with biologists. Biologist Raoul Francé introduced designer Moholy-Nagy to Biotechnik, the notion that plants could offer solutions to technical problems.

Moving forward to the 20th century, several designers, artists and architects developed projects having nature as the main source for creativity : from Luigi Collani to Ross Lovegrove, it is possible to see designers and architects using nature as the main source to create organic designs.

Nowadays, the Israeli-American designer and former professor of the MIT Neri Oxman opened up new possibilities when applying state of the art technology as 3d printers, Artificial intelligence and other combined with biomaterials for the development of design projects through new methods, often incorporating biology as the main path of information.

[31] https://www.researchgate.net/publication/373653278_DESIGN_AND_NATURE_A_HISTORY

Figure: Aguahoja I (2018)[32]. The Aguahoja Artifacts Display is a catalog of material experiments spanning four years of research that shows the range of aesthetics and behaviors the Mediated Matter Group elicited in medium- to large-scale prints through performative geometric toolpaths, generative design, bio-composite distributions, and variable fabrication parameters.

Bio-terms

The biologist Janine Benyus[33] popularized the notion that humans can emulate biological phenomena to design sustainable products and processes; she founded the Biomimicry Institute, a clearinghouse for biomimicry researchers. A resource supported by the Biomimicry Institute is an online database of nature's solutions, available at AskNature.org. Janine's book Biomimicry: Innovation Inspired by Nature - 1997 added environmental awareness and sustainability to the binomial design and innovation.

Figure : Growing method. Bio Jewellery - Tobie Kerridge and Nikki Stott 2003
Source: Royal College of Art, London

According to Cheon et all - 2011[34], several terms are used interchangeably for biomimetic or biologically inspired design as follows:

Bioengineering, biological engineering, biotechnical engineering: Application of engineering principles and tools, e.g., physics, mathematics, analysis, and synthesis, to solve problems in life sciences, and may involve integrating biological and engineering systems.

Biomechanics: Application of mechanical principles, e.g., mechanics, to study and model the structure and function of biological systems.

Biomedical engineering: Application of engineering principles and techniques to the medical field, e.g., design and manufacture of medical devices, artificial organs, limbs, etc.

Bionics: Application of biological function and mechanics to machine design. Jack E. Steele used the term - 1960 to mean 'like (ic) life (bio)' or systems that copy some function or characteristic from natural systems. However, the 1970s television series Bionic Woman, about a human with electromechanical implants, also gives 'bionic' the connotation of 'biological + electronics,' or the use of electronic devices to replace damaged limbs and organs.

Biomimetics: Used in the title of a paper by Schmitt, and defined as the 'study of formation, structure, or function of biologically produced substances and materials (as enzymes or silk) and biological mechanisms and processes (as protein synthesis or photosynthesis), especially for the purpose of synthesizing similar products by artificial mechanisms which mimic natural ones'.

Biomimesis, Biomimicry, Biognosis, Bioinspiration, Biomimetic design, Bioanalogous design, Biologically inspired design: Synonymous with biomimetics to mean emulating natural models, systems, and processes to solve human problems. The term 'biomimicry' is in the title of a popular book described above by Janine Benyus, which gives it a connotation of sustainability.

[32] https://www.architectmagazine.com/design/culture/neri-oxman-takes-her-interdisciplinary-moma-exhibition-online_o
[33] https://www.sciencedirect.com/science/article/abs/pii/S0007850611002137
[34] https://www.sciencedirect.com/science/article/abs/pii/S0007850611002137

Framing the Students Curriculum Model

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To help improve and integrate the model for a Model Student Curriculum that meets the needs of the 21st century and mainly for future generations, we must outline some methods to enhance a proposal to approach the content we developed in the Cocoon project.

For that, we must look to a comprehensive, learner-centered, competency-based curriculum for the current and future generations:

Multi-Method Approach to Learning:

- **Blend of Pedagogical Theories:** Combine experiential learning (like Kolb's Learning Cycle) with constructivist approaches (where students build knowledge through experiences), inquiry-based learning, and social constructivism (learning through collaboration and interaction).
- **Focus on Competence-Based Progression:** Define core competences such as critical thinking, creativity, digital literacy, and global citizenship that students should master at each level.
- **Adaptive Learning:** Use adaptive technology platforms that provide personalized learning paths and adjust to students' progress, ensuring that each learner moves forward based on mastery rather than time-based criteria.

21st-Century Skill Integration:

- **Core Competences and Lifelong Learning Skills:** Include not just academic knowledge, but life skills that support lifelong learning, adaptability, and emotional intelligence. Competences like collaboration, communication, critical thinking, and problem-solving are essential.
- **Future-Ready Skills:** Include training in digital literacy, data analysis, design thinking, and green competencies (GreenComp), focusing on sustainable and ethical decision-making.
- **Career-Linked Competences:** Ensure the curriculum aligns with evolving industry standards to prepare students for future job markets. Collaborate with industry professionals to provide insights on real-world applications of skills.

Interdisciplinary and Integrated Curriculum:

- **Thematic and Project-Based Learning:** Design interdisciplinary projects that address real-world issues (e.g., climate change, technology ethics). This will create students' awareness of real problems, allowing connections across fields and understanding complex systems.
- **STEM with Arts and Humanities:** Incorporate STEAM (STEM + Arts) to help students develop creativity alongside technical skills, fostering innovation.
- **Global and Sustainable Perspectives:** Use GreenComp as a guideline to ensure the curriculum addresses sustainability and global responsibility.

Scaffolded and Flexible Learning Experiences:

- **Developmental Approach:** Structure the curriculum so that each stage (secondary, VET, higher education, professional) builds upon the previous one.
- **Flexible Entry and Exit Points:** Allow students to join the curriculum at different levels or leave with competencies they've mastered, supporting those who may need to pause and resume their education.
- **Reflective Practice:** Integrate reflection at each stage, encouraging students to think about what they've learned, how they can apply it, and how it aligns with their personal and professional goals.

Continuous Assessment and Feedback:

- **Competence-Based Assessments:** Move beyond traditional exams to assessments that focus on real-world tasks, projects, and presentations. Use rubrics that assess skills mastery and application.
- **Formative Feedback Loops:** Incorporate continuous, formative feedback where students regularly receive input from peers, mentors, and teachers. This approach supports their growth throughout the learning process.
- **Self and Peer Assessment:** Encourage self-assessment and peer feedback, helping students take ownership of their learning and develop skills in critical evaluation.

Dynamic, Feedback-Driven Curriculum Development

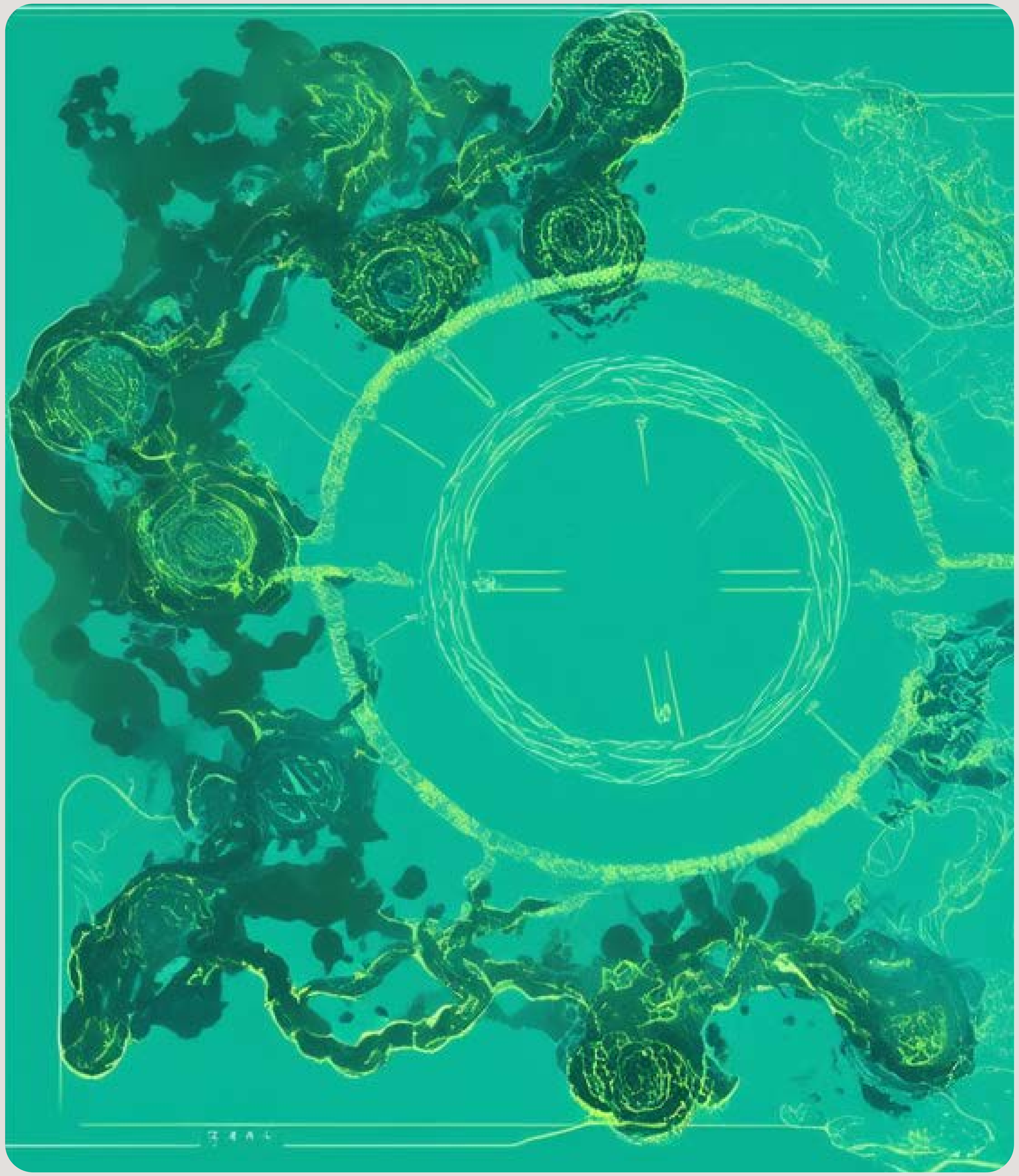
- **Wheeler's Model Application:** Use a cyclical approach for continuous improvement, revisiting and refining goals, content, learning experiences, evaluation, and adjustments based on feedback from students, teachers, and industry experts.
- **Incorporate Student Voice:** Regularly gather student input on curriculum effectiveness and adaptability. This helps ensure that the curriculum stays relevant and meets evolving needs.
- **Data-Driven Adjustments:** Use data analytics to identify areas where students struggle or excel, allowing for targeted interventions and updates to the curriculum.

