GENB
YOUNG BIOVOICES
FOR A SUSTAINABLE
FUTURE

D4.3

Impact monitoring and assessment Report – Second Period

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OUR CONSORTIUM

APRE Agenzia per la Promozione della Ricerca Europea
btg biomass technology group
LOBA®
PEDAL CONSULTING
European Schoolnet
ZSI
aiju INSTITUTO TECNOLÓGICO DEL PRODUCTO INFANTIL Y OCIO
Q-PLAN INTERNATIONAL
FVA NEW MEDIA RESEARCH
Hellenic Society for the Protection of Nature

Funded by the European Union

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Abstract	This deliverable consists of a report (linked to the second reporting period) on the assessment of GenB project's activities and Key Exploitable Results (KERs)
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Funded by the European Union

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1.1	25/04/2025	Adrián Chacón Carrascosa (AIJU), Pablo Busó (AIJU), Clara Blasco-López (AIJU)	Final version

Table of Abbreviations and Acronyms

Abbreviation	Meaning
AIJU	ASOCIACIÓN DE INVESTIGACIÓN DE LA INDUSTRIA DEL JUGUETE CONEXAS Y AFINES
APRE	AGENZIA PER LA PROMOZIONE DELLA RICERCA EUROPEA
BIOBEC	H2020 project, GA No. 101023381, https://biobec.eu/
BIOBRIDGES	H2020 project, GA No. 792236, https://www.biobridges-project.eu/
BIOVOICES	H2020 project, GA No. 774331, https://www.biovoices.eu/
BIOWAYS	H2020 project, GA No. 720762, https://www.bioways.eu/
BLOOM	H2020 project, GA No. 773983, https://bloom-bioeconomy.eu/
BTG	B.T.G. BIOMASS TECHNOLOGY GROUP BV
DoA	Description of Action
CoP	Community of Practices
D	Deliverable
Ec	Economic
En	Environmental
ES	Spain
EU	European Union
EUN	EUN PARTNERSHIP AISBL
FVA	FVA SAS DI LOUIS FERRINI & C
HSPN	Hellenic Society for the protection of nature
HE	Horizon Europe
KER	Key Exploitable Results
Kn	Knowledge
KIP	Key Impact Pathways
KPI	Key Performance Indicator
LAL	Learning Activation Lab
LOBA	GLOBAZ, S.A
M	Man
Me	Mean
MOOC	Massive Open Online Course
N/A	Not applicable
PEDAL	Pedal Consulting s.r.o.
PhD	Philosophie Doctor
QPLAN	Q-PLAN INTERNATIONAL ADVISORS PC
Sa	Satisfaction
Sc	Scientific
SDG	Sustainable Development Goal
So	Social
SO	Specific Objective

Abbreviation	Meaning
SOLO	Structure of Observed Learning Outcomes
SSH	Social Sciences and Humanities
T	Task
TBC	To Be Confirmed
TBD	To Be Developed
W	Women
WP	Work Package
y.o	Years old
ZSI	ZENTRUM FUR SOZIALE INNOVATION GMBH

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1 Executive Summary

The GenB project's Deliverable 4.3, "Impact Monitoring and Assessment Report – Second Period," presents a comprehensive evaluation of the project's outcomes across societal, scientific, economic, and environmental dimensions, alongside the achievement of its Specific Objectives (SOs) and Key Performance Indicators (KPIs). As a Coordination and Support Action (CSA) under Horizon Europe, GenB aimed to foster a "Bioeconomy Generation" by raising awareness, enhancing knowledge, and promoting sustainable behaviours among young people, educators, and multipliers. This report, spanning November 2022 to April 2025, assesses the effectiveness of GenB's activities and Key Exploitable Results (KERs) in aligning with the updated EU Bioeconomy Strategy, the European Green Deal, and the Sustainable Development Goals (SDGs).

The evaluation strategy, outlined in Deliverable 4.1, employed tailored methodologies: the "Activities Assessment" gauged immediate impacts of non-formal events on 383 participants across seven countries, revealing an 88% accuracy in bioeconomy understanding and high satisfaction (Me = 4.38/5). The "KER Assessment" analysed controlled interventions in schools (234 students) and a MOOC (139 teachers), demonstrating knowledge gains of 16.9% (students) and 14% (teachers), alongside sustained engagement. Scientifically, GenB produced four non-peer-reviewed articles and more than 1000 non-scientific publications, enhancing knowledge diffusion. Economically, indirect impacts were identified through policy influence (e.g., European Bioeconomy Strategy workshops) and employability prospects, while environmentally, alignment with nine SDGs and five Consumer Footprint Calculator variables underscored long-term sustainability potential. Monitoring of KPIs across SO1-SO6 confirmed near-complete achievement, with over 90% of targets met or exceeded, notably in educational outreach (e.g., 6000+ participants in SO3 activities).

These findings affirm GenB's success in cultivating bioeconomy awareness and capacity among future generations, supporting innovative governance and sustainable transitions. While direct economic and environmental impacts remain prospective, the project's indirect contributions—via education, policy engagement, and resource dissemination—position it as a catalyst for a climate-neutral Europe by 2050. Detailed results and methodologies are elaborated in subsequent sections, providing a robust foundation for scaling bioeconomy initiatives.

2 Introduction

2.1 Background of the GenB project

GenB supports the execution of the updated 2018 EU Bioeconomy Strategy and the priorities of the European Green Deal, contributing to the goal of a climate-neutral Europe by 2050 and the Sustainable Development Goals (SDGs). This involves the most significant EU-funded projects and initiatives in awareness and education (Transition2Bio, BIObec, AllThings.Biopro, WaysTUP!, BIOSWITCH, BLOOM, BIOVOICES, BIOWAYS, LIFT, Biobridges, BioCannDo, EuBioNet), as well as European and international school networks and experts in socio-economic sciences and humanities.

The primary goal of GenB is to cultivate awareness, sensitivity, and interest in environmental issues, sustainability, and circularity among the Generation Bioeconomy (GenB). To achieve this, GenB:

1. Co-creates innovative approaches in cooperation with young people, parents, teachers, and other formal and non-formal education professionals. Through societal innovation activities—such as the Common Ground Camp, Focus Groups, and Living Labs—GenB has developed formats, materials, and toolkits to foster knowledge on the bioeconomy and bio-based sectors.
2. Inspires and informs young people by raising awareness of the sustainable and circular bioeconomy, including career opportunities in bio-based industries. GenB has educated youth to adopt more sustainable and circular lifestyles, supports teachers in integrating environmental topics into their teaching, and empowers other key actors to promote the bioeconomy within their respective audiences.
3. Engages and empowers Bioeconomy Youth Ambassadors (GenB Ambassadors) as leaders of change. These ambassadors have played a crucial role in attracting and influencing their peers, amplifying their voices, and actively participating in the transition towards a sustainable bioeconomy.
4. Ensures long-term impact, scalability, and sustainability by implementing a robust communication strategy, fostering collaboration with other projects and initiatives, consolidating the GenB educational model, and has formulated policy recommendations for Ministries of Education and other decision-makers.

2.2 WP4 Objectives

The primary objective of WP4 aims to measure its impact, develop a sustainable and circular bioeconomy education model, and provide policy recommendations by implementing robust evaluation strategies, creating educational guidelines, and advising Ministries of Education to ensure effective integration into educational systems by:

- Maximising the impact of GenB activities, contents and tools (T4.1)
- Facilitating the exchange of best practices among education communities (national and European) and to transform the GenB Education Model into stakeholder-oriented, actionable knowledge (T4.2)

- Supporting the modernisation of the governance by making information and knowledge available and accessible to policymakers (T4.3)

This deliverable contains the results related to T4.1.

2.3 T4.1 Objectives

T4.1 Impact monitoring and assessment is devoted to configuring a sound impact monitoring and assessment strategy. Reliable impact indicators are to be included to monitor and assess the impact of the proposed GenB materials and activities for each of the seven interconnected actions of the GenB methodology (Co-create, Inspire & Inform, Educate, Engage, Empower and Take a role). The strategy also provides advice and guidance for fine-tuning, improvements, or corrective actions.

This deliverable is structured as follows:

- Section 1 introduces the executive summary.
- Section 2 presents the introduction.
- Section 3 provides a general explanation of the strategy designed to assess the impact in four dimensions.
- Section 4 to 7 detail the methodologies developed to measure societal, economic, scientific and environmental impacts, respectively. Each section presents the approach for capturing these impacts in a comprehensive manner.
- Section 8 presents the achievement of the Specific Objectives (SO) and Key Performance Indicators (KPIs).
- Section 9 presents the conclusions.
- Section 10 lists the references used for defining the monitoring and impact assessment processes of the GenB project.

2.4 Scope of the deliverable 4.3

This deliverable, D4.3 "Impact Monitoring and Assessment Report – Second Period," evaluates the impact of the GenB project's activities and Key Exploitable Results (KERs) during the second reporting period (Month 19 to Month 30), as part of Work Package 4 (WP4) – Impact Monitoring and Assessment. Building on the methodologies established in Deliverable 4.1 and following the initial assessment in Deliverable 4.2 (First Period), it focuses on assessing the societal, scientific, economic, and environmental dimensions of the project's outcomes, while verifying the achievement of Key Performance Indicators (KPIs) and Specific Objectives (SOs) outlined in the Description of Action (DoA). The scope encompasses the analysis of immediate educational impacts through the "Activities Assessment" in non-formal and informal settings (WP2 and WP3), which address the six interconnected actions of the GenB methodology (Co-create, Inspire & Inform, Educate, Engage, Empower, Take a Role), and the evaluation of specific KERs—such as BioHeroes: Let's Save the Planet!, The BioRace, and the MOOC—via the "KERs Assessment" in controlled educational environments (schools and online). It also includes the medium-term societal, scientific, and economic effects through the "KIPs Assessment," alongside a qualitative assessment of environmental impacts using the Consumer Footprint

Calculator and alignment with Sustainable Development Goals (SDGs). The target audiences evaluated include young people (aged 4-8, 9-13, and 14-19 years), teachers, multipliers, GenB Ambassadors, MOOC participants, and the GenB consortium, ensuring a comprehensive analysis of the project's influence across diverse stakeholders and contexts. This deliverable provides evidence-based insights to support the modernisation of governance, facilitate the exchange of best practices among educational communities, and inform policymakers, aligning with the European Green Deal and the EU Bioeconomy Strategy.

3 Global strategy for assessing the expected impact

The GenB project's global strategy for assessing its expected impact, initially outlined in Deliverable 4.1 (Section 3)[1], is designed to evaluate the quality and influence of GenB's initiatives in promoting bioeconomy awareness, advancing scientific knowledge, stimulating economic benefits, and contributing to environmental sustainability. By integrating tailored methodologies, the strategy captures immediate and long-term impacts, aligning with the project's overarching goals of fostering an informed, engaged, and sustainable bioeconomy generation. The assessment encompasses the societal and educational effects of activities and Key Exploitable Results (KERs), the scientific contributions to research and innovation, the economic value generated, and the qualitative environmental benefits, alongside a systematic tracking of progress against predefined targets. The data presented in this deliverable reflect the application of these methodologies, as detailed in subsequent sections.

