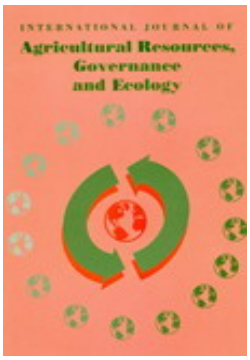
INDERSCIENCE PUBLISHERS
Linking academia, business and industry through research



International Journal of Agricultural Resources, Governance and Ecology

ISSN online: 1741-5004 - ISSN print: 1462-4605
https://www.inderscience.com/ijarge

Enacting possibility thinking in academic curricula: fostering higher education students' green skills for a sustainable future

Antonia Symeonidou, Mariantonietta Fiore, Danilo Audiello, Fedele Colantuono, Pamela Burnard

DOI: 10.1504/IJARGE.2025.10075073

Article History:

Received:	02 December 2024
Last revised:	05 December 2024
Accepted:	26 February 2025
Published online:	15 December 2025

Enacting possibility thinking in academic curricula: fostering higher education students' green skills for a sustainable future

Antonia Symeonidou

Cambridge Innovation Hub,
11c Kings Parade, Cambridge,
Cambridgeshire, CB2 1SJ, England
Email: antonia.symeonidou@gmail.com

Mariantonietta Fiore

Department of Economics,
University of Foggia,
R. Caggese 1, 71121, Foggia, Italy
Email: mariantonietta.fiore@unifg.it

Danilo Audiello*

Universitá degli studi di Bari Aldo Moro,
Piazza Umberto I, 1, 70121 Bari BA, Italy
Email: daniloaudiello@icloud.com
*Corresponding author

Fedele Colantuono

Department of Economics,
University of Foggia,
R. Caggese 1, 71121, Foggia, Italy
Email: fedele.colantuono@unifg.it

Pamela Burnard

Faculty of Education,
University of Cambridge,
184 Hills Road, Cambridge CB2 8PQ, England
Email: pab61@cam.ac.uk

Abstract: Education for sustainability and green skills development is at a critical crossroad. The current conditions and available resources allow an opportunity to redefine how higher education educates the next generation for the challenges of the 21st century. With the increasing urgency to address complex global challenges, such as environmental agricultural degradation, climate change and resources depletion, it is clear that traditional educational models are inadequate to prepare students as professionals for the future

workforce. Therefore, it is crucial to deliver calibrated education that builds students' problem-solving skills and the power of 'possibility thinking' through complex challenges. 'Possibility thinking' requires re-imagining what is not there (asking 'what if?') and creating paths and new possibilities beyond current worldview, expectation or experience (asking 'what can be?'). The project featured in this article aims to define a new paradigm for sustainability education using core aspects of 'possibility thinking'. Conclusions highlight the need for universities to integrate new scientific discoveries, emerging technologies, tools and interdisciplinary approaches.

Keywords: green skills; bioeconomy and governance; resource depletion; sustainability education (or sustainable futures); possibility thinking; academic curricula; higher education; HE.

Reference to this paper should be made as follows: Symeonidou, A., Fiore, M., Audiello, D., Colantuono, F. and Burnard, P. (2025) 'Enacting possibility thinking in academic curricula: fostering higher education students' green skills for a sustainable future', *Int. J. Agricultural Resources, Governance and Ecology*, Vol. 20, No. 6, pp.4–18.

Biographical notes: Antonia Symeonidou is a Creative Learning Educator, Entrepreneur, and Bioengineering PhD from the University of Cambridge, with a multidisciplinary career at the intersection of science, education, and innovation. She is the founder of the Cambridge Innovation Hub, where she leads initiatives that blend engineering, illusion, and storytelling to foster wonder-driven learning. She has developed over 800 hours of teaching material and delivered more than 200 talks worldwide, spanning technical topics, soft skills, and future-focused education. Her work includes university-level course design, museum exhibit design, and the creation of 'Stuporism' – a new movement promoting curiosity-led exploration across disciplines. In parallel, she retains strong ties with the international trade and supply chain finance industry, acting as a consultant and project manager allying with investors to efficiently channel funds into targeted industries and markets.

Mariantonietta Fiore is a Full Professor in Agricultural Economics at the University of Foggia, Italy and Rector's Delegate for International Affairs. She is a member of the Doctoral School of the Warsaw University of Life Sciences and a Senior Fellow of the EuroMed Academy of Business, included in the world's top 2% scientists list 2023. She is a scientific coordinator of NRRP, Erasmus and national projects, and was vice-coordinator of the SKIN (H2020) project. She has participated in many international conferences and Erasmus visits, received over 15 scientific awards, and authored more than 180 publications (80 in Scopus, H-index 24).

Danilo Audiello, aka Alexis Arts, is a Creative Director and Artist who has curated shows, exhibitions, and installations across the globe, and holds seven Guinness World Records. He holds a PhD in Economics and is the Chairman of the Academy of Magic and Science, an educational organisation born in the Accelerator of the Judge Business School at the University of Cambridge with the mission to re-invent education and creative thinking. He is currently working as a researcher at the University of Bari, focusing on stochastic models.