Supportive Learning Environment:

- **Social-Emotional Learning (SEL):** Integrate SEL practices to help students develop self-awareness, emotional regulation, and empathy.
- **Mentorship and Community Engagement:** Connect students with mentors and community partners, creating opportunities for networking, career exploration, and community-based learning.
- **Inclusive and Diverse Curriculum:** Ensure that materials and projects reflect diverse perspectives and are accessible to all students, fostering inclusivity and equity in learning.

Visual Representation:

- **To help visualize this model, consider using a multi-layered cycle diagram:**
  - The outer layer represents continuous development cycles, reflecting Wheeler's Model (Aims, Content, Experiences, Evaluation, Feedback).
  - Inner rings represent core competences and skills at each level, with the flexibility to adapt at different stages (e.g., secondary, VET, higher education, professional).
  - Central elements embody lifelong learning, adaptability, and sustainability, anchoring the curriculum's purpose.
- **Reflective Practice:** Teachers and students should regularly reflect on and adjust their approaches, aligning with a growth mindset that values learning through trial, reflection, and improvement.



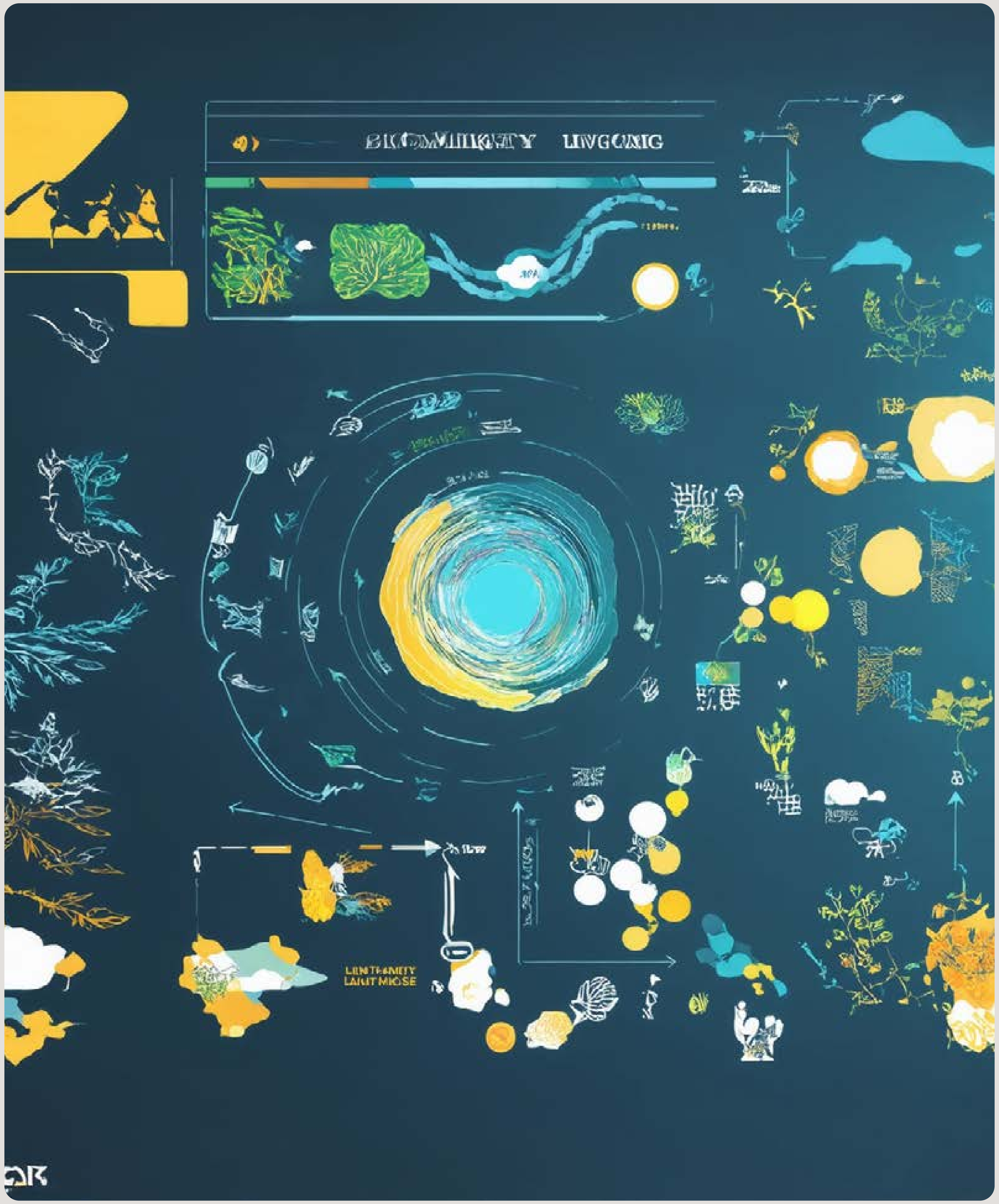
THE EMERGENT PROPOSING MODEL

Combining Kolb's Learning Cycle with Wheeler's Model of Curriculum Development and integrating GreenComp (Green Competence) concepts creates a dynamic, sustainable-focused Biodesign curriculum that builds skills progressively and encourages environmentally responsible innovation at each educational level.

This link can be the driver for the legitimation of education, meeting new mandates in the name of the defense of a set of democratic values that society deems crucial for the survival of human beings. It is, therefore, a move away from instructional practices towards a pedagogical rationality that recognizes the construction of culturally significant and humanly empowering learning under the logic of the pedagogical paradigm of communication. In this sense, if the curriculum is to be claimed by both teachers and students, it must simultaneously respond to the challenges set forth here and favor a future construction based on citizenship of full rights and duties.

However, if the notion of the curriculum can be subordinated to several assumptions and states, it should be emphasized the importance of what has been called a 'viscous' state (Estrela, 2023). In other words, a curriculum that presents consistency allows it to maintain its internal structure and be relevant in liquid times while, at the same time, including characteristics of communicability with the external conditions that influence and shape it. This involves recognizing the curriculum "as an educational process based on solidarity, compassion, and collective agreements" (Goodson & Petrucci-Rosa, 2020, p. 3) and the "curriculum knowledge as a social process, produced by multiple actors in different fields or levels" (Estrela, 2012, p. 109).

This is a process that requires co-creation from a dynamic interaction between these different actors. In today's uncertain, unstable, and unpredictable world, balancing preserving our historical heritage and addressing individual interests and needs is vital. Adopting a flexible curriculum that resists permanent change while allowing for necessary adjustments in different contexts can be the answer. In an analogy with physical concepts, this viscosity requires finding the balance between the socio-political and economic factors driving educational changes and the historical and cultural factors that ensure memory and professional culture. The challenge of creating a democratic and culturally relevant curriculum requires the integration of multiple voices and perspectives from the construction of narratives that foster the development of identity. The democratic curriculum values the uniqueness of all and each individual and acknowledges the diversity of the contexts. Thus, this also refers to inclusion, in which students are actively involved in the learning process while they can develop a sense of belonging to a community. This perspective thus becomes an opportunity for the construction of a more democratic and meaningful educational path since it invites all to rethink the social mission of the school, recognizing its transformative potential as well as its role in the construction of a fairer and more egalitarian future (Estrela & Lima, 2024).