3.1 Overview of the methodology

The methodology for assessing GenB's expected impact combines multiple approaches, each tailored to specific dimensions and objectives, as established in Deliverable 4.1 (Sections 4 to 9). For the societal dimension, the "Key Impact Pathways (KIPs) Assessment" evaluates long-term societal benefits through a consortium-completed questionnaire ("Societal Impact Assessment through KIPs," Appendix 3, D4.1), administered at Month 28. This is complemented by two educational-focused methodologies: the "Activities Assessment" measures immediate impacts of non-formal and informal events (Work Package 2) using a flexible questionnaire ("Societal – Educational Impact Assessment through GenB Activities," Appendix 4, D4.1) from Month 6 to Month 28, while the "KER Assessment" assesses specific KERs—such as BioHeroes: Let's Save the Planet!, The BioRace, and the MOOC—in controlled settings (schools and online) via a three-phase evaluation (pre, immediate post, follow-up; Appendix 5, D4.1) from Month 25 to Month 28. Both educational methodologies prioritize knowledge and satisfaction, using adapted scientific scales (e.g., Learning Activation Lab, Sulitest).

The scientific dimension employs the "KIPs Assessment" methodology, with a questionnaire ("Scientific Impact Assessment through KIPs," Appendix 7, D4.1) completed by the GenB consortium at Month 28, focusing on contributions to knowledge creation, diffusion, and human capital in research and innovation. Similarly, the economic dimension uses the "KIPs Assessment" approach, with a dedicated questionnaire ("Economic Impact Assessment through KIPs," Appendix 8, D4.1) administered at Month 28, evaluating innovation-based growth, job creation, and investment leveraging. For the environmental dimension, a qualitative assessment applies the "Consumer Footprint Calculator" (Section 7, D4.1), analysing 16 indicators via an expert-led registration form completed by the consortium at Month 28, alongside an alignment analysis of KERs with Sustainable Development Goals (SDGs). Finally, the monitoring of KPIs and SOs utilizes a global self-check table (Sections 8 and 9, D4.1), updated collaboratively by

[1] The deliverable has been updated on the request of the European Commission. Once it will be approved, please read the second version for a complete overview of the GenB project's global strategy for assessing expected impact.

consortium members to track progress against deadlines and quantitative targets outlined in the Description of Action (DoA), with results reported in this *D4.3 Impact Assessment - Second Period* (final results) and previously in *D4.2 Impact Assessment - First Period*.

An overall overview of the expected impact assessment configuration is shown in Figure 1.

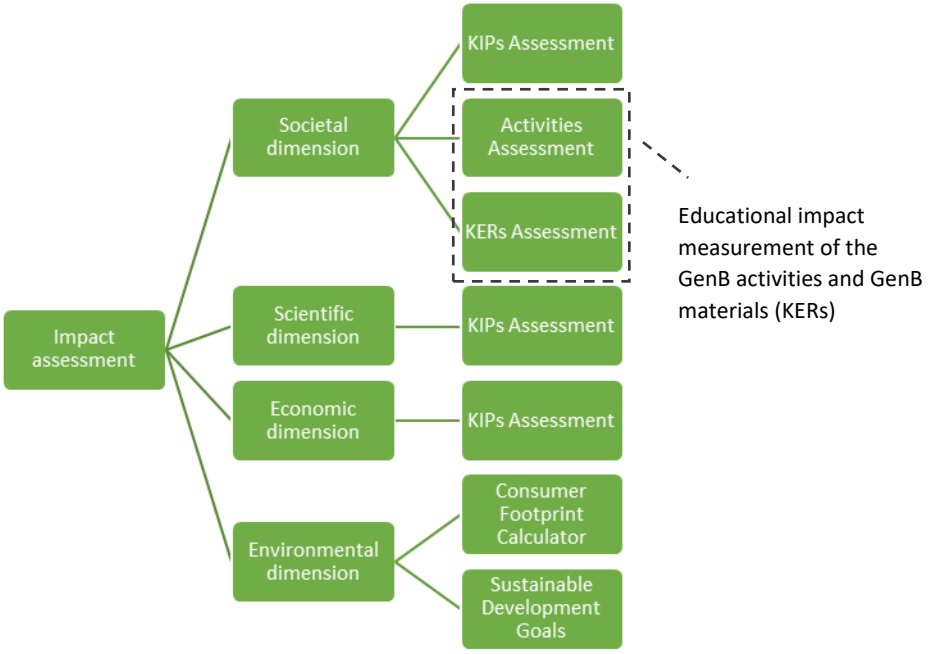

Figure 1. Overview of the expected impact assessment configuration.

In summary, the impact of the GenB project will be measured as follows: 1) the societal dimension will be assessed through "KIPs Assessment" methodology and the customised methodologies "Activities Assessment" and "KERs Assessment", 2) the scientific and 3) economic dimensions will both be measured through "KIPs Assessment" methodology, and 4) the environmental dimension will be evaluated through an expert analysis by employing the "Consumer Footprint Calculator" tool and the SDGs. Table 1 below provides an overview of the expected impact assessment strategy.

Table 1. Overview of the expected impact assessment

Dimension	Methodology	Objective	Tools and materials	Target audience
Societal	KIPs Assessment	Verify the alignment of GenB project results with EU policies (KIP's)	Survey. Questionnaire – "Societal impact assessment through KIP's" (D4.1 Appendix 3)	GenB consortium
	Activities Assessment	Analyse the change in knowledge, based on the self-assessment,	Survey. Questionnaire – "Societal–educational impact assessment	Pre- and early school children (4–8 y.o.) Elementary school children (9–13 y.o.)

Dimension	Methodology	Objective	Tools and materials	Target audience
		satisfaction and appeal of the GenB activities	through GenB activities". Two versions: Reduced and Full (Appendix 4)	High school students (14–19 y.o.) Teachers Multipliers GenB Ambassadors Other relevant participants
		Evaluate the perceived change in knowledge, based on the self-assessment, satisfaction and appeal of the GenB activities	Observation. Semi-structured informal interview	GenB consortium
	KERs Assessment	Analyse the level of change in knowledge and satisfaction	Survey. Questionnaire – "Societal–educational impact assessment through GenB materials (KERs)" (Appendix 5) Survey II. Questionnaire – educational impact assessment through MOOC" (Appendix 6)	Pre- and early school children (4–8 y.o.) Elementary school children (9–13 y.o.) High school students (14–19 y.o.)
				Participants in the MOOC
		Evaluate the perceived change in knowledge and satisfaction	Observation. Semi-structured informal interview	GenB consortium
Scientific	KIPs Assessment	Verify the alignment of GenB project results with EU policies (KIP's)	Survey. Questionnaire – "Scientific impact assessment through KIP's" (Appendix 7)	GenB consortium
Economic	KIPs Assessment	Verify the alignment of GenB project results with EU policies (KIP's)	Survey. Questionnaire – "Economic impact assessment through KIP's" (Appendix 8)	GenB consortium
Environment	Consumer Footprint Calculation	Identify the indicators included in the calculator that are addressed by the GenB project and determine the alignment of	Expert analysis method. Calculator – "Consumer Footprint Calculator" and SDGs analysis	GenB consortium

Dimension	Methodology	Objective	Tools and materials	Target audience
		the SDGs with the GenB KERs.		

3.2 Overview of the target audience

Regarding the target audience, the following groups have been identified:

- The three target groups of young people (pre- and early school children, elementary school children, and high school students) were involved in assessing societal impact through both the "Activities Assessment" and the "KERs Assessment".
- Young people, teachers, multipliers, GenB Ambassadors, and other relevant participants contributed to measuring societal impact via the "Activities Assessment".
- Participants in the MOOC were involved in assessing societal impact through the "KERs Assessment".
- The GenB consortium evaluated the societal, scientific, and economic impacts using the "KIPs Assessment". Additionally, they provided feedback on the engagement and appeal of GenB activities within the framework of the "Activities Assessment" and assessed the environmental impact through the Consumer Footprint Calculator.

Table 2 outlines a general overview of the types of participants, as well as the methodologies employed for each impact assessment and the context in which the data sources are produced.

Table 2. Overview of the target audience with the employed methodology and data source context

Target audience	KIPs Assessment (So., Sc., and Ec. Impacts)	Activities Assessment (So. Impact)	KERs Assessment (So. Impact)	Consumer Footprint Calculator (En. Impact)
Pre- and early school children (4–8 years old), Elementary school children (9–13 years old), and High school students (14–19 years old)	N/A	Various, provided by GenB activities	Educational institutions, within the framework of school interventions	N/A
Teachers, multipliers, GenB Ambassadors, and other relevant participants	N/A	Various, provided by GenB activities	N/A	N/A
Participants in the MOOC	N/A	N/A	MOOC capacity	N/A
GenB consortium	No context needed	Online meeting	N/A	No context needed

3.3 Key metrics and data segmentation for analysis

For a proper data analysis across these methodologies, the following terms are defined:

- Accuracy %: The percentage of participants providing correct responses to knowledge-based questions, indicating comprehension levels.
- Mean (Me): The average score of responses on Likert scales, reflecting central tendencies in perceptions or attitudes.
- Standard deviation (SD): A measure of response dispersion, where a lower value near 0 indicates consistency, and a higher value suggests variability.
- (W): Data segmented by women, enabling gender-specific insights.
- (M): Data segmented by men, facilitating gender comparisons.
- (4-8): Data segmented by participants aged 4 to 8 years, targeting pre- and early-school children.
- (9-13): Data segmented by participants aged 9 to 13 years, focusing on elementary school children.
- (14-18): Data segmented by participants aged 14 to 18 years, addressing high school students.

This integrated methodology ensures a holistic evaluation, capturing immediate educational outcomes, long-term multidimensional impacts, and progress toward project goals. Data collection spans various tools—questionnaires, quizzes, and expert analyses—processed to provide both quantitative metrics and qualitative insights, as further elaborated in subsequent sections of this deliverable.

4 Societal impact

To evaluate the societal impact of the GenB project, the methodology outlined in Deliverable D4.1 was employed. A questionnaire ("Societal Impact Assessment through KIPs," Annex 3 of Deliverable D4.1), based on the Key Impact Pathways (KIPs) of the European Commission, was designed by AIJU and distributed to the project coordinators and partners for completion in collaboration with AIJU.

Since the GenB project is a Coordination and Support Action (CSA), its primary objective has been to raise awareness, disseminate knowledge, and educate on bioeconomy, focusing on societal engagement rather than generating direct innovations or commercial outputs. Nevertheless, direct societal impacts have been identified in several key areas and are described in the following Section 4.1.