Fedele Colantuono is a Research Officer at the Department of Economics of the University of Foggia (Italy) and responsible for the project management of several EU funded projects, among those 'COREnet' dedicated to short food supply chain advisory systems. He graduated in Food Science and Technology

and he completed a PhD in Management Of Innovation in Agrifood systems at the University of Foggia, enriching his background in Agrifood supply chain with different working experiences. He is an expert in project management and international networks, in particular in the management of research activities and reporting of national and European projects related to different sectors and financed by various programs (e.g., PON, PRIN, FP7, Horizon Europe, H2020, Horizon Europe, ERASMUS +). He has gained different experiences at international level, not only at academic (Texas A&M University, USA), but also in the food industries (R&D Junior Manager at the Chiquita Food Innovation in The Netherlands), enlarging his skills on International relationships and agrifood chain.

Pamela Burnard is a Professor of Arts, Creativities and Educations at the University of Cambridge. She has authored or edited 25 books and over 150 refereed journal articles advancing theories of multiple creativities across all education sectors and the creative industries. She is a Co-Editor-in-Chief of *Thinking Skills and Creativity* and leads extensive transdisciplinary networks connecting universities, industry, schools and arts organisations. Her recent books include *Why Sciences and Arts Creativities Matter* (2020), *Doing Rebellious Research* (2022) and *The Routledge Companion to Creativities* (2023). She is a Fellow of the RSA, Chartered College of Teaching, and ISSCI, recognised internationally for her research on pluralising creativities.

1 Introduction

In recent years, society has progressively shifted towards sustainable practices and innovative solutions to address global challenges of agriculture and resource development, such as climate change and resource insufficiency (Cifuentes-Faura, 2022; Drejerska et al., 2018). This transformation has been significantly influenced by intelligent systems that boost efficiency and cost-effectiveness, all while addressing ecological and environmental considerations (Ragusa et al., 2021). On the other hand, the adoption of innovations in sustainability is essential, particularly through education and the preparation of future generations (Diederen et al., 2003; Diesendorf, 2001).

The ability to prepare a generation of students who can navigate the ever-changing technological, environmental and socio-economic landscapes and innovate in the bioeconomy and other green sectors, is crucial for the well-being of our societies, the competitiveness of our economies, and the preservation of our planet. Entering the 21st century, the concept of 'bioeconomy' is expanded beyond its initial focus on agriculture, now encompassing industries ranging from energy and healthcare to biotechnology. This expanded definition has placed emphasis, not only on the sustainable use of biological resources for food, but also on the production of bio-based products (such as bioplastics) as well as bioenergy. Colleges and universities have responded by adapting their curriculum to reflect this shift, by emphasising training that integrates life sciences with technology and business. The European Union (EU), recognising the potential of the bioeconomy to drive economic growth while addressing environmental challenges, launched the EU Bioeconomy Strategy in 2013. This ambitious strategy underscored the need for a skilled workforce capable of supporting a bio-based economy, prompting universities and vocational schools to expand their educational offerings in this field. As a result, courses on environmental-friendly bio-based technologies, circular economy

concepts, and the integration of digital tools like data analytics and artificial intelligence (AI) to enhance bioeconomic processes, were being increasingly incorporated into higher education (HE) curricula. Aligned with the United Nations' 2030 Agenda for Sustainable Development, which aims to eradicate poverty through improved education (UN, 2015), current strategies, models, and policies emphasise the importance of 'equi-lience' (equity and resilience) processes (Fiore, 2022). These approaches seek to establish a new balance between the demands of sustainable economic growth and the need for social, equitable, and environmental development (Spada et al., 2023). The traditional structure of HE curricula, especially in the sectors of agriculture and environmental science and related fields, was set up in the early 1900s with a strong focus on technical sector-specific knowledge transfer (Fongwa, 2013). Despite the introduction of sustainability concepts and circular economy principles, the fundamental format of courses and classroom settings has remained largely unchanged.

One of the most significant shifts in HE prior to the emergence of sustainability-driven curricula was the adoption of digital technology and data-driven approaches, which gained traction in recent years. However, while these changes have brought advancements, they have not adequately addressed the pressing need for green skills – a set of competencies critical for sustainable development. With the rise of machine learning and AI, the demand for up-skilling and re-skilling of students has become an imperative (Chakma and Chaijinda, 2020). It is high time that sustainability education undergoes a fundamental transformation. Education for sustainable development (ESD) represents UNESCO's strategic response to these global challenges. ESD aims to empower people with the knowledge, skills, values, attitudes and behaviours to live in a way that is good for the environment, economy, and society. It encourages people to make smart, responsible choices that help create a better future for everyone (Mohanty and Dash, 2018).

Building on the principles of 'possibility thinking', this work aims to outline a novel model for sustainability education thus nurturing HE students' green skills. 'Possibility thinking' requires both re-imagining what is not there (by asking 'what if'?) and creating paths and new possibilities that have previously been beyond our worldview, expectation, experience or comprehension, so that it can become a reality (by asking 'what else?'). The structure of this paper is as follows: first, the context of bio-economy is presented by highlighting the changing landscape of education and skills training. Then, the discussion focuses on the bioeconomy education in the EU. The methodology section introduces a new paradigm/model design to reshape education paths. Finally, the paper concludes with key insights and recommendations for future educational strategies.