Frameworks Overview

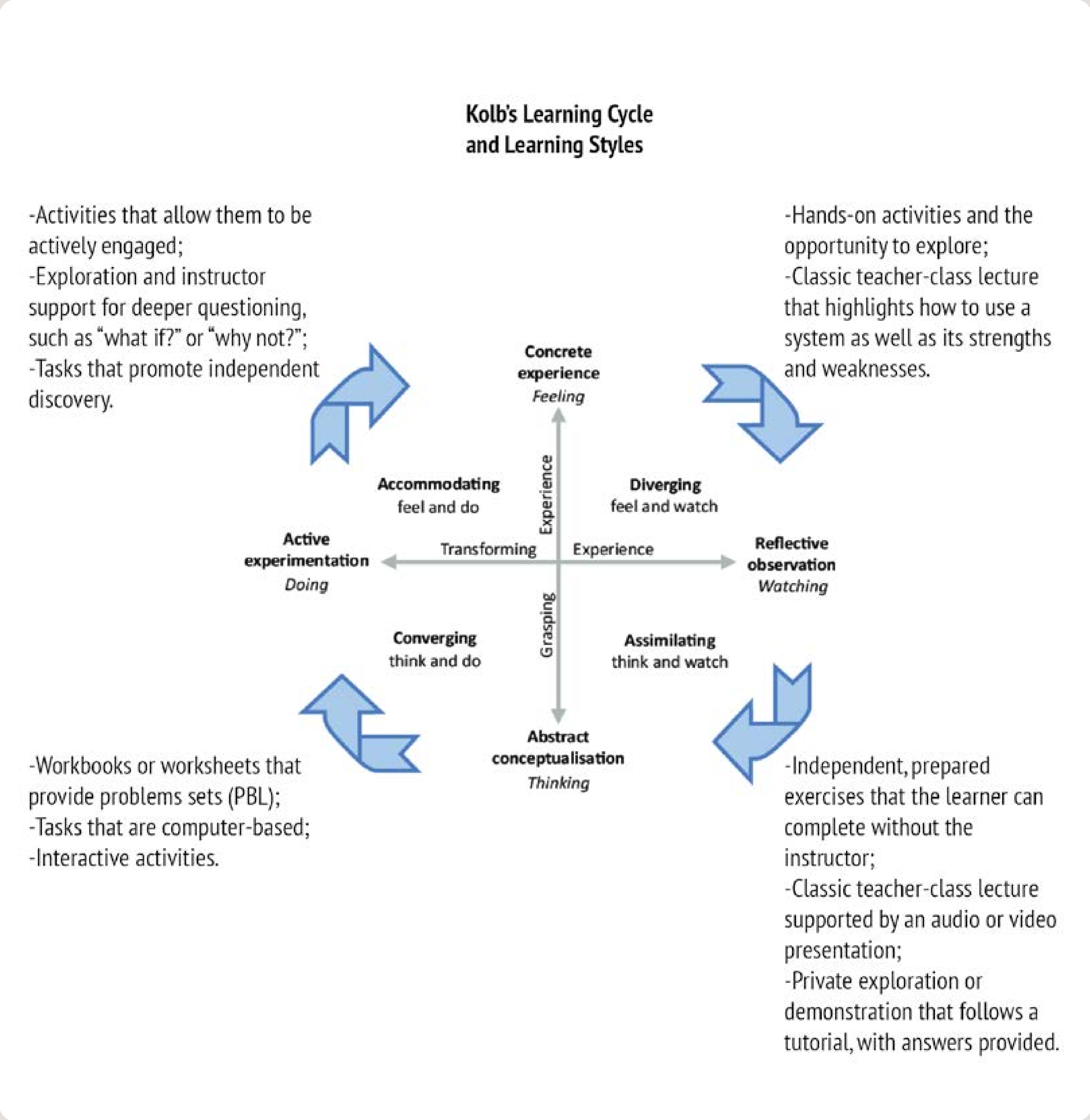
Kolb's Learning Cycle

Kolb's Learning Cycle guides the sequence of learning stages, with starting points and flow varying by educational level. In Kolb's Theory of Experiential Learning, the author proposed that experience was key in developing knowledge construction, as learning occurs through discovery and active participation. Kolb defined learning as "the process whereby knowledge is created through the transformation of experience" (Kolb, 1984).

Incorporating Kolb's Learning Cycle curriculum proposal provides a dynamic, experience-based approach that matches with practical, innovative fields like Biodesign. Kolb's Learning Cycle consists of four stages:

- **Concrete Experience (CE):** Hands-on experience and direct interaction.
- **Reflective Observation (RO):** Reflecting on the experience, identifying patterns or insights.
- **Abstract Conceptualization (AC):** Developing theories and understanding underlying concepts.
- **Active Experimentation (AE):** Applying the concepts to new situations and testing theories.

By adapting the entry point and flow of Kolb's cycle according to each educational level, students' learning experiences become both progressively challenging and appropriate to their developmental and professional stages.



McLeod, S. (2017). Kolb's Learning Styles and Experiential Learning Cycle. Simply Psychology
https://educationaltechnology.net/kolbs-experiential-learning-theory-learning-styles/

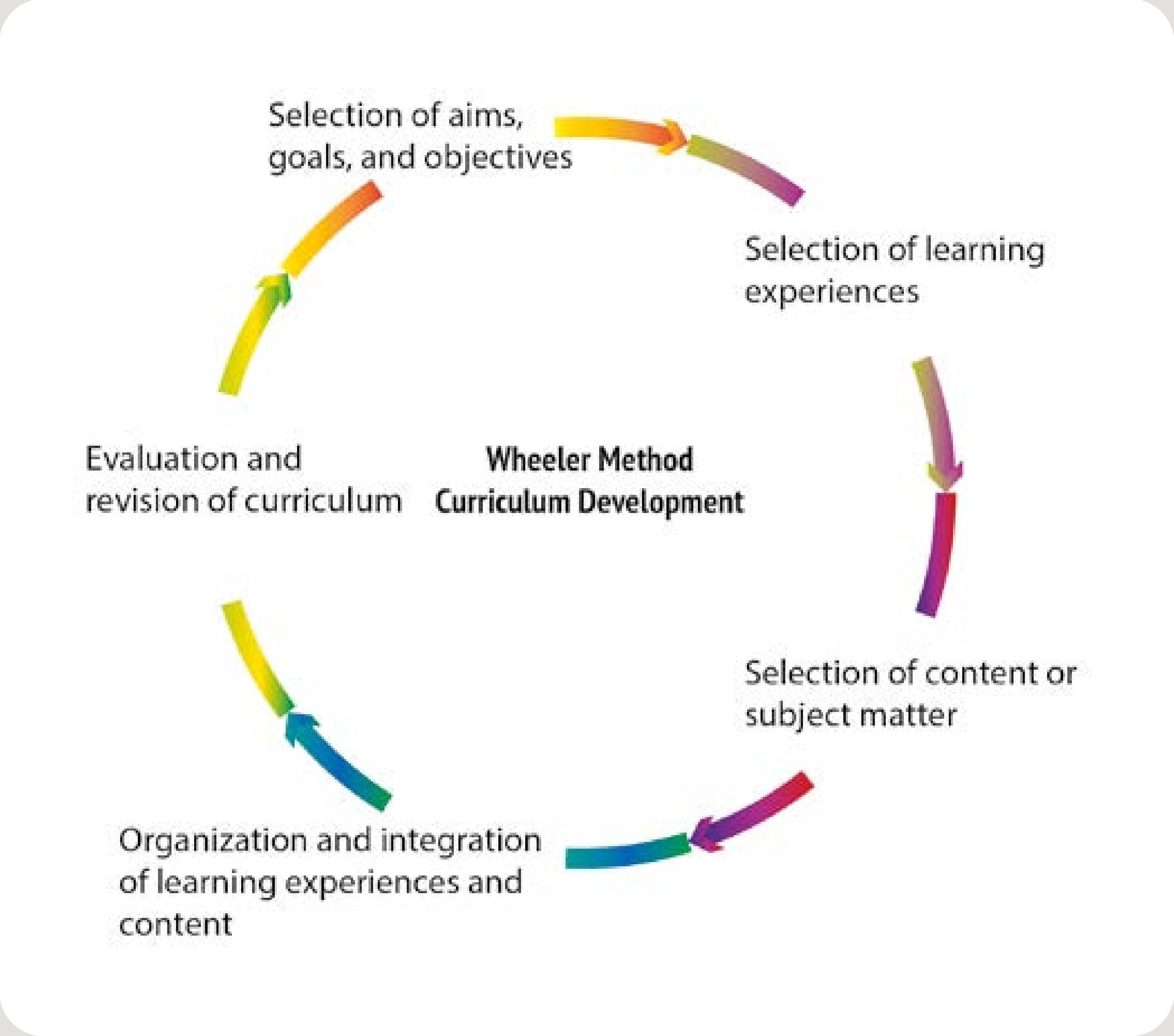
Wheeler's Model of Curriculum Development

Wheeler's Model of Curriculum Development is a cyclical framework for designing and improving curriculum that emphasizes continuous refinement based on evaluation and feedback. Developed by David Wheeler, this model moves away from traditional linear approaches to curriculum design, instead adopting a cycle that encourages ongoing assessment and adjustment. This makes it particularly effective for modern education, where adaptability and responsiveness are crucial.

Key Elements of Wheeler's Model:

- **Selection of aims, goals, and objectives**
- **Selection of learning experiences**
- **Selection of content or subject matter**
- **Organization and integration of learning experiences and content**
- **Evaluation and revision of curriculum**

Wheeler's Model of Curriculum Development: Focuses on a continuous, cyclical process with five elements:



Kelly, A. V. (2009). The Curriculum: Theory and Practice (6th ed.).

GreenComp

GreenComp (Green Competence Framework), introduced by the European Commission's Joint Research Centre (JRC) in 2022, is a framework for environmental and sustainability education. It aims to build a set of competences that empower people to live sustainably, engage with environmental challenges, and act for the climate. GreenComp outlines the competencies individuals need to understand, act, and think critically about sustainability and environmental issues.

European Commission's green skills framework with four competence areas:

- Embodying sustainability values, including the competence:
- supporting fairness
- promoting nature.