4.1 Societal KIPs Assessment

The application of the Societal KIPs in the GenB project identified three relevant KIPs from the Horizon Europe framework: KIP 4 (Addressing EU Policy Priorities through R&I), KIP 5 (Delivering Benefits through R&I Missions) and KIP 6 – Strengthening Uptake of R&I in Society. These are detailed and explained below.

1. GenB has directly supported EU policy priorities, notably the European Bioeconomy Strategy and the European Green Deal, by developing the GenB Toolkits—accessible online resources from Task 1.4 designed to educate and inspire on bioeconomy principles. This is related to KIP 6 – Strengthening Uptake of R&I in Society.

    a. These toolkits, encompassing games, quizzes, and educational content, provide a scalable platform that supports long-term policy goals, such as climate neutrality by 2050, through enhanced public understanding.
    b. By equipping educators and young people with actionable knowledge, the toolkits reinforce EU educational and sustainability agendas, fostering a societal foundation for policy implementation.

2. Through its awareness-raising and educational activities under WP2, GenB has delivered direct societal benefits by enhancing knowledge and engagement among over 90,000 participants, inspiring sustainable attitudes. This is related to KIP 4 and KIP 5 – Delivering Benefits through R&I Missions.

    a. The Activities Assessment (Section 4.2) achieved an 88% accuracy in bioeconomy understanding, cultivating a generation prepared to contribute to a circular bioeconomy.
    b. These educational outcomes, reaching a broad audience, enhance societal resilience and readiness to adopt sustainable practices, delivering tangible benefits aligned with EU sustainability missions.

3. GenB's activities have directly strengthened societal uptake by engaging over 90,000 participants, amplifying awareness and participation in bioeconomy initiatives through co-creation and dissemination. This is related to KIP 6 – Strengthening Uptake of R&I in Society.

    c. Initiatives such as Common Ground Camps (74 participants) and Focus Groups (1002 young people) fostered co-creation, bridging scientific knowledge and public action.
    d. This extensive outreach has cultivated an inclusive societal shift towards sustainability, reinforcing community-driven innovation across Europe.

By engaging over 90,000 individuals through WP2 activities, the project has delivered impactful educational experiences that directly support EU policy objectives, enhance societal benefits, and strengthen public participation. This unprecedented reach, complemented by the GenB Toolkits, underscores the transformative potential of GenB's initiatives, cultivating an informed and proactive populace that advances the European Green Deal and SDG ambitions, positioning GenB as a cornerstone for sustainable societal progress.

4.2 Activities Assessment

This section presents the outcomes of the "Activities Assessment," evaluating the immediate educational impact of GenB events conducted across diverse non-formal and informal settings. It assesses participants' knowledge gained and satisfaction levels, providing insights into the effectiveness of these initiatives in raising bioeconomy awareness. The activities and events were conducted as part of WP2 – Inspire, Inform, and Educate, and WP3 – Engage, Empower, and Take a Role. Specifically, the activities included:

- Role-play game on bioeconomy jobs
- TEDx pitches
- Bioeconomy careers infodays
- A day in biorefinery study visit
- Schools`projects to grow future entrepreneurs
- Educational activities using toolkits
- Bioeconomy talks/seminars inquiry-based learning
- Online bio educational village in English
- What´s bioeconomy MOOC
- How to use GenB toolkits
- Bioeconomy job profiles on factsheets explanation
- Informative webinar in partners´countries
- Bioeconomy village at large scale events
- Inside the bioeconomy experimental exhibit in existing public spaces
- BioArtGallery
- Capacity building webinars

- Workshops and webinars with GenB Ambassadors

4.2.1 Analysis of changes in knowledge, satisfaction and appeal of GenB activities

1. Methodology

The GenB project was conceived to promote bioeconomy awareness and engagement across diverse educational and societal contexts, necessitating a robust assessment of its activities' impact. This evaluation was critical to measure the extent to which GenB activities enhanced participants' knowledge of bioeconomy, their satisfaction with the interventions, and the overall appeal of the proposed approaches. Understanding these dimensions ensures that the project's efforts align with its objectives of fostering informed and motivated communities capable of contributing to sustainable development goals.

The assessment engaged a broad range of participants, including young people, teachers, multipliers, GenB Ambassadors, and other stakeholders involved in the activities' implementation. This diversity reflects the project's ambition to reach varied audiences across different countries and settings, from formal school environments to informal educational events. As consequence, a questionnaire titled "Societal – Educational Impact Assessment through GenB Activities" (see Appendix 4 of D4.1) have been designed and completed by young people and other participants during the activities to assess the impact of GenB activities within the activities' environment.

The questionnaire, available in a reduced version (used as the baseline for all activities) and a full version (with additional questions based on the event), assessed the activities' appeal and was based on participants' self-perception, their effect on bioeconomy knowledge or interest. Given the flexibility of activities across various countries and settings, a general analysis was prioritised using the reduced version.

Additionally, for a deeper and long-term impact evaluation, the "KER Assessment" methodology (see Section 4.2 of D4.1) was developed, leveraging the project's Key Exploitable Results (KERs), with details provided in Section 4.3 of this deliverable. The data presented in the named section reflects the application of these methods. For further details on the methodology approaches employed, refer to Deliverable 4.1. Together, these efforts underscore the strategic importance of assessing GenB's contributions, offering valuable evidence to refine and scale bioeconomy education initiatives.

Figure 2 shows an overview of the structure, objectives and scales employed in GenB activities assessment questionnaire to assess both knowledge gain and participant satisfaction.

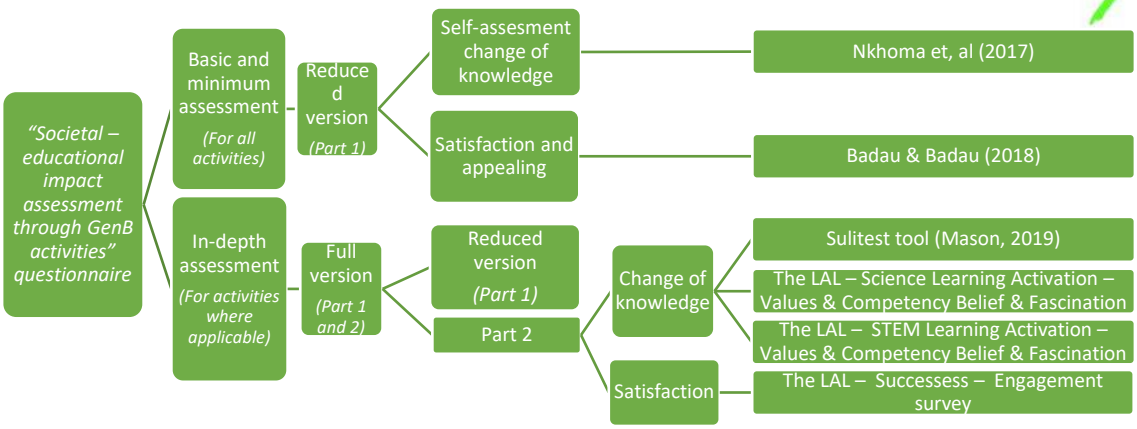

Figure 2. Overview of the structure, objectives and scales employed in GenB activities assessment questionnaire

2. Data analysis

Regarding the data analysis, bivariate analyses were conducted using Gandia Barbwin, a statistical data analysis software. To describe the results concerning knowledge and satisfaction regarding bioeconomy across different demographic groups in the sample, several two-tailed Student's t-tests (95% confidence interval) were performed. These tests compared the results based on one demographic variable: gender (men vs. women), with the primary objective of identifying potential gender gaps in the theme and the adaptation of the activities.

Age-based segmentation was excluded from the analysis due to an uneven distribution of responses across different age groups, making comparisons unreliable. The purpose of this evaluation is to gain a comprehensive understanding of the effectiveness of GenB activities and their potential impact, with a focus on identifying gender gaps and reinforcing the commitment to equality between men and women.

3. Sample description

The quantitative study includes a total sample of 383 participants (with a sampling error of +- 5, 01%), consisting of participants (men and women) from different countries which are Spain, Italy, Greece, Slovakia, Austria, Netherlands and Belgium.

Regarding gender, 53% of the survey participants are women, and 47% are men.

4. Self-perception of knowledge

Following their participation in the GenB activities, 88% of participants demonstrated a correct understanding of the bioeconomy definition. In terms of gender, 90% of women and 85% of men accurately identified what the bioeconomy entails, with no statistically significant gender differences observed.

These findings indicate that participants demonstrated a high level of knowledge about bioeconomy after participating in the GenB activities, alongside a clear comprehension of its meaning and a positive initial engagement with the topic, as shown in Table 3.

Table 3. Bieoconomy knowledge in activities participants

Question	Correct answer	Accuracy % n=383	Accuracy % (M)	Accuracy % (W)
Do you know what bioeconomy is?	a) **Bioeconomy is the economy based on using natural resources, such as plant and animals, sustainability to produce food, energy, and products without harming the environment**	88%	85%	90%
	b) Incorrect answers			

5. *Degree of influence on participants in terms of bioeconomy values*

Table 4. Bioeconomy values presents detailed results on bioeconomy values, showing the overall positive perception of bioeconomy and its applications.

Table 4. Bioeconomy values among participants

Question	Mean n=383	Standard deviation	Mean (M)	Mean (W)
How important is for you to learn bioeconomy?	3.53	0.76	3.49	3.57
Bioeconomists think about how to make the world work better. How important is this to you?	3.62	0.88	3.60	3.64
Bioeconomy makes the world a better place to live.	3.40	0.76	3.38	3.42
I think bioeconomists are the most important people in the world.	2.49	0.87	2.41	2.57
Bioeconomy is the most important thing in the world for me to learn.	2.46	0.93	2.30	2.60
Knowing bioeconomy is important for being a good citizen.	3.08	0.87	3.04	3.13
I think bioeconomy is more important to know than anything else.	2.14	1.01	2.09	2.19
I think bioeconomy ideas are valuable.	3.37	0.76	3.32	3.42
I believe that knowing about bioeconomy is important for all jobs.	2.80	0.84	2.80	2.80
In general, I love bioeconomy activities.	3.29	0.54	3.29	3.30

The results indicate that participants generally value bioeconomy as an important area of knowledge, particularly for its role in education and problem-solving. On a 4-point Likert scale, the overall average score was 3.02, suggesting a positive perception of bioeconomy's relevance. The highest-rated statements were:

- "Bioeconomists think about how to make the world work better. How important is this to you?" (Me = 3.62, SD = 0.88)
- "How important is it for you to learn bioeconomy?" (Me = 3.53, SD = 0.76)
- "Bioeconomy makes the world a better place to live." (Me = 3.40, SD = 0.76)

On the other hand, the lowest-rated items indicate that while participants acknowledge the importance of bioeconomy, they do not see it as the most important subject compared to others:

- "I think bioeconomy is more important to know than anything else." (Me = 2.14, SD = 1.01)
- "I think bioeconomists are the most important people in the world." (Me = 2.49, SD = 0.87)
- "Bioeconomy is the most important thing in the world for me to learn." (Me = 2.46, SD = 0.93)

The highest-rated responses emphasised the importance of learning about the bioeconomy and its value in improving the world. However, when the bioeconomy was compared to what participants considered most important—whether in terms of people, learning priorities, or other responsibilities—the average scores show lower results. The activities successfully met their objective of raising awareness and educating participants, positioning the bioeconomy as a valuable topic within a broader landscape of interests and responsibilities. This supports GenB's approach to integrating the bioeconomy into the everyday lives of young people, rather than displacing other areas.