2 The bioeconomy curriculum: historical context

Over the last century, the concept of 'bioeconomy – which involves utilising biological resources, processes and principles to foster economic development – has undergone major shifts, with education following this transformative journey (Fiore et al., 2022; Jaroslaw et al., 2018; Fiore et al., 2018). The roots of bioeconomy education can be traced back to the era when scientific advancements in fields like biology, agriculture, and chemistry began to reshape industrial practices (Stegmann et al., 2020). Early agricultural education made emphasis on increasing and maximising output based on conventional farming systems, improved crop varieties and the use of chemical aids

(Durham and Mizik, 2021). At its core, it was about ensuring food security and fostering economic development in rapidly industrialising countries. The fusion of technology and science with agriculture gained momentum in the mid-20th century, which in this context was epitomised during the green revolution between the 1950s and 1960s. During this period, substantial investments were made in agricultural education as well as crop and pest improvement through at universities and research institutions.

One of the main educational objectives was to prepare a generation of agricultural scientists, engineers and agronomists to meet global food needs. The green revolution was successful in giving a significant boost to agricultural productivity and its ensuing gross domestic product (GDP), but it also created unintended consequences for the environment, such as depletion of energy sources, the degradation of soil, depletion of water resources and biodiversity loss. Such challenges emphasised the requirement of a sustainable way to exploit natural resources and warranted the basement for bioeconomy education. By the 1980s and 1990s, the environmental and social consequences of industrial agriculture were becoming increasingly apparent, reinforcing the urgency of adopting sustainable development principles. In 1987, the Brundtland Report published was highly influential at many levels of educational priorities, introducing sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Hajian and Kashani, 2021). This marked a pivotal shift, as agricultural education began to move beyond 'just agriculture' and towards sustainability, ecological conservation, and responsible resource management. Bioeconomy education subsequently began to emerge as an interdisciplinary and cross-disciplinary field, integrating knowledge from biology, ecology, economics and social sciences. Educational programs started to integrate topics related to renewables, waste reduction, sustainable agriculture and biotechnological developments focused on reducing ecological footprints. Universities and research centres began offering specialised courses and degrees in environmental science, sustainable agriculture, and biotechnology, reflecting the growing demand for professionals with expertise in sustainability.

2.1 The changing landscape of higher education and skills training

The world has undergone profound transformations in recent decades, particularly in the ways we access and use information. Digital technologies, the internet, social media and in particular machine learning and AI over the past few years or so have changed the education space forever by making information more widely accessible than ever before. This shift has far-reaching implications for how we approach sustainability education. In the age of hyper-connectivity, the ability to access, process, and apply information rapidly has become a key skill. Yet, the sheer volume of data available presents a great difficulty of pinpointing a trustworthy source while also using that knowledge to create deep understanding of ecological systems and sustainable practices. The emphasis in HE is shifting away from simply acquiring knowledge toward developing creative and critical thinking skills that enable students to problem-solve in a constantly evolving environment. The development of 'possibility thinking' requires students to open out their perspectives to entertain new possibilities from what is to which might be (Chappell and Craft, 2011). Now is the time to rethink and re-engineer education systems to equip people for a rapidly transforming world, where automation, AI and other technological advancements are already reshaping – and will continue to reshape – the nature of many

jobs. Schwab (2017) advocates for an education system that focuses on critical thinking, emotional intelligence, and adaptability – skills that are essential for thriving in a future-driven by technology and rapid change.

3 Bioeconomy education in the EU

The EU has taken significant steps to position bioeconomy as a cornerstone of sustainable growth. Education and training play a crucial part in these efforts, giving people access to the knowledge and skills necessary to contribute to the bioeconomy across all areas including agriculture, forestry, usages based on biotechnology or circular economy practices. The EU has recognised the strategic importance of bioeconomy education, integrating it in its broader sustainability and green growth agenda. The EU bioeconomy strategy emphasises the need for education and training programs that equip individuals to with the skills required to tackle the challenges of the bioeconomy, such as ensuring the transition to a sustainable, low-carbon economy and fostering innovation. The strategy advocates for enhancing the skills of workers, fostering multidisciplinary learning, and promoting entrepreneurship in bioeconomy sectors. To achieve this mission, EU bioeconomy education and training programmes have been designed to cover all education relevant disciplines from primary/secondary school curriculum to tertiary (higher) and vocational trainings. Many universities in the EU have incorporated bioeconomy-related topics into existing courses and academic programs, already offered at the tertiary level, especially for agricultural sciences, environmental studies, engineering, and biotechnology. Programs such as MSc and PhD in bioeconomy, sustainable agriculture, and circular economy are becoming increasingly common across European institutions, often combining both technical expertise and sustainability awareness.