- Embracing complexity in sustainability, including the competences:
- systems thinking
- critical thinking
- problem framing

- Envisioning sustainable futures, including the competences:
- futures literacy
- adaptability
- exploratory thinking

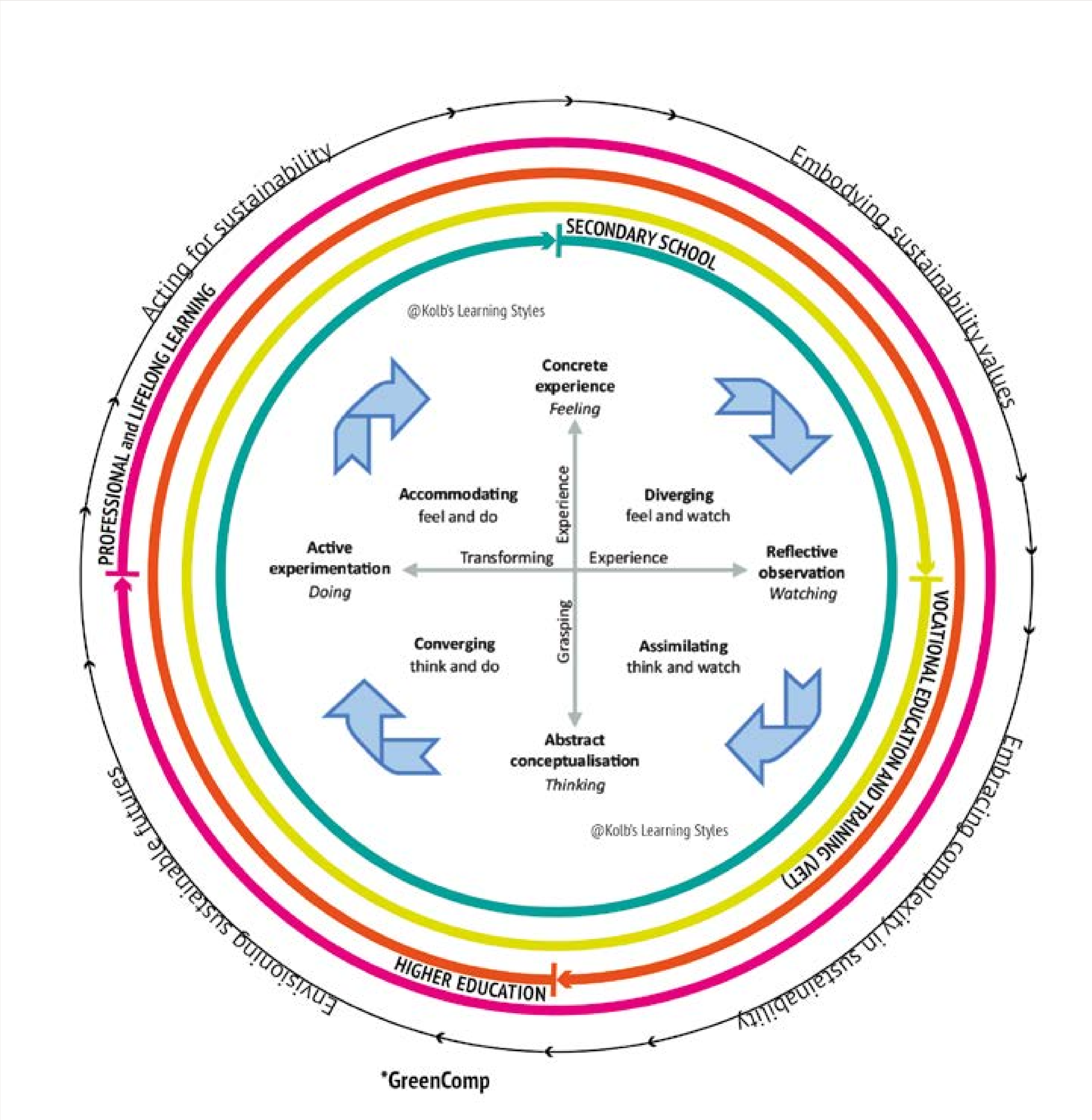
- Acting for sustainability, including the competences:
- political agency
- collective action
- individual initiative

GreenComp (Green Competence Framework):

AREA	COMPETENCE	DESCRIPTOR
1. Embodying sustainability values	1.1 **Valuing sustainability**	To reflect on personal values; identify and explain how values vary among people and over time, while critically evaluating how they align with sustainability values.
	1.2 **Suppþrting fairness**	To support equity and justice for current and future generations and learn from previous generations for sustainability.
	1.3 **Promoting nature**	To acknowledge that humans are part of nature; and to respect the needs and rights of other species and of nature itself in order to restore and regenerate healthy and resilient ecosystems.
2. Embracing complexity in sustainability	2.1 **Systems thinking**	To approach a sustainability problem from all sides; to consider time, space and context in order to understand how elements interact within and between systems.
	2.2 **Critical thinking**	To assess information and arguments, identify assumptions, challenge the status quo, and reflect on how personal, social and cultural backgrounds influence thinking and conclusions.
	2.3 **Problem framing**	To formulate current or potential challenges as a sustainability problem in terms of difficulty, people involved, time and geographical scope, in order to identify suitable approaches to anticipating and preventing problems, and to mitigating and adapting to already existing problems.
3. Envisioning sustainable futures	3.1 **Futures literacy**	To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future.
	3.2 **Adaptability**	To manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.
	3.3 **Exploratory thinking**	To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods.
4. Acting for sustainability	4.1 **Political agency**	To navigate the political system, identify political responsibility and accountability for unsustainable behaviour, and demand effective policies for sustainability.
	4.2 **Collective action**	To act for change in collaboration with others.
	4.3 **Individual initiative**	To identify own potential for sustainability and to actively contribute to improving prospects for the community and the planet.

Bianchi, G., Pisiotis, U. and Cabrera Giraldez, M., GreenComp The European sustainability competence framework, Punie, Y. and Bacigalupo, M. editor(s), EUR 30955 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-53201-9, doi:10.2760/821058, JRC128040.

COCOON MODEL STUDENT CURRICULUM

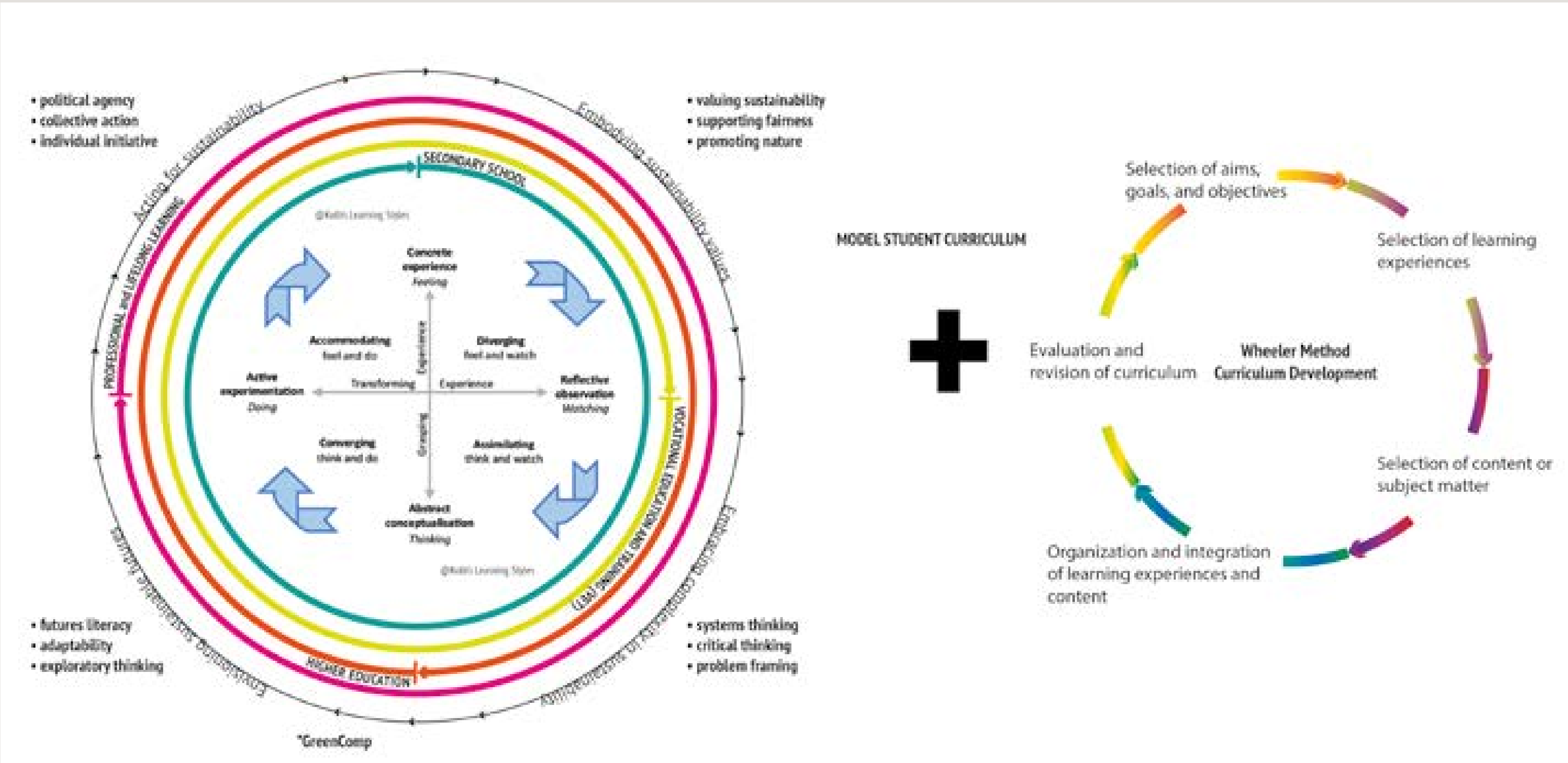


Developed by Susana Leonor (2o24)