Regarding gender, significant differences are observed in the variable "Bioeconomy is the most important thing in the world for me to learn," with women (2.60) showing a higher level of agreement than men (2.30). However, this difference is not sufficient to detect a gender gap, as the activities are equally effective in sparking interest in bioeconomy among both genders.

6. Participants' engagement

Table 5 shows how the participants engage during the GenB Activities activity and their overall level of commitment to it, allowing conclusions to be drawn about how they felt during the activity. Affective, cognitive, and behavioural engagement are assessed through the selected items.

Table 5. Activities participants 'engagement

Question	Mean n=383	Standard deviation	Mean (M)	Mean (W)
During this activity: I felt bored.	1.47	0.82	1.48	1.46
During this activity: I felt happy.	3.46	0.75	3.49	3.44
During this activity: I felt excited.	3.29	0.86	3.25	3.31
During this activity: I was daydreaming a lot.	1.71	0.96	1.69	1.73
During this activity: I was focused on the things we were learning most of the time.	3.11	1.06	3.04	3.17
During this activity: I was busy doing other tasks	1.58	0.87	1.57	1.58

Question	Mean n=383	Standard deviation	Mean (M)	Mean (W)
During this activity: I talked to others about stuff not related to what we were learning.	1.64	0.90	1.65	1.63
During this activity: Time went by quickly.	3.09	1.04	3.12	3.07

The data show a high level of emotional and cognitive engagement, as participants felt happy (Me= 3.46) and excited (Me= 3.29), and they did not feel bored (Me= 1.47). Additionally, distraction was low, as they were focused most of the time (Me= 3.11) and were not busy with other tasks (Me= 1.58) or talking about unrelated topics (Me= 1.64). Overall, the data suggest a positive experience with GenB Activities, confirming that the design and implementation of GenB activities effectively fostered high emotional and cognitive engagement among participants. The design could be slightly refined to further enhance full attentiveness. No significant gender differences are observed.

7. Participants' satisfaction

Finally, participants were asked questions to assess the overall satisfaction with the activities, aiming to determine if the GenB activities were effectively structured and to identify potential improvements for the future. Only this aspect of evaluation is assessed using a 5-point Likert scale.

As shown in Table 6, the highest-rated statements were:

- "The activity was fun and entertaining." (Me = 4.41, SD = 0.82)
- "I am satisfied with this activity" (Me = 4.38, SD = 0.81)
- "The activity increases my knowledge about bioeconomy." (Me = 4.35, SD = 0.88)

On the other hand, the lowest-rated items were:

- "When I grow up, I would like to work in something related to bioeconomy." (Me = 3.05, SD = 1.50)

Table 6. Activities participants´ satisfaction

Question	Mean n=383	Standard deviation	Mean (M)	Mean (W)
The activity was fun and entertaining.	4.41	0.82	4.40	4.42
The activity is recommendable for different age categories.	4.12	1.06	4.13	4.11
I am satisfied with this activity.	4.38	0.81	4.41	4.36
The activity increases my knowledge about bioeconomy.	4.35	0.88	4.33	4.36
I will try to apply the knowledge learned about bioeconomy in the activity.	3.99	1.05	3.90	4.07
I want to apply what I have learned about bioeconomy in my daily life.	3.82	1.18	3.73	3.89
I would like to learn more about bioeconomy.	3.98	1.18	3.90	4.05

Question	Mean n=383	Standard deviation	Mean (M)	Mean (W)
When I grow up, I would like to work in something related to bioeconomy.	3.05	1.5	3.02	3.06
I understand the impact of bioeconomy on the world around us.	3.79	1.2	3.67	3.90

In this regard, this evaluation concludes that the GenB activities, were highly effective in generating a significant level of satisfaction, enjoyment, and learning among participants. This is reflected in their perception of the activities as entertaining and educational, as well as in their intent to apply the acquired bioeconomy knowledge in daily life and their desire to further explore the topic, although interest in bioeconomy-related careers remained more moderate. Notably, the strong agreement with the statement "The activity increases my knowledge about bioeconomy" (4.35) underscores the activities' effectiveness in enhancing knowledge, a critical factor for achieving a positive impact in the medium and long term. These findings highlight GenB's capacity to inspire and engage younger generations, fostering the practical integration of the bioeconomy into their everyday lives.

No significant gender differences were observed.

4.2.2 Evaluation of perceived change of knowledge – partner´s feedback

Overall, the partners observed a positive shift in the knowledge and understanding of bioeconomy concepts among both students and educators, facilitated by interactive learning methods and continuous engagement throughout the project. The following results highlight the key findings and insights gained from the various activities and experiences carried out by the GenB project partners, reflecting the impact of the bioeconomy-focused educational initiatives on participants across different contexts and settings.

In Italy, the main lesson learnt by APRE and FVA is that raising awareness among young people about bioeconomy concepts and the transition to a sustainable and circular system requires multiple steps and ongoing, active communication. This continuous engagement is essential to reinforce their knowledge and ensure that they remain committed over time.

Moreover, the direct involvement of young people in the GenB activities, such as the co-creation of project results and participation in the GenB Ambassador Programme, significantly accelerates their learning process. It also strengthens their awareness of the positive impact they can have on their communities and their role in the circular bioeconomy transition. For instance, in Italy, during APRE's Living Labs, younger students composed a rhyming song, which was performed during their school's Sustainability Day before peers, parents, and teachers. On the other hand, high school students who participated in FVA's Living Labs co-created the escape game "Escape4Future - Chemistry meets Circular Bioeconomy" to stimulate awareness and interest among young people towards green chemistry and circular bioeconomy. In this game, players face a highly relevant challenge: the planet is trapped in a linear lifestyle and consumption model, causing short- and long-term consequences such as climate change, biodiversity loss, resource scarcity, and an increase in non-renewable fossil-origin waste, such

as plastic. The complete game involves solving six interconnected puzzles addressing various themes of green chemistry and bioeconomy through practical experiments or games, aiming to find a way towards a more sustainable and circular lifestyle.

Furthermore, the teachers and educators who participated in the project activities communicated to APRE and FVA that the concepts and results presented in the events have been integrated into their students' curricula, demonstrating a practical and sustainable impact of the initiatives.

In a different context, European Schoolnet implemented activities primarily with educators and multipliers, and the outcomes indicate that structured professional development programmes significantly enhance teachers' confidence and ability to introduce bioeconomy concepts into their classrooms. Specifically, the MOOC and interactive workshops demonstrated that when educators are provided with clear, practical resources and training, they feel better equipped and, consequently, more eager to incorporate bioeconomy topics into various subjects, making sustainability education more accessible and engaging for students.

Furthermore, during the workshops and the course, participants highlighted the importance of practical, real-world applications of bioeconomy principles, which would enable them to help students grasp the relevance of bioeconomy beyond the classroom. They also noted that various opportunities for collaboration and knowledge-sharing among themselves allowed them to exchange ideas, strategies, and best practices for teaching bioeconomy more effectively.

In Austria, ZSI identified several lessons learnt for effectively engaging participants in bioeconomy education through the GenB activities. Firstly, simplifying content by focusing on key information helps prevent overwhelming younger audiences. Additionally, allocating sufficient time for activities enhances workshop quality, particularly when showcasing bio-based materials or brainstorming ideas. Balancing idea development with time constraints is crucial, as limited time can cause frustration, for example, in co-creation activities within the living labs. Moreover, teacher preparedness is essential for co-creation concepts like living labs. During local capacity-building activities, face-to-face sessions proved highly effective, allowing for hands-on learning, deeper engagement, and better facilitator observation of participant needs. Conducting sessions in German helped participants grasp and communicate bioeconomy concepts more effectively within their communities. In addition, complementary online meetings with ambassadors provided flexible, targeted support. Lastly, timing challenges emerged for multiplier and teacher workshops, as teachers had limited availability during the day, and lunchtime sessions were not ideal for multipliers, which needs to be considered when planning activities with these target groups.

In Greece, throughout the implementation of the GenB project, Q-PLAN learnt that engaging young people in bioeconomy-related activities requires sustained effort and multiple points of interaction. A single event is rarely sufficient to secure long-term commitment, and continuous exposure through diverse activities proved far more effective. Many young people do not immediately see the connection between bioeconomy and their daily lives, making it essential to bridge this gap through relatable examples and interactive content. One of the most powerful

motivators for youth engagement was peer influence: young people trust recommendations from their friends more than from experts, and when one individual becomes active in bioeconomy initiatives, they often inspire classmates, friends, and online communities to follow suit.

In this context, the GenB Ambassador Programme effectively leveraged this dynamic, providing relatable role models who encouraged others to participate. Creativity and hands-on activities also played a crucial role in engagement; young people responded positively to opportunities that allowed them to experiment, design, and innovate, whether through biomaterials, sustainable product creation, or gamified learning experiences. This aligns with the experiences shared by other partners, such as APRE and FVA, who found that co-creation activities—like developing bioeconomy-themed escape rooms or composing songs—helped young people internalise complex concepts in a more fun and memorable way.

Beyond creative engagement, Q-PLAN observed that young people are highly motivated by environmental and social impact, but what truly inspires them is seeing their peers take action. When bioeconomy activities are framed as opportunities to contribute to a larger movement, they become far more attractive. The role of educators and multipliers also proved essential in sustaining engagement beyond the project's activities, as many teachers who participated in GenB later integrated bioeconomy topics into their lessons and subjects.

Additionally, practical considerations such as language, accessibility, and timing had a significant impact on engagement. Localised content in the native language—for example, capacity-building seminars in Greek containing real Greek career examples, real action calls derived from Greece, and Greek ambassadors' chats on social media for fast interaction—improved comprehension. Scheduling constraints for teachers and multipliers also needed to be carefully managed, as daytime and lunchtime sessions were often inconvenient. Finally, storytelling and social media emerged as powerful tools for amplifying the project's reach. Young people who actively participate in bioeconomy initiatives often share their experiences through social media, events, and personal narratives, making bioeconomy careers and concepts more appealing to their peers. Overall, Q-PLAN's experience in GenB highlighted that sustained interaction, peer-driven engagement, hands-on learning, and the involvement of educators and multipliers are all essential elements in fostering lasting youth participation in the bioeconomy.