Key policy documents, such as the European green deal and the farm to fork strategy, reflect this commitment by embedding eco-innovation-related re-skilling and upskilling are embedded within conventional policies frameworks. Furthermore, the European skills agenda for sustainable competitiveness, social fairness and resilience (European Commission, 2020) was established to support individuals and business in developing more and high-quality skills, while ensuring theirpractical application in fostering sustainable competitiveness, while guaranteeing social equity. Through initiatives such as Horizon Europe or Erasmus+, the EU actively supports education and research on bioeconomy domains, by funding studies and fostering transnational collaboration. Recently, sustainable bioeconomy education and training programs have been developed to facilitate a transition to a circular economy. Paris et al. (2023) have published a comprehensive review of current practices of bioeconomy education and training in the EU. Notably, the GreenComp program was developed with the goal of fostering learning on environmental sustainability within the EU and more specifically to define a set of European sustainability competences as reference framework to feed into education programmes in order to equip learners with knowledges, skills, mindsets and attitudes that foster new ways of thinking, planning and acting in an empathetic, responsible and caring manner for our planet and public health (Bianchi et al., 2022). The Erasmus+ program has been instrumental in enhancing transnational cooperation between universities, research institutions, and industries involved in the bioeconomy. It facilitates joint degree programs, internships, and research collaborations focused on bioeconomy

and sustainability. Notably, regional initiatives like the BIOEAST, which is focused on Central and Eastern Europe, aim to enhance bioeconomy training through regional partnerships. The initiative CL4Bio, was designed to revolutionise the training methodology in HE and foster collaboration across borders that led to the development of innovative training material for teaching bioeconomy using creative learning practices that involve creative expression in the context of academic learning. Supporting creative learning involves harnessing imagination, curiosity and open-mindedness to 'possibility thinking' (that is, to ask 'what if?' and 'what else?') which catalyse possibilities for solving problems (CL4Bio Erasmus+, 2023; Beghetto, 2021).At the vocational training level, several EU member states offer specialised courses in bioeconomy-related sectors, including organic farming, renewable energy, and sustainable forestry. These programs are often developed in collaboration with industry stakeholders to ensure alignment with the current and future job market demands.

4 Methods starting from possibilities thinking: a new paradigm for sustainability education

There is a notable lack of a comprehensive and collaborative perspective that effectively combines interdisciplinary advancements with global challenges. Additionally, HE curricula lack a holistic and internationalised vision. To address the complex challenges of the 21st century, educators must adopt innovative approaches that extend above and beyond traditional teaching methods. One such approach is possibilities thinking (Craft et al., 2012; Burnard et al., 2006), as an aspect of creativity in learning. This pedagogical framework is designed to leverage critical thinking, and multi-dimensional exploration of a presented case, multiple meanings of a perceived reality and multiple potential solutions to a problem, in order to cultivate green skills by encouraging learners to ask the 'what ifs', to imagine sustainable futures, to think systemically, and innovate within ecological and economic constraints.

4.1 Core aspects of possibilities thinking

- Imaginative/creative exploration: encouraging students to visualise sustainable solutions and question the status quo of what is known and what is possible (asking 'what if?') and being curious (asking 'what else can be?') by visualising not what is possible or probable but rather what is impossible. And by visualising the impossible, they begin to see it as possible and set out to focus on solving the problems in order to make new possibilities happen.
- Problem-based learning: fostering critical thinking by engaging learners in real-world sustainability challenges, such as the global supply chain management crisis affecting cross-border trade transactions, that the University of Foggia students of the department of economics were tasked to identify solutions – being solutions-oriented – by assuming the roles of the various stakeholders involved (Symeonidou et al., 2023a).
- Resilience building: teaching students to be determined and to adapt to changing environmental and economic conditions by exploring diverse strategies and solutions

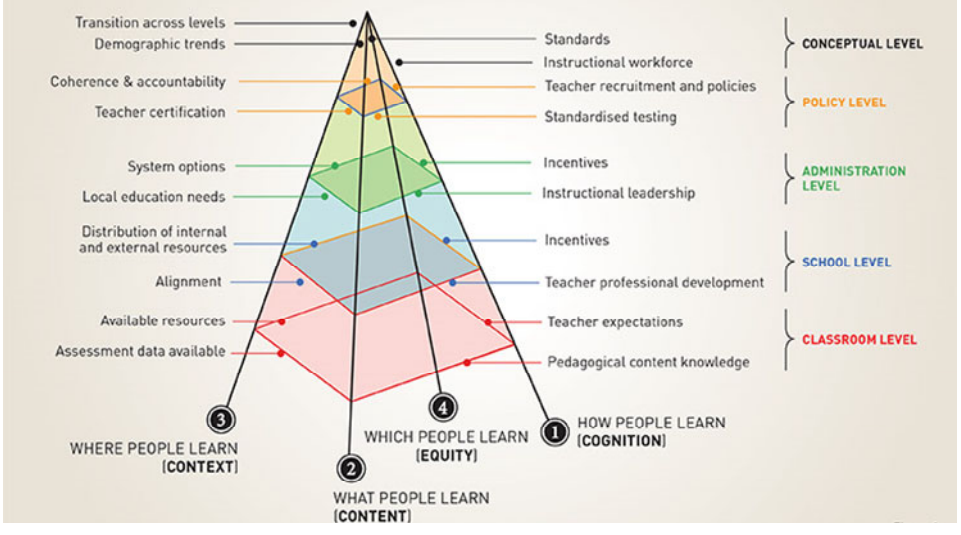
and be able to persevere and insist on focusing on solving problems and on new possibilities.

The globalisation of economy, combined with the development of digital technologies has reshaped industries and altered the distribution of labour. With sustainability being a global priority, green skills have become one of the significant drivers of economic competitiveness. Nations that prioritise education systems designed to develop these competencies will be significantly better positioned to thrive in the emerging green economy. The shift towards sustainability is not just an environmental imperative but an economic one as well. The future of economic leadership will belong toy nations that can innovate – to create renewable energy, sustainable agriculture and circular economies. However, this requires a workforce skilled in sustainable practices, systems thinking, ecological management, etc. Which means, the importance of education is crucial in building the capacity to address these global challenges discussed.