Model student curriculum framework

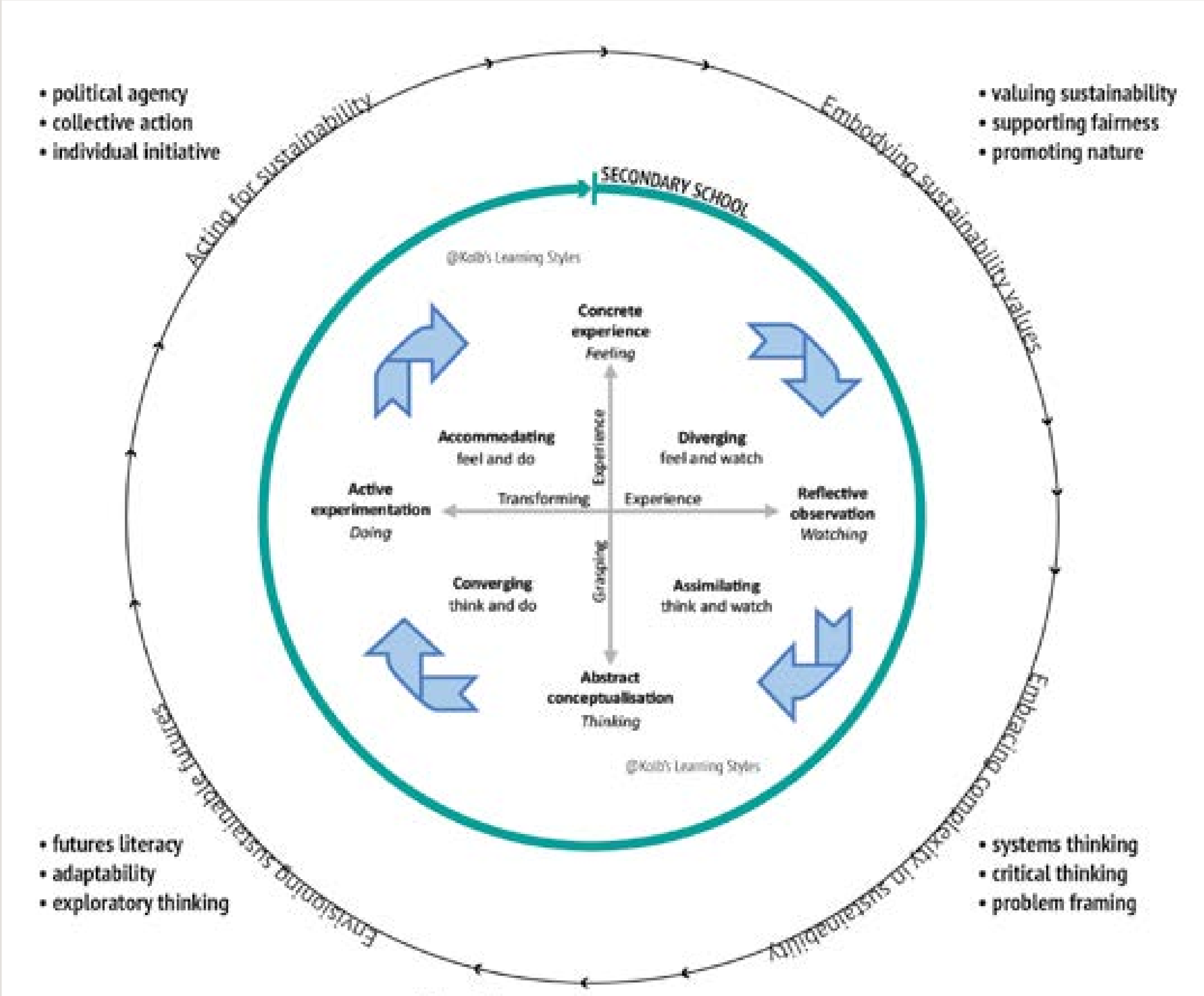
This integrated curriculum framework, blending Kolb's Learning Cycle with Wheeler's Model and GreenComp principles, ensures that students at every educational level develop green competencies, practical skills, and a thorough understanding of biodesign and sustainability. This approach nurtures eco-consciousness and prepares future professionals to lead in sustainable biodesign and mainly creates a dynamic, sustainable-focused Biodesign curriculum that builds skills progressively and encourages environmentally responsible innovation at each educational level.

In this sense, this framework entails democratic values and meets viscous features which allow the search for answers to effective learning. This innovation, based on context and purposes, does not forget the teacher as a qualified partner (Trindade & Cosme, 2016) and takes citizenship at the heart ofthe curriculum by building social knowledge by "student's own hands". According to Dewey (1933) and Shon (1983), reflective thinking is the way to improve education.



Developed by Susana Leonor (2024)

1. Secondary Education



*GreenComp

1-Curriculum Structure

1.1-Aims and Goals: Spark interest in sustainability and biodesign, emphasizing the importance of environmentally responsible design inspired by nature.

1.1.1- GreenComp Focus: Embodying sustainability values, including the competences by introducing basic concepts in ecological awareness and biomimicry.

1.2-Content: Basic biology, environmental science, design principles, and an introduction to sustainability in design:

-Introduction to Biology and Design Basics
- **-Key Topics:** Cell biology, genetics, ecology, environmental science, basics of design thinking.
- **-Skills Emphasized:** Scientific method, basic lab skills, creativity in problem-solving.

-Introduction to Biodesign Concepts
- **-Key Topics:** Biomimicry (design inspired by nature), sustainable materials, introduction to ecosystems.
- **-Project-Based Learning:** Simple biodesign projects, such as creating biomimicry-inspired models.
- **-Skills Emphasized:** Observation, critical thinking, introductory CAD (Computer-Aided Design) tools.

-Ethics and Sustainability in Design
- **-Key Topics:** Ethical considerations in biotechnology, environmental impact, life-cycle analysis.
- **-Skills Emphasized:** Ethical reasoning, systems thinking.

-Fieldwork and Experiments
- **-Activities:** Visit local ecosystems, observe natural forms, and document ideas for bio-inspired designs.
- **-Sample Project:** Design a simple eco-friendly product or propose sustainable solutions based on local environmental needs.

1.2.1-GreenComp Focus: Embracing complexity in sustainability, including
The competences are acquired through understanding the role of design in environmental impact.

1.3-Learning Experiences (Concrete Experience > Reflective Observation > Abstract Conceptualization > Active Experimentation):

1.3.1-Concrete Experience: Begin with hands-on projects like observing and mimicking biological structures in nature. Activities could include building simple biodesign prototypes inspired by biomimicry.

1.3.2-Reflective Observation: Encourage students to reflect on the experience by documenting what they observed, analyzing how nature's designs solve specific problems, and discussing their insights in small groups.

1.3.3-Abstract Conceptualization: Introduce basic theories in biology and design, such as ecological relationships, sustainable design principles, and materials science. Students conceptualize how their observations align with these principles.

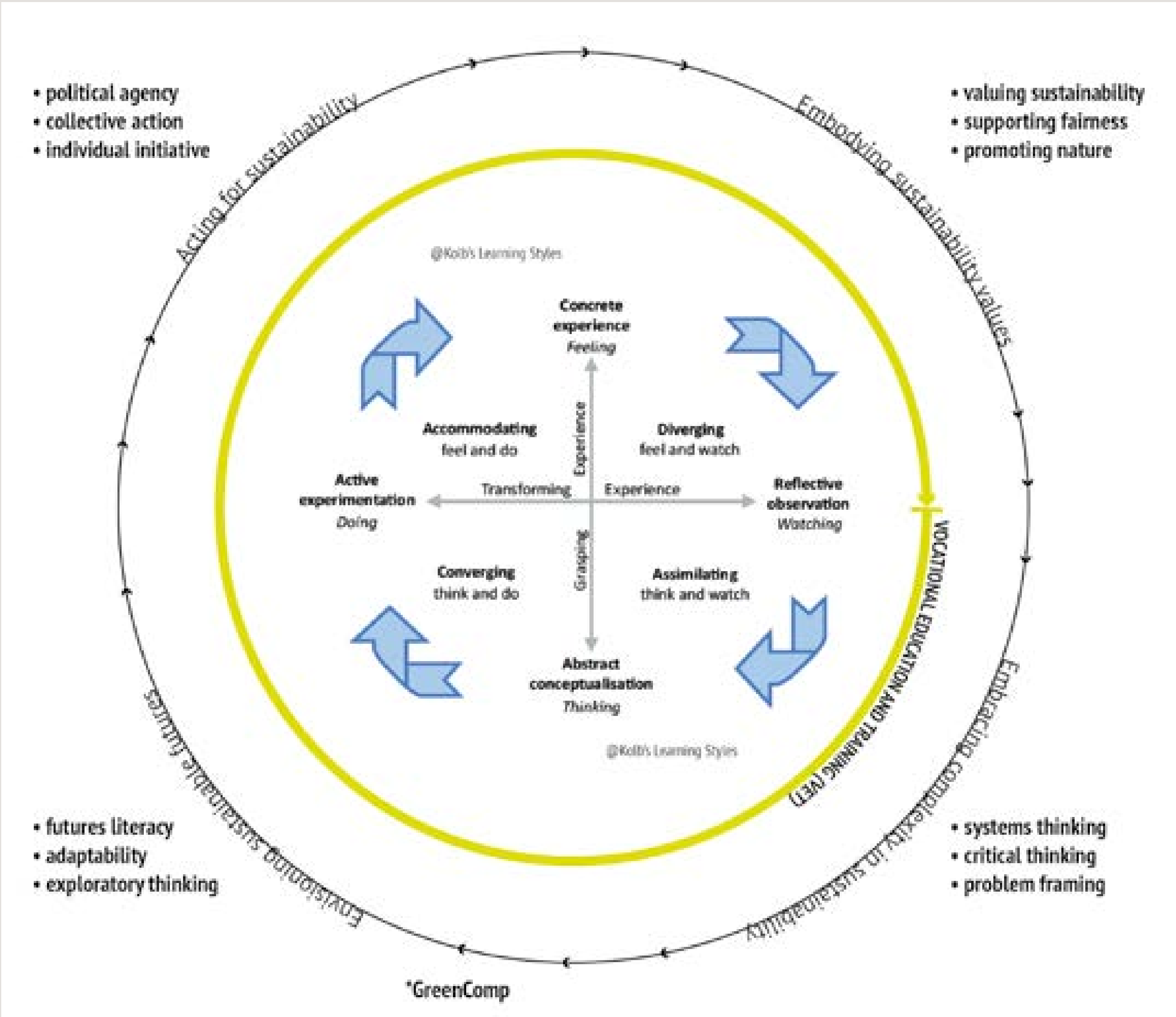
1.3.4-Active Experimentation: Students then experiment with improving their designs, adjusting materials or forms to make them more efficient, functional, or sustainable. They may present their projects, receive feedback, and iterate based on new insights.