In Slovakia, bioeconomy is not taught in the national curriculum, so all GenB activities represented an additional effort beyond regular teaching. However, these activities provided an opportunity to explore its connection with existing subjects such as science, environmental studies, geography, and economics, enabling cross-curricular integration.

Furthermore, following student activities, which were typically observed or debriefed with staff afterwards, bioeconomy was implicitly integrated into the curriculum. Staff expressed a desire to include bioeconomy content within their science, sustainability, and business-based lesson plans. Although curriculum changes take time, bioeconomy can be gradually integrated through cross-disciplinary learning projects. PEDAL supported this process of dialogue, enabling teachers to naturally integrate bioeconomy into current pedagogical models.

Moreover, GenB materials were well received among teachers, who appreciated that they were planned and simple to implement. However, a few teachers required additional instructional guidance, such as step-by-step instructional videos, teaching guides, or best-practice examples, to ease their teaching process. Providing further instructions on how to include bioeconomy in different subjects and age groups would enable teachers to incorporate these topics more effectively.

Additionally, students' responses varied with age. Younger children responded more readily, while older students tended to require more time and interactive elements, such as daily applications or problem-solving challenges, to stimulate interest. Once engaged, they responded positively to discussions and experiential learning, making the topic more relevant and interesting to them.

Moreover, flexibility in pedagogy was key. Traditional lectures were not as effective as laboratory work, debates, and problem-solving exercises. PEDAL helped plan engaging activities that connected bioeconomy with everyday contexts, ensuring the topic was not perceived as purely theoretical.

Furthermore, although many teachers were interested in bioeconomy topics, awareness among educators remains low. Further training and professional development would help integrate it more into the curriculum. PEDAL facilitated knowledge-sharing among educators to exchange ideas and best practices, enabling long-term interaction beyond GenB's short-term activities.

Lastly, the effectiveness of bioeconomy learning was impacted by time constraints and the need for additional resources. Educators preferred pre-prepared materials and organised lesson plans that could be implemented within limited teaching time. Schools with greater curriculum flexibility or extracurricular activities were able to implement these ideas more effectively.

In Spain, during the implementation of the GenB project at AIJU's ToyLab Experience in Ibi (Alicante), we observed how the activities enabled both children and educators to learn new concepts about bioeconomy.

In the case of the educators, in addition to showing great interest during the sessions, they asked questions about the products presented in the game. Many wanted to know which toys were made with bioplastics so they could have them in their schools and progressively replace those that were deteriorating. At the end of the workshop, while the children enjoyed free time in the playroom, teachers approached us to ask about certain toys and whether they were made with bioplastics. Furthermore, during the activities, several educators commented on the importance of introducing more initiatives of this kind into their daily school routines. Some even mentioned their intention to start composting the waste generated by the children in the playground, while others shared experiences, they were already carrying out in their schools related to bioeconomy. Overall, the educators highly valued the initiative and highlighted the importance of addressing these topics through play and fun.

Meanwhile, the children enjoyed the workshops while learning key concepts about bioeconomy. They were very attentive and participative, sharing examples of sustainable practices carried out

by their families. They asked questions enthusiastically and showed great curiosity about everything they were taught. One of the topics that surprised them the most was the manufacturing process of products, for example, paper made from elephant and cow excrement. When smelling and touching it, they were amazed to notice it had no odour, which sparked even more interest in asking how paper could be made from excrement.

At the end of the activities, while enjoying their free time in the playroom, it was exciting to see how, among the hundreds of toys available, many children sought out those made with bioplastics—the same ones we had shown during the activity. They loved smelling, touching, and playing with them. For us, it was very rewarding to see them leave the playroom with new knowledge and having enjoyed the experience.

4.2.3 Activities Assessment conclusion

The activities implemented within the framework of the GenB project have proven highly effective in achieving its objectives of inspiring, informing, educating, and engaging younger generations with the bioeconomy, as evidenced by the results obtained across the various evaluations conducted. Participants demonstrated a significant level of satisfaction, enjoyment, and emotional and cognitive engagement during the activities, underscoring their entertaining nature and their ability to foster an initial positive connection with the bioeconomy. Furthermore, a substantial increase in knowledge about the subject was observed, with a high proportion of participants accurately recognising its definition and valuing its role in sustainability and global improvement, highlighting the educational effectiveness of the activities.

Nevertheless, while the bioeconomy was perceived as an important and valuable topic, it was not regarded as an absolute priority compared to other areas of learning or career pathways, reflecting a balanced perspective among participants. This can be explained by the general lack of awareness regarding how the bioeconomy connects not only to future job opportunities but also to university degree programmes. This perception, combined with their intent to apply the acquired knowledge in their daily lives and their interest in further exploring the topic, indicates that GenB successfully integrated the bioeconomy into the broader spectrum of young people's interests and responsibilities, rather than positioning it as an exclusive focus. The absence of significant gender differences in responses further reinforces the inclusivity and accessibility of the activities, underscoring the GenB project's latent commitment to reducing the gender gap.

Collectively, these findings confirm that the GenB activities, as designed and delivered, not only raised awareness of the bioeconomy but also laid the groundwork for a positive medium- and long-term impact, cultivating a generation that is both informed and motivated to contribute to the sustainability goals of the European Green Deal. This medium- and long-term commitment is embodied in the GenB Educational Model and the Policy Recommendations, which are expected to have broader educational and policy implications, and from the GenB Community of Practices (CoP) which the Consortium is willing to create after the end of the project to maintain the legacy of the project and continue to educate and raise the awareness of the new

generations towards the sustainable and bioeconomy transition. The detailed outcomes supporting these conclusions are presented in the corresponding tables of this section.

4.3 KERs Assessment

The objective of the "KERs Assessment" was to evaluate the exploitable results of GenB, analysing their potential to enhance knowledge that would endure over time and remain accessible to society after the project's completion, providing a comprehensive understanding of the bioeconomy. This methodology was developed to obtain a complete picture of the project's impact through a formal, controlled, and structured evaluation, which was not possible to achieve solely through the project's activities. To accomplish this objective, two evaluation scenarios were developed:

- An evaluation of schools in two European countries (Spain and Slovakia) and an evaluation of the MOOC, a course exclusively designed for teachers and delivered by EUN, through which the impact of the GenB project on this group was assessed.

Through these scenarios, the impact of the GenB project on the Bioeconomy Generation was evaluated from the perspective of the two most direct agents of change: students aged 4 to 18 in the first scenario and teachers in the second scenario.

For more information, the methodology of the KER Assessment is detailed in Deliverable 4.1.

4.3.1 Analyse the level of change of knowledge and satisfaction – School interventions

1. Background

To evaluate the KERs, a formal settings in schools were used, and specific KERs were selected. In the school interventions, the selected KERs specifically focused on the "game or gamified educational experience": the BioRace (developed under T1.4), and the "Role-play game on bioeconomy job profiles": BioHeroes: Let´s save the planet! (developed under T2.2, Inspire and Inform Students in Bioeconomy Careers). The game-based learning approach is a constant in the project due to its widespread approval in the academic and educational fields, given its proven effectiveness. For this reason, these two tools have been selected. Additionally, it is a friendly way to engage them in participation, as they will readily embrace this type of material in the school environment.

The target group that utilized them consisted of three categories of young people: Pre- and early school (4-8 y.o.), Elementary School (9-13 y.o.) and High School (14-18 y.o.).

These types of materials were chosen because they are among those expected to have an educational impact beyond the project's conclusion. Through this approach, a comprehensive picture was obtained of how these KERs impacted knowledge and satisfaction regarding the bioeconomy.

2. Methodology

To systematically evaluate the impact of the school intervention on young people's knowledge and perceptions of bioeconomy, a structured sequence designed to measure knowledge acquisition, satisfaction, and self-perceived learning progress was applied.

The evaluation process consisted of three key phases:

- Pre-evaluation phase: Before commencing the intervention, participants completed an initial questionnaire to assess their baseline knowledge of bioeconomy. This involved responding to the GenB Quizzes, which served as a self-assessment tool to gauge their perception of their knowledge levels before engaging with the intervention material.
- Immediate post-evaluation phase: Upon completing the intervention, participants answered a second questionnaire designed to measure knowledge acquisition and satisfaction levels. This phase utilized scientific scales to ensure a robust evaluation of learning outcomes and perceived course effectiveness.
- Follow-up evaluation phase: At least one week later, participants retook the GenB Quizzes (initial questionnaire) to assess potential knowledge gains and retention over the course of the training. This final assessment allowed for a comparative analysis of pre- and post-course knowledge, providing insight into the effectiveness of the KERs in fostering bioeconomy competencies.

Table 7 summarizes the structured procedure for implementing the assessment methodology:

Table 7. Characteristics of the procedure for conducting the "School Assessment"

Part No.	Item adaptation	Tools and materials	Timing	Dimension of application
1	Pre-evaluation	Survey. Questionnaire – "Societal – educational impact assessment through GenB materials (KERs)" (D4.1. Appendix 5A)	Before the activity	Kn. through conducting quizzes as a tool to measure self-perception of knowledge change (not through scientific scales).
2	Immediate Post-evaluation	Survey. Questionnaire – "Societal – educational impact assessment through GenB activities" (Appendix 5B)	At the end of the activity	Kn. through scientific scales Sa. through scientific scales
3	Follow-up evaluation	Survey. Questionnaire – "Societal – educational impact assessment through GenB materials (KERs)" (Appendix 5C)	After the activity (at least 1 week)	Kn. through conducting quizzes as a tool to measure self-perception of knowledge change (not through scientific scales)."

The GenB Bioeconomy quizzes served to establish the participants' baseline knowledge of bioeconomy and determine, through a comparison of results, whether there was an increase in knowledge by the end of the KERs assessment. Specifically, the "20 Bioeconomy quizzes for social media and training for high schools" were selected for testing with young people aged 14 to 19. The "20 Bioeconomy quizzes for social media and high school training" were one of the

materials developed under Task 1.4, Toolkits for Young People, Teachers, and Other Multipliers, which formed part of the GenB Toolkit. It consisted of 20 quizzes—likely using multiple-choice and true/false questions—designed to assess and enhance users' knowledge on key topics such as sustainability, bio-based plastics, waste management, and the circular economy, among others. To ensure the questions were appropriately understood by the other two age groups (ages 4-8 and 9-13), a team of pedagogues from AIJU concluded that for the 9-13 age range, the content of the quizzes was appropriate and perfectly comprehensible. However, for the 4-8 age range, the questionnaire was reduced to a total of 8 questions, as recommended by the experts, as shown Table 8.