4.2 The way forward: rethinking curriculum and pedagogy

Higher educational institutions must undergo a paradigm shift in their curriculum and Pedagogy to meet the demands of the bioeconomy and sustainable development. This includes not only embedding sustainability into current curricula but also adopting innovative methods of teaching that focus on creativity, critical thinking and interdisciplinary collaboration. A fundamental starting point is rethinking how learning is organised (Figure 1 – Lemke and Sabelli, 2008).

Figure 1 How learning is organised (see online version for colours)



Source: Lemke and Sabelli (2008)

4.3 Rethinking learning structures

To create a learning environment that aligns with sustainability goals, universities must integrate key pedagogical strategies, including:

- Interdisciplinary courses: combining knowledge from diverse scientific sectors, such as agronomy, environmental science, and economics, will provide a holistic understanding of sustainability challenges.
- Community engagement: encouraging students to work on sustainability projects within their local communities and scale these initiatives to regional and national levels, fostering a sense of civic responsibility and practical application of green skills.
- Flexible/personalised learning pathways: offering students the opportunity to explore diverse topics related to sustainability, allowing them to tailor their education pathway to their specific interests and career goals.
- Possibility thinking': inviting students to open out their perspectives to entertain new possibilities from what is to which might be.

4.4 Aligning with European sustainability competencies

The core principles of this model align closely with the council recommendation on encouraging cooperation in learning for environmental sustainability and operates within the 'European sustainability competence framework' (GreenComp) including 12 competencies organised into 4 areas:

1 Embodying sustainability values

2 Embracing complexity

3 Envisioning sustainable futures

4 Enacting sustainability.

To achieve this aim, the '4 returns model framework', emphasising an assemblage of four critical (and interdependent) outcomes:

1 Inspiration – fostering motivation and vision for sustainable change.

2 Social returns – strengthening community resilience and collaboration.

3 Natural returns – restoring and preserving ecosystems.

4 Financial returns – supporting sustainable economic models.

The '4 returns model framework' supports achievement of most of the SDGs and is itself based particularly around SDG17 (partnerships for the goals). Actively involved in addressing the European green deal initiatives and key parts, including the EU Forest strategy for 2030, EU Action plan for 0 pollution, EU Farm-to-fork strategy, EU Soil strategies for 2030, and EU Biodiversity strategy for 2030, these universities aim to achieve educative sustainability goals.

5 First conclusions: up-skilling the bio-economist of the future

The seven survival skills are 'critical thinking and problem solving'; 'collaboration across network's and 'leading' by influence; agility and adaptability; 'initiative and

entrepreneurship'; 'effective oral and written communication'; 'accessing and analysing information'; and 'curiosity and imagination' (Wagner, 2008). Drawing insights from a European survey (Ramalho Ribeiro et al., 2023) on skill needs for sustainable agri-food and forestry, being sectors in transition to novel processes, the sustainability skills, digitalisation skills, sector-specific skills, soft skills and entrepreneurial skills were the ones prioritised in training needs. To prepare the 21st century workforce, a profound transformation of the entire education system is required but particularly in HE. Job markets have become more polarised as many of the mid-skill jobs that developed during the 20th century, particularly in manufacturing, have been eliminated by new technologies or outsourced to emerging economies. For agricultural professionals to transition towards a sustainable future, the identified categories of skills were systems perspective, lifelong learning, knowledge integration, building networks and learning communities, technical sector-specific knowledge and skills (Sørensen et al., 2021).

To prepare students for these challenges, HE institutions must embrace innovative methodologies like lecture-shows, interactive talks, and creative learning strategies, as highlighted in the CL4Bio Erasmus+ (2023) initiative.

- Inter, trans and cross-disciplinary understanding: bioeconomists must have a strong foundation in multiple disciplines, including biology, ecology, economics, and technology. They need to understand the science behind bio-based resources, the economics of sustainable development, and the technological innovations driving the bioeconomy. The Erasmus+ project CL4Bio (see https://cl4bio.web.ua.pt/) emphasised the multidisciplinary and cross-disciplinary nature of developing holistic, sustainable solutions.

- Systems thinking: a core skill for future bioeconomists is systems thinking which involves comprehending and navigating the interdependence among natural, economic, and social systems. This skill is crucial for designing sustainable bioeconomic models that consider the full life cycle of resources, from production and consumption to waste management and recycling. Systems thinking helps bioeconomists identify synergies, optimise resource use, and mitigate unintended environmental impacts. Global citizenship education empowers students to become proactive global citizens who can solve complex, interconnected problems such as climate change and inequality (UNESCO, 2013). During the Erasmus+ CL4Bio project, HE lecturers were trained to practice systems thinking with their students, by using possibility thinking approach to project on a canvas possible interactions and development of dynamics in a potential real-world application of their proposed solutions to challenges.

- Sustainability expertise: familiarity of sustainable best practices is essential for bioeconomists. They must be proficient in strategies like circular economy principles, sustainable agriculture, renewable energy, and waste minimisation. This skillset empowers them to lead the shift in the direction of more environmentally friendly processes and policies, aiding the world in obtaining sustainability objectives like those laid out within the UN's sustainable development goals (SDGs).