1.3.5-GreenComp Focus: Envisioning sustainable futures, including the competencies through small-scale design projects imagining sustainable products.

1.4-Evaluation: Assess student engagement, prototype creativity, and understanding of biodesign concepts.

1.5-Feedback and Adjustment: Collect feedback from student reflections to adjust activities and project complexity.

2.Vocational Education and Training (VET)



2-Curriculum Structure

2.1-Aims and Goals: Develop practical skills in biodesign, preparing students for green technology and sustainable production.

1.1.1-GreenComp Focus: Embracing complexity in sustainability, including the competencies in material choices and production impact on the environment.

2.2-Content: Fundamentals of biomaterials, biofabrication, green chemistry, and sustainable production processes:

-Foundations of Biodesign and Fabrication
-Key Topics: Bio-based materials (e.g., mycelium, algae), biomanufacturing basics, sustainable production methods.
-Skills Emphasized: Hands-on prototyping, basic lab protocols, and safety standards in biomanufacturing.

-Biomaterials Science
-Key Topics: Properties of bioplastics, cellulose, and microbial materials; microbial cultures.
-Lab Work: Cultivating microorganisms (e.g., for biodegradable packaging).
-Skills Emphasized: Microbial cultivation, lab equipment use, and safe material handling.

-Introduction to Computational Design
-Key Topics: CAD for biodesign, simulation of bio-inspired models, 3D modeling basics.
-Tools: Introduction to accessible software like Tinkercad or Blender.
-Skills Emphasized: Digital design, material simulation.

-Industry Practicum or Internship
-Practical Experience: Placements in biodesign labs, local, sustainable design companies, or research facilities.
-Capstone Project: Design a biodesign prototype that addresses a real-world problem, incorporating sustainable materials and design.

2.2.1-GreenComp Focus: Acting for sustainability, including the competences by training students in sustainable fabrication and material processing.

2.3-Learning Experiences (Reflective Observation > Abstract Conceptualization > Active Experimentation > Concrete Experience):

2.3.1-Reflective Observation: Start with case studies and analysis of biodesign projects in the industry, encouraging students to discuss and reflect on existing examples of biofabricated materials (e.g., mycelium leather, bio-packaging). This builds a foundation of awareness and critical thinking about design choices and sustainability.

2.3.2-Abstract Conceptualization: From these reflections, introduce the underlying scientific principles of biomaterials, microbial cultivation, and lab safety. Students develop an understanding of key concepts like biocomposites, bio-based polymers, and environmental impact.

2.3.3-Active Experimentation: Provide students with opportunities to apply these concepts through experimentation—such as creating bio-composite materials, working with microbial cultures, or simulating sustainable design models using CAD.

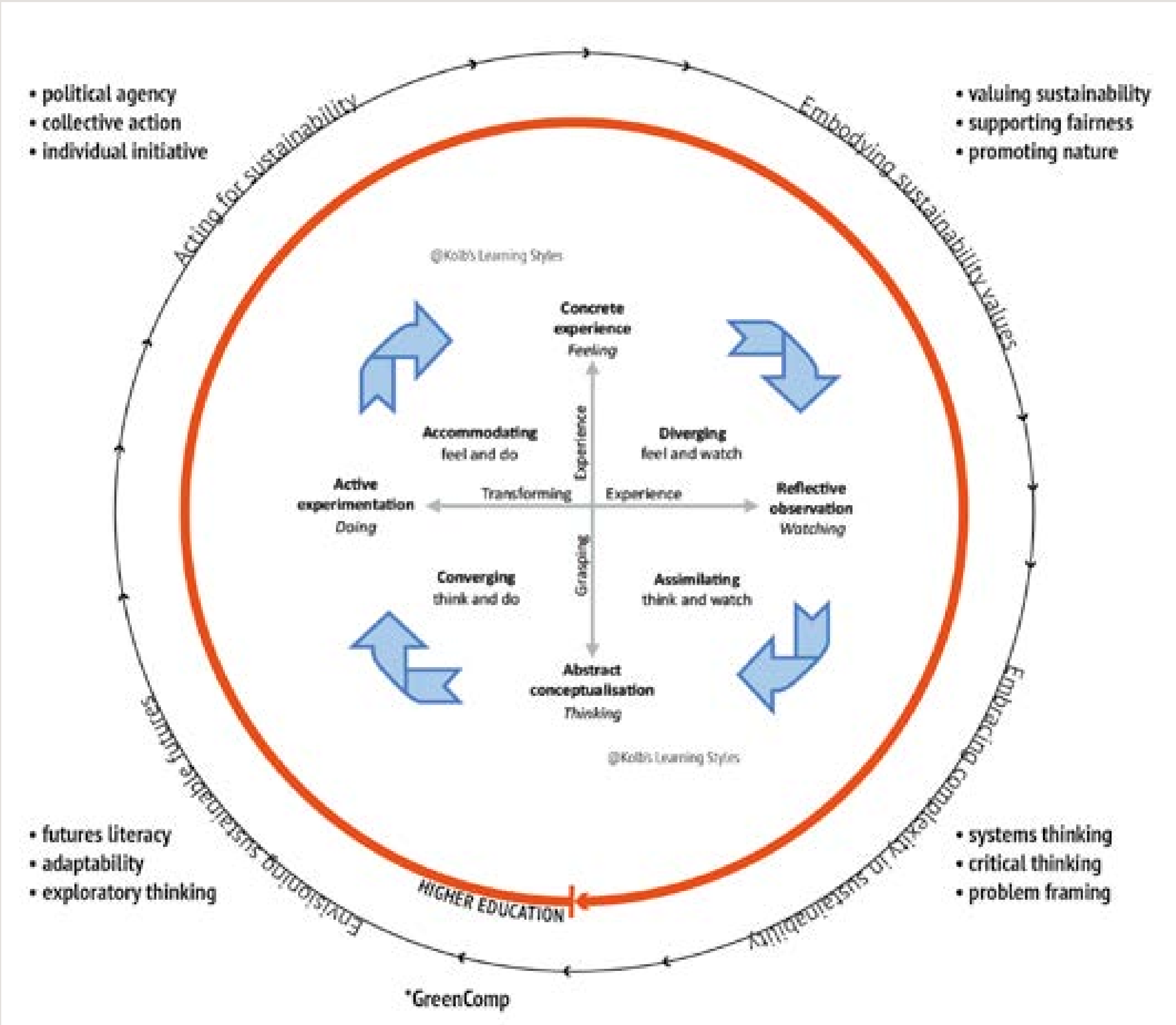
1.3.4-Concrete Experience: Students bring their designs to life through hands-on lab work, creating prototypes, or working on a project in collaboration with industry mentors. This experience solidifies their practical skills and prepares them for real-world applications.

2.3.5-GreenComp Focus: Embodying sustainability values, including the competencies through project-based learning that incorporates green values into biomanufacturing practices.

2.4-Evaluation: Assess prototype functionality, sustainability, and adherence to green design principles.

2.5-Feedback and Adjustment: Use industry feedback and student reflections to refine project focus areas, integrating new green techniques as needed.

3. Higher Education (Undergraduate and Graduate Levels)



3-Curriculum Structure

3.1-Aims and Goals: Equip students with expertise in biodesign theory, advanced biomanufacturing, and green innovation leadership.

3.1.1- GreenComp Focus: Envisioning sustainable futures, including the Competences by planning and designing for long-term environmental sustainability.

3.2-Content: Systems biology, synthetic biology, bioinformatics, advanced biomaterials, and green design principles:

-Biodesign Theory and Applications
- **-Key Topics:** Systems biology, synthetic biology, computational biology, environmental impact assessment.
- **-Coursework:** Introduction to genetics and molecular biology relevant to biodesign.
- **-Skills Emphasized:** Analytical thinking, scientific research methods.

-Advanced Biomaterials and Biofabrication Techniques
- **-Key Topics:** Engineering of bio-composites, bioprinting, tissue engineering, advanced microbial applications.
- **-Lab Work:** Hands-on experience with bioreactors, advanced CAD tools, bioprinters, and tissue scaffolding.
- **-Skills Emphasized:** Experiment design, biomaterial engineering, lab automation.

-Computational Biodesign and Data Analysis
- **-Key Topics:** Bioinformatics, data-driven design, computational modeling of biological systems.
- **-Tools:** Advanced CAD (SolidWorks), data analysis (R, Python), and modeling software (MATLAB).
- **-Skills Emphasized:** Computational biology, data interpretation, predictive modeling.

-Capstone Biodesign Project
- **-Project Scope:** Develop a novel biodesign application that solves a pressing ecological or industrial issue.
- **-Deliverables:** A functioning prototype, research paper, and presentation to a panel of industry experts.

-Ethics, Policy, and Entrepreneurship in Biodesign
- **-Key Topics:** Ethical implications of synthetic biology, patent law, environmental policy, business modeling for biotech.
- **-Skills Emphasized:** Policy analysis, bioethics, startup skills.

3.2.1-GreenComp Focus: Embracing complexity in sustainability, including the competences in environmental impact assessments and sustainable production design.