Table 8. Reduced version of the quizzes for ages 4-8

Item 1	"Have you ever heard the word "bioeconomy"?"
Item 2	"Do you know what bioeconomy is? "
Item 3	"Can bio-based plastics be recycled and pollute less?"
Item 4	"Can you make fuel from?"
Item 5	"Why do we use renewable energy?"
Item 6	"What is better for the bioeconomy?"
Item 7	"Why do non-biodegradable materials like plastics harm the environment in the long term?"
Item 8	"What is an important characteristic of non-renewable energy?"

The evaluation has been carried out in the following schools:

- Colegio Marqués de Dos Aguas in Bétera, Spain.
- Colegio Santo Domingo Savio in Petrer, Spain.
- Základná škola Vajanského in Lučenec, Slovakia
- Gymnázium in Fiľakovo, Slovakia
- Gymnázium Jána Chalúpku in Brezno, Slovakia
- Základná škola ALMA in Zvolen, Slovakia

For more details on the methodology, refer to D4.1.

Figure 3 shows an overview of the structure, objectives, scales and tool employed in GenB materials assessment questionnaire to assess both knowledge gain and participant satisfaction.

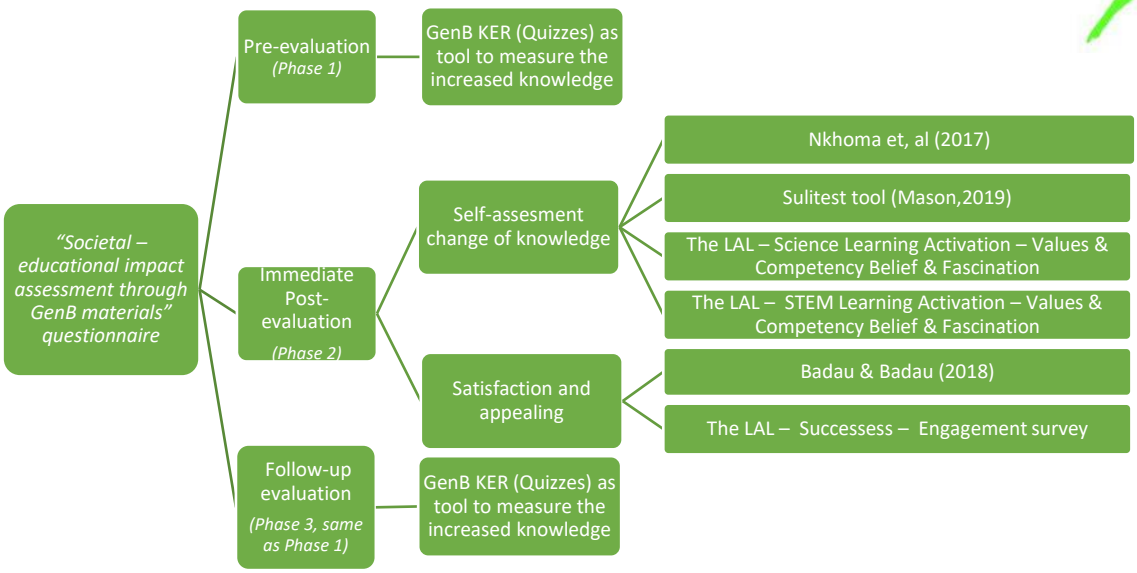

Figure 3. Measurement variables, scientific measurement scales and questionnaire structure for KERs Assessment

3. Data analysis

Bivariate analyses were conducted using Gandia Barbwin, a statistical data analysis software. To describe the results concerning knowledge and satisfaction regarding bioeconomy across different demographic groups in the sample, several two-tailed Student's t-tests (95% confidence interval) were performed. These tests compared the results based on two demographic variables: gender (men vs. women) and age (three groups: Pre-school and early-school (4-8 y.o), Elementary school (9-13 y.o) and High school (14-19 y.o.)).

4. Sample description

The quantitative study includes a sample of 469 participants (with a sampling error of ± 4,69%), consisting of young people (men and women) from Slovakia and Spain. For the youngest age group, 325 participants were included in the sample (±5.44% sampling error) due to the adaptation of the questionnaire for younger children. These questions are marked with an asterisk (*) in the data analysis.

Of the 469 participants, 234 (with a sampling error ±6.41%) will directly participated in the use of the project's toolkits, while 235 (with a sampling error ±6.39%) will be part of the control group, who completed only the pre-questionnaire and the follow-up questionnaire without taking part in the GenB intervention.

Regarding gender, 50% of the survey participants are women, and 50% are men. This balanced representation provides an ideal foundation for identifying potential gender gaps, enabling a thorough examination of the KERs impact on knowledge and satisfaction regarding bioeconomy while highlighting any differences in perspective or engagement between genders.

Regarding the age distribution of participants in the GenB Bioeconomy quizzes, the evaluation included a total of 469 young individuals across three distinct age groups. The pre-school and early-school group (ages 4-8) consisted of 144 participants (31%), the elementary school group (ages 9-13) included 158 participants (34%), and the high school group (ages 14-19) comprised 167 participants (35%). This distribution ensured a balanced representation of the target audience, allowing for a comprehensive assessment of the KERs impact on knowledge and satisfaction regarding bioeconomy across different developmental stages.

5. Pre- evaluation – School results

Prior knowledge in young people – Overall & gender analysis

Table 9 presents the results from questions assessing the knowledge of bioeconomy among students aged 4 to 18 years during the evaluation of KERs in schools, as part of the pre-questionnaire[2]. Overall, only 27% of the responses were correct across all age groups, indicating a relatively low level of understanding across the board. Specifically, students showed better performance in questions such as "Can bio-based plastics be recycled?" with 50% correct responses, "What does the bioeconomy refer to?" with 40% correct responses, and "Do you know what bioeconomy is?" with 38% correct responses. On the other hand, the main areas for improvement were evident in more complex or technical questions, such as "What is biomimicry?" with only 13% correct responses, "What are barriers to the development of the biofuel market?" with 14% correct responses, and "Where are bio-based plastics recycled?" with 16% correct responses.

Overall, the results suggest that students have a better grasp of basic concepts related to bioeconomy, while more technical and specific aspects remain challenging for this age range. This limited initial knowledge was expected, as this pre-questionnaire was conducted before the implementation of the KERs. Bioeconomy is not a topic typically covered in school curricula, nor widely popularised among young people yet. This highlights the need for educational initiatives like GenB to bridge this gap and foster awareness and understanding of bioeconomy among future generations.

Regarding the gender analysis, only two variables showed significant differences, with woman demonstrating greater knowledge: "The dominant application for bio-based plastics is…" (31% for men vs. 42% for women) and "Which of the following best describes Life Cycle Assessment (LCA) in the context of the bioeconomy?" (21% for men vs. 33% for women). Nevertheless, these differences do not indicate a gender gap, as the overall knowledge of bioeconomy among men and women is practically the same. Therefore, it can be concluded that both groups began the GenB intervention with a similar level of understanding.

[2] It should be noted that questions marked with an asterisk (*) were not answered by the youngest age group (ages 4-8), and these results are based on a sample of 325 participants (with a sampling error of ±5.44%).

Table 9. Prior knowledge in young people

Question	Correct answer	Accuracy % n=469	Accuracy % (M)	Accuracy % (W)
Do you know what bioeconomy is?	**c) Bioeconomy is the economy based on using natural resources, such as plant and animals, sustainability to produce food, energy, and products without harming the environment** d) Incorrect answers	38%	39%	37%
Are all bio-based plastics biodegradable?*	a) Yes **b) No** c) I don´t know	32%	32%	32%
Can bio-based plastics be recycled?	**a) Yes** b) No c) I don´t know	50%	51%	49%
The dominant application for bio-based plastics is…*	a) Automotive **b) Packaging** c) Footwear d) Electronics e) I don´t know	37%	31%	42%
Where are bio-based plastics recycled?*	**a) Chemical recycling plants** b) They cannot be recycled c) They descompose in the ground d) Composing facilities e) I don't know	16%	16%	16%
You can make fuel out of...	a) Wood b) Used cooking oil c) Horse poop **d) All of them** e) I don´t know	23%	24%	22%
In what forms can biofuel be presented?*	a) Solid b) Liquid c) Gas **d) All of them** e) I don´t know	32%	30%	34%
What are barriers to the development of the biofuel market?*	a) High production cost b) Lack of affordable raw materials c) Insufficient infrastructure **d) All of them** e) I don´t know	14%	13%	15%
In what areas does the bioeconomy works?*	a) Agriculture b) Production and manufacturing	33%	33%	33%

Question	Correct answer	Accuracy % n=469	Accuracy % (M)	Accuracy % (W)
	c) Forestry and fishing **d) All of them** e) I don´t know			
What is the primary goal on integrating renewable energies into the bioeconomy?	a) To use up non-renewable resources **b) To reduce fossil fuel use and support sustainability** c) To ignore issues in energy d) I don´t know	36%	35%	37%
Bioeconomy…*	a) Contributes to the reduction of CO2 emissions b) Reuses waste to produce new materials and energy c) Creates new jobs **d) All of them** e) I don´t know	40%	38%	42%
Which of the following best describes Life Cycle Assessment (LCA) in the context of the bioeconomy?*	a) A method to increase agricultural yield b) **A technique to evaluate the environmental impact of a product throughout its lifespan** c) A process to improve the genetic modification crops d) A strategy for marketing bio-based products e) I don´t know	27%	21%	33%
Which of these processes optimize resources the bioeconomy?	a) Simply disposing of waste in landfills **b) Processing residues or by-products into raw materials** c) Burning all waste materials d) Avoiding the generation of waste altogether	32%	34%	30%
What is the difference between upcycling and downcycling in the recycling process?*	a) Upcycling creates lower quality and value materials, while downcycling improves quality and value b) Both processes create materials of the same quality	18%	15%	21%

Question	Correct answer	Accuracy % n=469	Accuracy % (M)	Accuracy % (W)
	c) Downcycling produces lower quality and value materials, while upcycling enhances quality and value d) Upcycling and downcycling are unrelated to recycling e) I don´t know			
Which of the following statements about composting is true?*	a) Composting involves burning organic waste to generate energy **b) Composting converts organic waste and improves soil quality** c) Composting is a method for recycling plastics d) All of them are true	21%	20%	22%
What does biodegradation refer to? *	a) Burning organic waste to make energy b) Making new materials with chemicals c) Recycling plastics using machines **d) Microorganisms breaking down organic materials** e) I don´t know	21%	22%	21%
What is biomimicry?*	**a) Imitating natural processes and systems to solve human problems** b) Creating synthetic materials using biotechnology c) Breeding animals for specific genetic traits d) The study of fossils and ancient life forms e) I don´t know	13%	14%	12%
Why do non-biodegradable materials, like plastics, pose long-term environmental risks?	a) They descompose quickly but leave harmful residues b) They are easily absorbed by natural processes **c) They persist for a long time and can harm ecosystems and wildlife** d) They break down into harmless substances	22%	21%	23%

Question	Correct answer	Accuracy % n=469	Accuracy % (M)	Accuracy % (W)
	that benefit the environment e) I don´t know			
What is an important feature of non-renewable energy sources?	a) They are always being made by nature b) They don´t harm the environment much c) They can be used forever without running out **d) They will run out because they can´t be replaced quickly** e) I don´t know	22%	23%	21%
Which of the following is an example of a green job?	a) Coal miner **b) Solar panel installer** c) Oil rig worker d) Plastic factory worker e) I don´t know	34%	34%	34%
What is the benefit associated with bio-based plastics their recycling, and their environmental impact?	a) They increase greenhouse gas emissions **b) They reduce dependence on fossil fuels** c) They are non-biodegradable d) They contribute to ocean pollution e) I don´t know	35%	34%	36%

Prior knowledge in young people – Age analysis

The results of the questions aimed at assessing the knowledge of bioeconomy among students across three age groups (4-8, 9-13, and 14-19 years) during the evaluation of KERs in schools, as part of the pre-questionnaire, indicate varying levels of understanding. The 14-19 age group performed the best, with an average of 34% correct answers, followed by the 4-8 age group with 24%, and the 9-13 age group with the lowest average at 23%. In contrast, the younger groups exhibited lower performance, particularly the 4-8 age group. The results suggest a gradual improvement in knowledge with age, which is expected given the findings of the pre-questionnaire. Finally, It is expected that the oldest group demonstrates greater prior knowledge and better performance, particularly in broader questions that may have been addressed in secondary education subjects, reflecting their increased exposure to related concepts, as shown in Table 10.