- Big data analysis and digital skills: we already live in a 'big data' economy and the plethora of data available empowers the digitally literate bioeconomists of the future to stay ahead of the curve. Bioeconomists must possess strong analytical skills, including proficiency in data analysis, statistical modelling, and digital tools such as

geographic information systems (GIS) and big data analytics. Additionally, familiarity with emerging technologies like AI, machine learning, and blockchain can enhance their ability to optimise bioeconomic systems, predict trends, and make informed decisions (Morandini et al., 2023). Possibility thinking can equip bioeconomists with the ability to shift perspectives, identify possible misdirection in the data collection, statistical data analysis and data presentation methods.

- 'Possibility thinking' (conceptualised as being central to creative learning and which includes creative thinking, innovation and problem-solving skills): future bioeconomists must of course be possibility thinkers (which include creative thinkers, innovators and problem-solvers) who develop innovative solutions to complex bioeconomic challenges. It takes a combination of critical thought, creativity, and flexibility. Be creative, reimagine, make possibilities happen: bioeconomists need to get innovative and devise sustainable innovations to design new bio-based products, efficient resources and ways to decrease environmental footprints. Students need to critically engage with the word's problems and act as agents of change (Freire and Freire, 1994).
- Policy and regulatory awareness: understanding what bioeconomic initiatives have been enacted or proposed by various authorities and other nations, understanding the constraints imposed by policies associated with environmental protection, resource management, and public health is critical to bioeconomists. Bioeconomists should be knowledgeable about international and local regulations, environmental policies, and incentive structures that promote sustainable practices. This awareness allows them to navigate regulatory environments effectively and push for policy changes favourable towards bioeconomic development.
- Entrepreneurial mindset: there is an increasing amount of entrepreneurship opportunities that will come as the bioeconomy continues to grow. Bioeconomists with an entrepreneurial mindset will be in position to spot market gaps, build sustainable business models and drive innovations in areas such as bioenergy, bioplastics and sustainable agriculture. This will be particularly important for anyone who wants to start their own bio-based focused start-ups or lead projects within already established organisations that are looking to expand their efforts in this area. During the Erasmus+ CL4Bio project, university students were invited to identify and research the work of startups active in the aforementioned areas and create a mockup of their own startup, training in the process a series of entrepreneurial skills and soft skills.
- Collaboration and communication skills: bioeconomists will be required to share their findings in a way that various stakeholders – policymakers, industry stakeholders, and the wider public as well as scientists who may not be expert in the field of bioeconomy – can understand. This surpasses what we would refer to as 'science communication' and extends beyond, to cover cultural differences, understanding the contrasting interests that various stakeholders may have in their agenda, etc. Teamwork skills are also needed, as many bioeconomy projects are cross-disciplinary and cross-sectoral. Partnership-building and enabling inter-/trans-and cross-disciplinary coordination is an essential element for success in bioeconomic practices. During the Erasmus+ CL4Bio project, students were engaged in presentation marathons, preparing to interact and connect with different audiences,

they were trained in debating as individuals, designing new possibilities, posing new questions, solving problems as manifest in the learning engagement, while competing in teams, battling one another.

- Ethical and social awareness: with the increasing focus on sustainability, bioeconomists must also consider the ethical and social implications of their work. This includes understanding the impact of bioeconomic activities on communities, biodiversity, and ecosystems. The bioeconomist of the future should be guided by principles of social equity, responsible innovation, and environmental stewardship, to ensure that bioeconomic development is inclusive and equitable.
- Lifelong learning and adaptability: the future that current university students are training for, may be very different to what the modern projections and models predict. Advances in technology, changes in policy, feedback mechanisms in nature and shifting societal values are some of the drivers of this change. Future bioeconomists need to be committed to lifelong learning, continuously updating their skills and knowledge to keep pace with new developments. Adaptability and resilience are also key, as bioeconomists must be able to respond to emerging challenges and opportunities in a dynamic and uncertain global landscape.

6 Final conclusions: the future of bioeconomy education

Looking ahead, the future of bioeconomy education depends on its ability to adapt to the changing global landscapes in which new challenges and opportunities arise. There is a growing emphasis on ensuring students are acquiring the 'green skills' for sustainability such as systems thinking, resilience, and innovation to navigate climate change and broader resource constraints and ecological degradation. For future generations to thrive in a world that faces both ecological and social crises, education systems must foster 'possibility thinking', systems and design thinking, resilience, and environmental stewardship (Wals and Corcoran, 2023). As we now move forward towards a sustainable bio-based economy, universities will need to adapt and facilitate integration at many levels with new scientific discoveries in both agriculture and materials needs, by implementation of emerging technologies, and interdisciplinary approaches. Advancing new approaches to bioeconomy education is essential for preparing the next generation of leaders, scientists, and entrepreneurs to drive sustainable economic growth while safeguarding the planet's biological resources. The journey of bioeconomy education, from its roots in traditional agricultural sciences to its current status as a multidisciplinary field focused on sustainability, reflects the broader societal shift towards a greener, more sustainable future. As we continue to confront global environmental challenges, it is critical that HE learns how to transform ideas into reality through 'possibility thinking', that is, making possibilities happen that support a bioeconomy as both an enabler of economic development and environmental conservation.