3.3-Learning Experiences (Abstract Conceptualization > Active Experimentation > Concrete Experience > Reflective Observation):

3.3.1-Abstract Conceptualization: Begin with in-depth coursework in biodesign theory, such as synthetic biology, bioinformatics, and advanced biomaterials. Students study the conceptual frameworks that drive biodesign innovation and sustainability, developing complex theories and models.

3.3.2-Active Experimentation: Students then apply these theories to lab work and projects, like bioprinting, creating synthetic tissue scaffolds, or developing bio-inspired designs through computational modeling.

3.3.3-Concrete Experience: This stage involves building or testing prototypes and conducting field studies to observe the outcomes of their experimentation, gaining practical experience and immediate feedback on their applications.

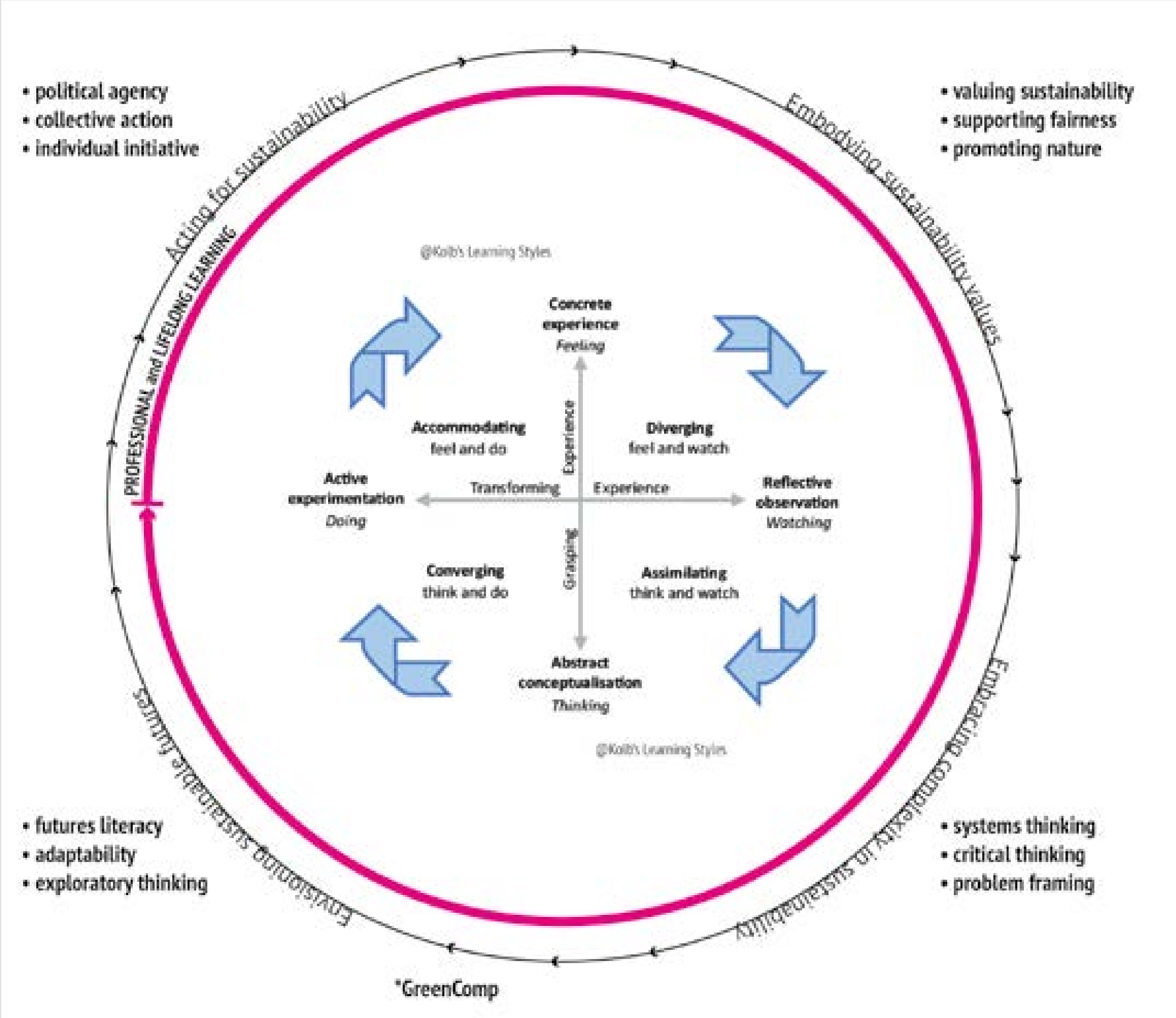
3.3.4-Reflective Observation: Students analyze their results, comparing outcomes with initial hypotheses, identifying insights, and refining their theories. Group discussions, research presentations, and project critiques promote reflection on what worked and what could be improved.

3.3.5-GreenComp Focus: Acting for sustainability, including the competencies through applied research and development of sustainable design solutions.

2.4-Evaluation: Assess research quality, prototype viability, and contributions to sustainability in design.

2.5-Feedback and Adjustment: Use feedback from research, industry partners, and project presentations to update the curriculum and introduce emerging green technologies.

4. Professional / Lifelong Learning



4-Curriculum Structure

2.1-Aims and Goals: Enable professionals to apply biodesign expertise in the industry, fostering green leadership and innovative applications.

1.1.1- GreenComp Focus: Acting for sustainability, including the competences through strategic green solutions and impact-driven design.

2.2-Content: Biodesign innovation, green tech applications, and sustainability leadership; specialized green competencies for targeted industries:

-Advanced Biodesign and Sustainable Innovation
-Key Topics: Cutting-edge biomaterials (e.g., synthetic tissues, biodegradable plastics), advanced bioprinting, bio-augmented reality.
-Skills Emphasized: Research translation to industry, advanced material engineering, innovation management.
-Biodesign Leadership and Project Management
-Key Topics: Design project management, stakeholder engagement, interdisciplinary team leadership.
-Skills Emphasized: Strategic planning, project management, leadership in innovation contexts.
-Specialized Modules (e.g., Bioelectronics, Biopharmaceuticals, Food Biodesign) -
-Modules tailored to specific industries (e.g., bioelectronics, sustainable packaging, or biomedical design).
-Skills Emphasized: Industry-specific applications, technical specialization.
-Business and Commercialization of Biodesign Products
-Key Topics: Market research, regulatory compliance, sustainable business practices, intellectual property.
-Skills Emphasized: Business model development, patenting, market adaptation for biotech solutions.
-Professional Certification Project or Innovation Portfolio
-Capstone: Develop an innovation portfolio showcasing completed projects, research outcomes, and contributions to sustainable biodesign.
-Industry Presentation: Pitch to industry stakeholders or present at a biodesign or sustainability conference.

4.2.1-GreenComp Focus: Embodying sustainability values, including the Competence by embedding sustainability as a core part of business strategy and design philosophy.

4.3-Learning Experiences (Active Experimentation > Concrete Experience > Reflective Observation > Abstract Conceptualization):

4.3.1-Active Experimentation: Professionals start with experimental projects that apply advanced biodesign concepts, such as developing a biodesign solution for a specific industry problem. Examples include using biofabrication techniques for sustainable packaging or creating bio-based electronics for environmental applications.

4.3.2-Concrete Experience: These experiments lead to tangible prototypes or solutions that are tested in real-world settings. Professionals may pilot their innovations in a commercial or industrial context, gathering performance data and user feedback.

4.3.3-Reflective Observation: After testing, they assess the effectiveness of their designs, reflect on what improvements could be made, and consider how these solutions impact the ecosystem or meet sustainability goals.

4.3.4-Abstract Conceptualization: Based on these observations, they refine their understanding of biodesign principles and update their approach, contributing new insights and potentially influencing industry standards or biodesign practices.

4.3.5-GreenComp Focus: Envisioning sustainable futures, including the competences by planning sustainable design approaches for the industry.

4.4-Evaluation: Evaluate the success of prototypes, impact on sustainability goals, and feedback from industry applications.