Table 10. Prior knowledge in young people – Age analysis

Question	Correct answer	Accuracy % n=469	Accuracy % (4-8)	Accuracy % (9-13)	Accuracy % (14-18)
Do you know what bioeconomy is?	**a) Bioeconomy is the economy based on using natural resources, such as plant and animals, sustainability to produce food, energy, and products without harming the environment** b) Incorrect answers	38%	16%	42%	52%
Are all bio-based plastics biodegradable?*	a) Yes **b) No** c) I don´t know	32%	-	29%	34%
Can bio-based plastics be recycled?	**a) Yes** b) No c) I don´t know	50%	43%	52%	55%
The dominant application for bio-based plastics is…*	a) Automotive **b) Packaging** c) Footwear d) Electronics e) I don´t know	37%	-	33%	40%
Where are bio-based plastics recycled?*	**a) Chemical recycling plants** b) They cannot be recycled c) They descompose in the ground d) Composing facilities e) I don't know	16%	-	11%	20%
You can make fuel out of...	a) Wood b) Used cooking oil c) Horse poop **d) All of them** e) I don´t know	23%	6%	23%	40%
In what forms can biofuel be presented?*	a) Solid b) Liquid c) Gas **d) All of them** e) I don´t know	32%	-	27%	36%
What are barriers to the development of the biofuel market?*	a) High production cost b) Lack of affordable raw materials c) Insufficient infrastructure **d) All of them** e) I don´t know	14%	-	10%	17%
In what areas does the bioeconomy works?*	a) Agriculture b) Production and manufacturing c) Forestry and fishing **d) All of them** e) I don´t know	33%	-	19%	45%

Question	Correct answer	Accuracy % n=469	Accuracy % (4-8)	Accuracy % (9-13)	Accuracy % (14-18)
What is the primary goal on integrating renewable energies into the bioeconomy?	a) To use up non-renewable resources **b) To reduce fossil fuel use and support sustainability** c) To ignore issues in energy d) I don´t know	36%	18%	25%	60%
Bioeconomy…*	a) Contributes to the reduction of CO2 emissions b) Reuses waste to produce new materials and energy c) Creates new jobs **d) All of them** e) I don´t know	40%	-	26%	53%
Which of the following best describes Life Cycle Assessment (LCA) in the context of the bioeconomy?*	a) A method to increase agricultural yield b) **A technique to evaluate the environmental impact of a product throughout its lifespan** c) A process to improve the genetic modification crops d) A strategy for marketing bio-based products e) I don´t know	27%	-	28%	26%
Which of these processes optimize resources the bioeconomy?	a) Simply disposing of waste in landfills **b) Processing residues or by-products into raw materials** c) Burning all waste materials d) Avoiding the generation of waste altogether	32%	61%	11%	26%
What is the difference between upcycling and downcycling in the recycling process?*	a) Upcycling creates lower quality and value materials, while downcycling improves quality and value b) Both processes create materials of the same quality **c) Downcycling produces lower quality and value materials, while upcycling enhances quality and value** d) Upcycling and downcycling are unrelated to recycling e) I don´t know	18%	-	19%	17%

Question	Correct answer	Accuracy % n=469	Accuracy % (4-8)	Accuracy % (9-13)	Accuracy % (14-18)
Which of the following statements about composting is true?*	a) Composting involves burning organic waste to generate energy **b) Composting converts organic waste and improves soil quality** c) Composting is a method for recycling plastics d) All of them are true	21%	-	19%	24%
What does biodegradation refer to? *	a) Burning organic waste to make energy b) Making new materials with chemicals c) Recycling plastics using machines **d) Microorganisms breaking down organic materials** e) I don´t know	21%	-	18%	25%
What is biomimicry?*	**a) Imitating natural processes and systems to solve human problems** b) Creating synthetic materials using biotechnology c) Breeding animals for specific genetic traits d) The study of fossils and ancient life forms e) I don´t know	13%	-	8%	17%
Why do non-biodegradable materials, like plastics, pose long-term environmental risks?	a) They descompose quickly but leave harmful residues b) They are easily absorbed by natural processes **c) They persist for a long time and can harm ecosystems and wildlife** d) They break down into harmless substances that benefit the environment e) I don´t know	22%	4%	34%	26%
What is an important feature of non-renewable energy sources?	a) They are always being made by nature b) They don´t harm the environment much c) They can be used forever without running out **d) They will run out because they can´t be replaced quickly** e) I don´t know	22%	21%	21%	24%
Which of the following is an	a) Coal miner **b) Solar panel installer** c) Oil rig worker	34%	-	32%	35%

Question	Correct answer	Accuracy % n=469	Accuracy % (4-8)	Accuracy % (9-13)	Accuracy % (14-18)
example of a green job?	d) Plastic factory worker e) I don´t know				
What is the benefit associated with bio-based plastics their recycling, and their environmental impact?	a) They increase greenhouse gas emissions **b) They reduce dependence on fossil fuels** c) They are non-biodegradable d) They contribute to ocean pollution e) I don´t know	35%	-	20%	50%

Prior young people's green habits – Overall & gender analysis

Concerning the analysis of young people's green habits prior to their participation in the KERs assessment, the objective has been to determine whether these activities can promote a change in their habits. To conduct this analysis, each item in Table 11 is evaluated using a Likert scale from 1 to 5 points, with 1 being disagree and 5 being agree. For data analysis, we will consider the mean and standard deviation, as shown in Table 11.

Young people demonstrate the highest agreement with actions related to energy conservation, particularly: "I turn off the lights/television when I leave a room" with 4.34 points, "I reduce the use of heating or air-conditioning to limit energy consumption" with 3.40 points, and "I have increased the number of organic fruits and vegetables that I eat" with 3.34 points. However, the lowest agreement is observed in actions related to sustainable behaviours and awareness, particularly: "I reduce the amount of meat that I eat" with 2.18 points, "I talk to other people about their environmentally friendly behaviours" with 2.25 points, and "I watch TV programs, videos, or movies on environmental issues" with 2.53 points.

Regarding the gender analysis, a significant difference is observed in the action "I reduce the amount of meat that I eat," where women show greater agreement (2.41 points) compared to men (1.93 points). However, it cannot be concluded that there is a gender gap in green habits prior to participating in the project, as the differences in other actions are minimal and do not indicate a consistent pattern.

Table 11. Prior young people green habits

Question	Mean n=469	Standard deviation	Mean (M)	Mean (W)
I turn off the lights/television when I leave a room	4.34	0.94	4.34	4.34
I unplug appliances that are left in stand-by mode*	3.25	1.06	3.06	3.40
I reduce the use of heating or air-conditioning to limit energy consumption*	3.40	1.03	3.34	3.45
I reduce the time I take showers to save water	3.26	1.30	3.29	3.22
I watch TV programs, videos or movies on environmental issues	2.53	1.27	2.48	2.58

Question	Mean n=469	Standard deviation	Mean (M)	Mean (W)
I have increased the amount of organic fruits and vegetables that I eat.*	3.34	1.11	3.24	3.42
I talk to other people about their environmentally friendly behaviors.*	2.25	1.13	2.08	2.39
I reduce the amount of meat that I eat*	2.18	1.20	1.93	2.41
In general, if I have to go by car, I try to carpool.	3.06	1.25	2.99	3.11
In general, I use public transport instead of the car.	2.72	1.44	2.69	2.74
In general, I ride a bike, scooter or walk instead of using the car	2.92	1.23	3.02	2.81

Prior young people's green habits – Age analysis

Regarding the age analysis, a notable difference is observed in the action "I reduce the time I take showers to save water," where the youngest group (4-8 years) shows the highest agreement (4.01 points), followed by the 9-13 age group (3.07 points), and the lowest agreement in the 14-19 age group (2.78 points), indicating that older youths tend to take longer showers. This trend may be explained by the fact that younger children often shower under the influence of their parents, who typically set shorter shower times, whereas older youths have more autonomy in their routines. However, it cannot be concluded that there is a significant age-related gap in green habits prior to participating in the project, as the differences in other actions are minimal and do not indicate a consistent pattern.

Table 12. Prior young people's green habits – Age analysis

Question	Mean n=469	Standard deviation	Mean (4-8)	Mean (9-13)	Mean (14-18)
I turn off the lights/television when I leave a room	4.34	0.94	4.41	4.32	4.29
I unplug appliances that are left in standby mode*	3.25	1.06	-	3.29	3.24
I reduce the use of heating or air-conditioning to limit energy consumption*	3.40	1.03	-	3.43	3.35
I reduce the time I take showers to save water	3.26	1.30	4.01	3.07	2.78
I watch TV programs, videos or movies on environmental issues	2.53	1.27	2.50	2.55	2.50
I have increased the amount of organic fruits and vegetables that I eat.*	3.34	1.11	-	3.40	3.26
I talk to other people about their environmentally friendly behaviours.*	2.25	1.13	-	2.40	2.10
I reduce the amount of meat that I eat*	2.18	1.20	-	2.39	1.97
In general, if I have to go by car, I try to carpool.*	3.06	1.25	-	3.11	2.94
In general, I use public transport instead of the car.	2.72	1.44	2.86	2.69	2.61
In general, I ride a bike, scooter or walk instead of using the car*	2.92	1.23		3.00	2.86

6. *Immediate post- evaluation – School results*

After completing the intervention with the KERs in schools, the 234 participants completed the questionnaire with the aim, on the one hand, to assess young people's satisfaction and engagement with the games, and on the other hand, to understand how the games may influence young people in terms of values, fascination, competency beliefs, and knowledge regarding bioeconomy.