As we collectively tackle the two challenges of environmental degradation and economic uncertainty, it is imperative that we rethink how we educate the next generation and equip them for an uncertain and certainly unknown future. The integration of 'Possibility Thinking' into sustainability education can shape and drive a powerful framework to equip students with the green skills needed to build a sustainable future. Cultivating creative ways of thinking, adaptability in response to change, and

collaboration with parties of different perspectives, educators can inspire their students to envision and create a more sustainable world.

The time for a major transformation in HE is now.

As we look to the future and future-making in HE, the role of asking 'what if?' and 'what might be' is paramount for promoting sustainability and green skills. 'Possibility Thinking' will be crucial in shaping a resilient and prosperous society. It is not just about preparing students for jobs – it is about preparing them to be stewards of the planet and guardians of the earth capable of making a positive impact in the world they inherit.

Funding

Co-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 National Agency of Erasmus+ Programme. Neither the European Union nor the National Agency of Erasmus+ Programme can be held responsible for them. Project Number: 2022-1-PL01-KA220-HED-000087008.

References

Beghetto, R.A. (2021) 'Creative learning in education', in: Kern, M.L. and Wehmeyer, M.L. (Eds.): *The Palgrave Handbook of Positive Education*, pp.473–491, Palgrave Macmillan, Cham, https://doi.org/10.1007/978-3-030-64537-2_19.

Bianchi, G., Pisiotis, U. and Cabrera Giraldez, M. (2022) *GreenComp The European Sustainability Competence Framework* (No. JRC128040), Joint Research Centre (Seville site).

Brundtland, G.H. (1987) *Our Common Future: Report of the World Commission on Environment and Development*, UN-Dokument A/42/427, Geneva.

Burnard, P., Craft, A., Cremin, T., Duffy, B., Hanson, R., Keene, J. and Burns, D. (2006) 'Documenting 'possibility thinking': a journey of collaborative enquiry', *International Journal of Early Years Education*, Vol. 14, No. 3, pp.243–262, https://doi.org/10.1080/09669760600880001.

Chakma, S. and Chaijinda, N. (2020) /Importance of reskilling and upskilling the workforce', *Interdisciplinary Scripatum Chonburi Journal*, Vol. 6, No. 2, pp.23–31.

Chappell, K. and Craft, A. (2011) 'Creative learning conversations', *Educational Research*, Vol. 53, No. 3, pp.363–385.

Cifuentes-Faura, J. (2022) 'European Union policies and their role in combating climate change over the years', *Air Quality, Atmosphere and Health*, Vol. 15, No. 8, pp.1333–1340.

CL4Bio Erasmus+ (2023) *Creative Learning for Boosting Bio-Economy within HEIs' Curricula* [online] https://cl4bio.web.ua.pt (accessed 12 December 2023).

Craft, A., Cremin, T., Burnard, P., Dragovic, T. and Chappell, K. (2012) 'Possibility thinking: culminative studies of an evidence-based concept driving creativity?', *Education*, Vol. 41, No. 5, pp.538–556, https://doi.org/10.1080/03004279.2012.656671.

Diederen, P., Van Meijl, H. and Wolters, A. (2003) 'Modernisation in agriculture: what makes a farmer adopt an innovation?', *International Journal of Agricultural Resources, Governance and Ecology*, Vol. 2, Nos. 3–4, pp.328–342.

Diesendorf, M. (2001) 'Models of sustainability and sustainable development', *International Journal of Agricultural Resources, Governance and Ecology*, Vol. 1, No. 2, pp.109–123.

Drejerska, N., Perzanowski, M., Gołębiewski, J. and Fiore, M. (2018) 'From a concept to implementation of food chain within the Circular Economy paradigm: the case of Poland', *Rivista Di Studi Sulla Sostenibilita*, Article 1, https://doi.org/10.3280/RISS2018-001007.

Durham, T.C. and Mizik, T. (2021) 'Comparative economics of conventional, organic, and alternative agricultural production systems', *Economies*, Vol. 9, No. 2, p.64.

European Commission (2020) *European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Commission Bioeconoomy Strategy (2013) [online] https://research-and-innovation.ec.europa.eu/research-area/environment/bioeconomy/bioeconomy-strategy_en (accessed 2 December 2023).

European Commission: Directorate-General for Research and Innovation (2013) *A Bioeconomy Strategy for Europe: Working With Nature for a More Sustainable Way of Living*, Publications Office [online] https://data.europa.eu/doi/10.2777/17708 (accessed 14 May 2025).

Fiore, M. (2022) 'Equilience (equity+ resilience) for global well-being', in *Encyclopedia of Quality of Life and Well-Being Research*, pp.1–3, Springer International Publishing, Cham.

Fiore, M., Sauvée, L. and Wiśniewska-Paluszak, J. (2022) 'Opportunities and challenges of EU farm-to-fork strategy', *International Food and Agribusiness Management Review*, Vol. 25, No. 5, pp.703–707.

Fiore, M., Spada, A., Contò, F. and Pellegrini, G. (2018) 'GHG and cattle farming: CO-assessing the emissions and economic performances in Italy', *Journal of Cleaner Production*, Vol. 172, pp.3704–3712.

Fongwa, N.S. (2013) *Universities in Regional Development: Knowledge Transfer in a Less Favoured Region*, Doctoral Dissertation, University of the Free State.