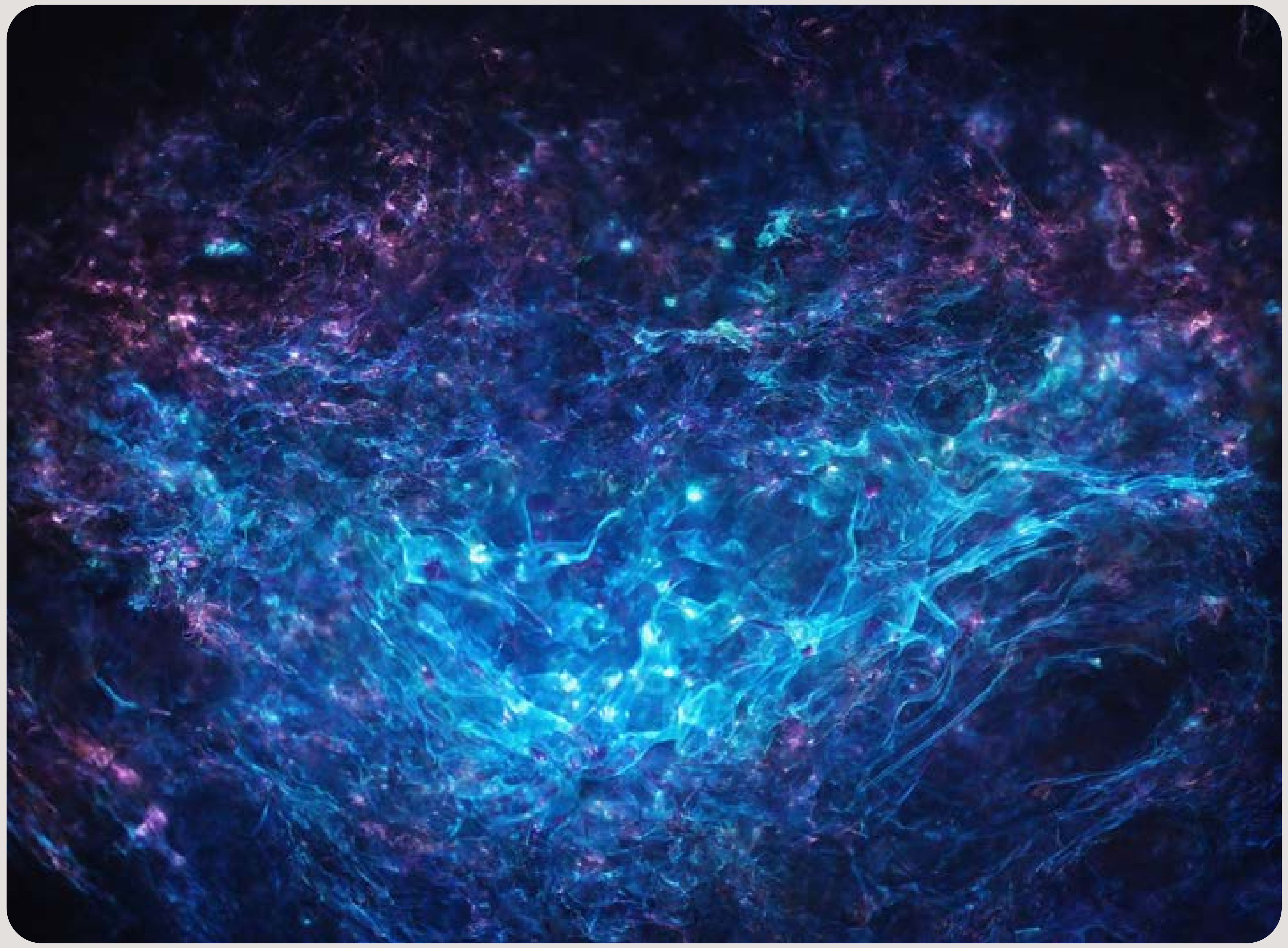
4.5-Feedback and Adjustment: Incorporate industry insights to adjust curriculum, keeping it relevant to cutting-edge green technology developments and market needs.

Conclusion

Model

The diagram presents an innovative integration of Kolb's experiential learning cycle and the Wheeler method of curriculum development, framed within a sustainability and lifelong learning context. It aligns learning processes (experiencing, observing, thinking, and doing) with essential competencies for sustainability, such as systems thinking, critical thinking, and adaptability. By embedding these skills across secondary education, vocational training, and higher education, the model fosters future literacy and promotes individual initiative, collective action, and political agency.

This approach locks for an innovative vision by synthesizing well-established pedagogical theories with contemporary sustainability priorities, creating a framework for transformative education. It emphasizes iterative curriculum development, ensuring relevance and adaptability to evolving global challenges. Ultimately, the model not only equips learners with critical skills but also instills values like fairness and environmental stewardship, cross-fertilization between different knowledge fields, and aligning education with the goals of sustainable development.



Advancing Biodesign Education through the CoCoon Project: Methodologies, Methods, and Biomodules

The methodologies and methods developed in CoCoon deliverable D3.3 demonstrate significant potential for integration across multiple educational and professional sectors. These methodologies, coupled with teaching and learning approaches, are designed to support educational innovation efforts targeting various CoCoon audience groups. Furthermore, they aim to foster inclusivity in the green transition by bridging diverse actors and disciplines. By embedding robust biodesign skills into diverse curricula, CoCoon emerges as a groundbreaking and fully innovative educational initiative.

Deliverables D3.2 and D3.3 identified biobased solutions with substantial potential for broader implementation. These solutions were subsequently transformed into comprehensive educational resources, including courses, seminars, workshops, and instructional tools. The incorporation of courses on biobased designs, emphasizing living materials, was systematically tested during the co-development phase of Work Package 3. This phase engaged the learning environments of various CoCoon partners to refine and validate the methodologies and resources.

Crucially, CoCoon's methodology and learning methods were developed in close alignment with deliverable D3.4, the Biomodule framework. Each Biomodule was designed to complement and enhance the progressive development of skills and competencies in biodesign. The Biomodules offer flexibility, enabling lifelong learners to acquire skills at their own pace without requiring completion of a full biodesign course. This modular approach supports the cultivation of green skills within the maker community, fostering engagement and innovation.

The CoCoon methodology, in conjunction with the Biomodules, provides adaptive learning systems tailored to the green transition. By facilitating the adoption of innovative methods at a pace suited to different target groups and audiences, these resources promote biodesign integration across a wide array of educational contexts. This adaptability supports the advancement of green innovations within educational frameworks.

Deliverable D3.4 successfully met its goals and objectives through the following key contributions:

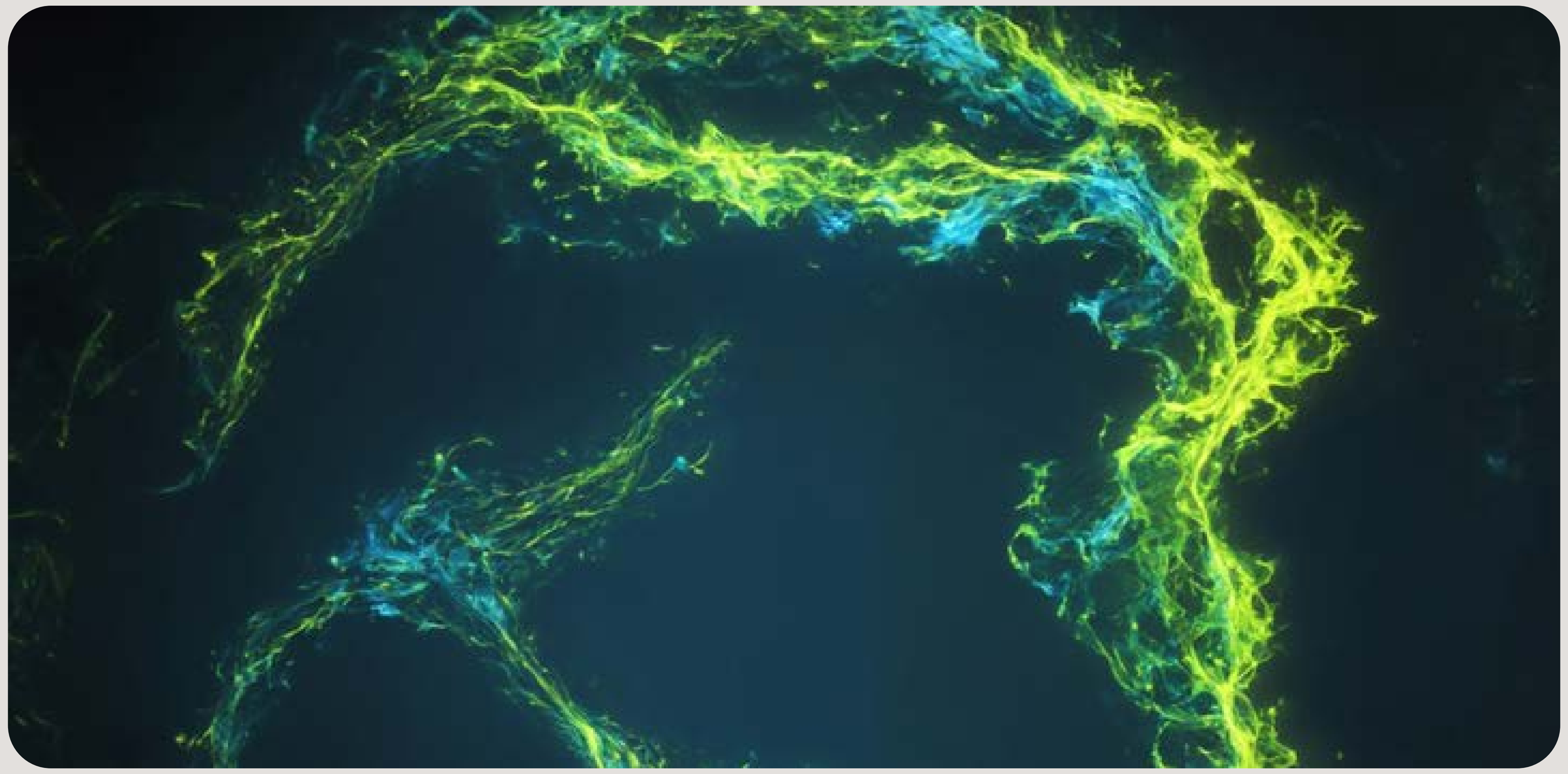
•Integration of Biodesign Methodology into Education
Biodesign methodologies and learning approaches were embedded into vocational education and training (VET), higher education, and lifelong learning contexts. The primary focus was on empowering learners by enhancing bio-prototyping skills, supported by digital technologies.

•Incorporation of GreenComp
The Biomodules for teachers and trainers incorporated the GreenComp frameworks to foster learner agency within biodesign education, promoting sustainable practices and entrepreneurial competencies.

•Redefining Teacher Education
Courses and methodologies were developed to inspire teachers to redesign traditional courses by integrating GreenComp-aligned sustainable practices, ensuring long-term impact on teaching strategies.

•Transformation of Fab Labs and Makerspaces
The project proposed the evolution of Fab Labs and makerspaces into Bio Fab Labs, emphasizing a hands-on, practical approach to the green transition and biodesign education.

•Educational Innovation Pathways
Through deliverable D3.3, the CoCoon project offers the educational community a robust infrastructure for establishing innovation pathways in biodesign education. These resources empower educators and learners to actively contribute to the green transition by embedding sustainability into their practices and fostering collaboration across disciplines



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