Freire, P. and Freire, A.M.A. (1994) *Pedagogy of Hope: Reliving Pedagogy of the Oppressed,* Continuum, New York, USA.

Hajian, M. and Kashani, S.J. (2021) 'Evolution of the concept of sustainability. From Brundtland Report to sustainable development goals', in *Sustainable Resource Management*, pp.1–24, Elsevier, Oxford, UK.

Jaroslaw, G., Perzanowski, M., Drejerska, N. and Fiore, M. (2018) 'From a concept to implementation of food chain within the circular economy paradigm: the case of Poland', *rivista di studi sulla sostenibilità*, Vol. 8, No. 1, pp.71–86.

Lemke, J.L. and Sabelli, N.H. (2008) 'Complex systems and educational change: towards a new research agenda', *Educational Philosophy and Theory*, Vol. 40, No. 1, pp.118–129, https://doi.org/10.1111/j.1469-5812.2007.00401.x.

Mohanty, A. and Dash, D. (2018) 'Education for sustainable development: a conceptual model of sustainable education for India', *International Journal of Development and Sustainability*, Vol. 7, No. 9, pp.2242–2255.

Morandini, S., Fraboni, F., De Angelis, M., Puzzo, G., Giusino, D. and Pietrantoni, L. (2023) 'The impact of artificial intelligence on workers' skills: upskilling and reskilling in organisations', *Informing Science*, Vol. 26, pp.39–68.

Paris, B., Michas, D., Balafoutis, A.T., Nibbi, L., Skvaril, J., Li, H., Pimentel, D., da Silva, C., Athanasopoulou, E., Petropoulos, D. et al. (2023) 'A review of the current practices of bioeconomy education and training in the EU', *Sustainability*, Vol. 15, No. 2, p.954, https://doi.org/10.3390/su15020954.

Ragusa, C., Tsai, I.T. and Aleksandrovna, I.G. (2021) 'Special issue on: IoT in agriculture', *Editorial. International Journal of Agricultural Resources, Governance and Ecology*, Vol. 17, Nos. 2–4, pp.1–2.

Ramalho Ribeiro, A., Goodburn, B., Mayor, L., Lindner, L.F., Knöbl, C.F., Trienekens, J., Rossi, D., Sanna, F., Berruto, R. and Busato, P. (2023) 'Skill needs for sustainable agri-food and forestry sectors (II): insights of a European survey', *Sustainability*, Vol. 15, No. 5, p.4115, https://doi.org/10.3390/su15054115.

Schwab, K. (2017) *The Fourth Industrial Revolution*, Portfolio Penguin, London, England.

Sørensen, L.B., Germundsson, L.B., Hansen, S.R., Rojas, C. and Kristensen, N.H. (2021) 'What skills do agricultural professionals need in the transition towards a sustainable agriculture? A qualitative literature review', *Sustainability*, Vol. 13, No. 24, p.13556, https://doi.org/10.3390/su132413556.

Spada, A., Fiore, M. and Galati, A. (2023) 'The impact of education and culture on poverty reduction: evidence from panel data of European countries', *Soc Indic Res*., https://doi.org/10.1007/s11205-023-03155-0.

Stegmann, P., Londo, M. and Junginger, M. (2020) 'The circular bioeconomy: its elements and role in European bioeconomy clusters', *Resources, Conservation and Recycling*, Vol. 10, No. 6, p.100029.

Symeonidou, A., Fiore, M., Colantuono, F., Audiello, D. and Burnard, P. (2023a) 'Creative problem-solving practices amplifying threshold concepts of 'green', 'circular' and 'bio economy': emerging evidence from an instrumental case study of modules involving undergraduate Italian economics students', in *Book Of Abstracts Of Open Workshop In 'Sharing Good Practices In The Field Of Creative Learning And Bio-Economy From Invited And Partners' Organizations*, UA Editora University of Aveiro, https://doi.org/10.48528/2ay1-rm91.

Symeonidou, A., Fiore, M., Audiello, D., Colantuono, F., and Burnard, P. (2023b) 'Higher education creative pedagogies: evidencing perceived impact on lifelong learning from the creative learning 4 bioeconomy (CL4bio) Erasmus project', in Antonicelli M., D'Uggento A.M., Maggino F., Marin C., Tarzia A., Trapani M. (Eds.): *AIQUAV Conference 2023 Quality of Life: Challenges and Opportunities in the Crossroads of the Mediterranean*, Associazione Italiana per gli Studi sulla Qualità della Vita, Università degli Studi di Bari Aldo Moro.

UN General Assembly (2015) *Transforming our World: the 2030 Agenda for Sustainable Development*, A/RES/70/1, 21 October 2015.

UNESCO (2013) *Global Citizenship Education: Preparing Learners for the Challenge of the 21st Century*. United Nations Educational, Scientific and Cultural Organization (UNESCO).

Wagner, T. (2008) *The Global Achievement Gap: Why Even Our Best Schools Don't Teach the New Survival Skills Our Children Need--and What We Can Do About It*, Basic Books.

Wals, A.E. and Corcoran, P.B. (Eds.) (2023) *Learning for Sustainability in Times of Accelerating Change*, Wageningen Academic, Leiden, The Netherlands, https://doi.org/10.3920/978-90-8686-757-8.