This questionnaire has been adapted to a 4-point Likert scale, as its scientific basis is the Learning Activation Lab, which uses scales with this scoring system. For more details on the methodology and the scientific scales used in the development of the questionnaire, see Deliverable 4.1.

Degree of influence on young people in terms of values – Overall and gender analysis

Table 13 presents the detailed results on young people's perceptions of Bioeconomy Values (n = 139), highlighting a generally moderate perception of bioeconomy and its applications. The results indicate that young people recognise the value of bioeconomy as an area of knowledge, particularly in its practical applications and understanding of the world, though they do not prioritise it as the most important subject. On a 4-point Likert scale, the overall average score across all items was 2.57, suggesting a moderate positive perception of bioeconomy's relevance.

The highest-rated statements were:

- "Bioeconomists think about how to make things work better. How important is it for you to think like this?" (Me = 3.12, SD = 0.85)
- "How important is it for you to learn about bioeconomy?" (Me = 2.92, SD = 0.91)
- "Knowing bioeconomy helps me understand how the world works." (Me = 2.77, SD = 0.80)

On the other hand, the lowest-rated items indicate that young people do not view bioeconomy as the most critical area of knowledge or bioeconomists as the most important figures:

- "I think bioeconomists are the most important people in the world." (Me = 2.07, SD = 0.84)
- "Bioeconomy is the most important thing in the world for me to learn." (Me = 2.23, SD = 0.87)
- "I think bioeconomy is more important to know than anything else." (Me = 2.35, SD = 0.98)

These results suggest that young people value the bioeconomy for fostering practical thinking and enhancing their understanding of global systems. This aligns with Expectancy-Value Theory (Eccles & Wigfield, 2002)[3], which posits that individuals are more likely to engage in learning when they perceive its utility for personal development or societal goals and these findings also align with research suggesting that science-related values develop based on personal and social

[3] Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. Annual Review of Psychology, 53, 109-132.

experiences (Eccles, 2005[4]; Lyons, 2006[5]). According to Identity Development Theory (Tan & Barton, 2007[6]), the extent to which young people integrate bioeconomy-related values into their identity depends on their exposure to and understanding of the subject. The moderate scores may reflect limited exposure to bioeconomy in their educational or daily life, influencing their prioritisation of the field.

No significant gender differences were observed, as shown in Table 13.

Table 13. Bioeconomy values among young people in schools

Question	Mean n=234	Standard deviation	Mean (M)	Mean (W)
How important is it for you to learn about bioeconomy?	2.92	0.91	2.75	3.10
Bioeconomists think about how to make things work better. How important is it for you to think like this?	3.12	0.85	3.07	3.17
Bioeconomy makes the world a better place to live.	2.70	1.18	2.73	2.66
I think bioeconomists are the most important people in the world.	2.07	0.84	2.14	1.99
Bioeconomy is the most important thing in the world for me to learn.	2.23	0.87	2.29	2.16
Knowing bioeconomy is important for being a good citizen.	2.59	1.08	2.61	2.57
I think bioeconomy is more important to know than anything else.	2.35	0.98	2.35	2.35
I think bioeconomy ideas are valuable.	2.66	1.01	2.70	2.62
Knowing bioeconomy helps me understand how the world works.	2.77	0.80	2.64	2,90
Thinking like a bioeconomist will help me do well in all my classes	2.36	0.79	2.29	2.42
Knowing bioeconomy is important for all jobs.	2.55	0.75	2.50	2.61

Degree of influence on young people in terms of values – Age analysis

Table 14 presents the detailed results on bioeconomy values among young people (n = 234), segmented by age groups (4-8 years, 9-13 years, and 14-18 years), highlighting differences in perceptions of bioeconomy and its applications. The results indicate that younger age groups tend to exhibit a more positive perception of bioeconomy, while older groups show a more moderate stance, potentially reflecting differences in educational focus and exposure. On a 4-point Likert scale, the overall average scores across all items were 2.75 for the 4-8 years group, 2.53 for the 9-13 years group, and 2.45 for the 14-18 years group, suggesting a generally positive

[4] Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. En A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 105-121).
[5] Lyons, T. (2006). Different countries, same science classes: Students' experiences of school science in their own words. *International Journal of Science Education, 28*(6), 591-613
[6] Tan, E., & Barton, A. C. (2007). Unpacking science for all through the lens of identities-in-practice: The stories of Amelia and Ginny. Cultural Studies of Science Education, 2(2), 361-392.

perception that decreases with age, with the youngest group showing the highest overall interest.

A comparison across age groups reveals notable differences, particularly between the youngest (4-8 years) and oldest (14-18 years) cohorts. The 4-8 years group consistently shows higher means in key items related to the perceived importance and relevance of bioeconomy:

- "How important is it for you to learn about bioeconomy?" (4-8: 3.26 vs. 14-18: 2.66, difference = 0.60)
- "Knowing bioeconomy helps me understand how the world works." (4-8: 3.21 vs. 14-18: 2.56, difference = 0.65)
- "Thinking like a bioeconomist will help me do well in all my classes." (4-8: 2.84 vs. 14-18: 2.09, difference = 0.75)
- "Knowing bioeconomy is important for all jobs." (4-8: 3.02 vs. 14-18: 2.35, difference = 0.67)

These differences, exceeding 0.5 points in several cases, suggest a potentially significant shift in perception, indicating greater engagement and fascination among the youngest group. The 9-13 years group generally falls in between, with means closer to the 14-18 years group in most items, reflecting a transitional phase in educational focus.

The higher means among the 4-8 years group support the hypothesis that younger children exhibit a stronger affinity for bioeconomy values. This can be explained by their educational stage, where curricula tend to be more holistic, often integrating nature-based learning and fostering curiosity about sustainability. In contrast, the 14-18 years group, likely in secondary or pre-university education, may have chosen specialised tracks (e.g., sciences, humanities, or arts), which could disconnect them from bioeconomy topics if not explicitly included in their educational curricula. This aligns with Identity Development Theory (Tan & Barton, 2007[7]), suggesting that older students' identities are more shaped by their chosen academic paths, potentially reducing their engagement with interdisciplinary themes like bioeconomy.

Table 14. Bioeconomy values among young people in schools – Age analysis

Question	Mean n=234	Standard deviation	Mean (4-8)	Mean (9-13)	Mean (14-18)
How important is it for you to learn about bioeconomy?	2.92	0.91	3.26	2.85	2.66
Bioeconomists think about how to make things work better. How important is it for you to think like this?	3.12	0.85	3.32	3.05	2.98
Bioeconomy makes the world a better place to live.	2.70	1.18	2.74	2.75	2.60
I think bioeconomists are the most important people in the world.	2.07	0.84	2.17	2.02	2.01
Bioeconomy is the most important thing in the world for me to learn.	2.23	0.87	2.23	2.23	2.22

[7] Tan, E., & Barton, A. C. (2007). Unpacking science for all through the lens of identities-in-practice: The stories of Amelia and Ginny. Cultural Studies of Science Education, 2(2), 361-392.

Question	Mean n=234	Standard deviation	Mean (4-8)	Mean (9-13)	Mean (14-18)
Knowing bioeconomy is important for being a good citizen.	2.59	1.08	2.49	2.72	2.54
I think bioeconomy is more important to know than anything else.	2.35	0.98	2.26	2.40	2.38
I think bioeconomy ideas are valuable.	2.66	1.01	2.68	2.71	2.59
Knowing bioeconomy helps me understand how the world works.	2.77	0.80	3.21	2.55	2.56
Thinking like a bioeconomist will help me do well in all my classes	2.36	0.79	2.84	2.17	2.09
Knowing bioeconomy is important for all jobs.	2.55	0.75	3.02	2.35	2.35

Degree of influence on young people in terms of fascination – Overall & gender analysis

Regarding fascination, the items that provide the most information when assessing students' attitudes toward bioeconomy have been selected. The results show that participants perceive a moderate level of fascination with bioeconomy. On a 4-point Likert scale, the overall average score across all items was 2.68, indicating a generally positive but not overly enthusiastic engagement with the topic.

The statement with the highest score was:

- "Bioeconomy makes me feel excited." (Me = 2.92)
- "In general, I find bioeconomy very interesting." (Me = 2.91)

These values suggest that students experience a moderate-to-high level of excitement and interest in bioeconomy, reflecting a positive perception of its appeal, though not reaching the maximum level of the scale.

On the other hand, the statement with the lowest score was:

- "I need to know how bioeconomy works." (Me = 2.13)

This result indicates that while bioeconomy is seen as interesting, it is not perceived as an urgent or essential need for students to understand, suggesting a lower level of intrinsic curiosity or perceived necessity.

No significant gender differences were observed, as shown in Table 15.

Table 15. Bioeconomy fascination among young people in schools

Question	Mean n=234	Standard deviation	Mean (M)	Mean (W)
I wonder about how bioeconomy works every day.	2.15	1.04	2.14	2.16
In general, when my students work on bioeconomy content, I love it.	2.78	0.82	2.68	2.90
In general, I find bioeconomy very interesting.	2.91	0.79	2.82	3.01
After a really interesting bioeconomy activity is over, I look for more information about bioeconomy	2.77	0.98	2.68	2.86
I need to know how bioeconomy works.	2.13	1.06	2.24	2.02

Question	Mean n=234	Standard deviation	Mean (M)	Mean (W)
I want to read everything I can find about bioeconomy.	2.47	0.93	2.51	2.42
I want to know everything about bioeconomy.	2.76	1	2.74	2.78
I want to know how to do everything that bioeconomists do	2.80	1.03	2.79	2.81
After a really interesting bioeconomy activity is over, I can't stop thinking about it	2.78	1.06	2.75	2.81
I talk about how bioeconomy work with friends or family	2.84	1.01	2.83	2.85
I love bioeconomy!	2.77	1.09	2.91	2.62
Bioeconomy makes me feel excited	2.92	1.05	2.97	2.87
I am interested in and want to learn more about the bioeconomy	2.79	1.07	2.87	2.69
I know the impact of the bioeconomy on the world around us	2.61	1.04	2.66	2.56
In the future, I would like to work in something related to the bioeconomy	2.69	1.02	2.64	2.76
I know what I need to learn to work in the bioeconomy	2.52	1	2.55	2.48
I want to know how to do everything related with my favourite theme on bioeconomy (biomaterials, bioenergy, farming, etc.)	2.80	1.03	2.92	2.64

Degree of influence on young people in terms of fascination – Age analysis

Table 16 presents the detailed results on fascination values among young people (n = 234), segmented by age groups (4-8 years, 9-13 years, and 14-18 years), highlighting varying levels of fascination with bioeconomy and its applications. The results indicate that no significant differences were found in the overall level of fascination with bioeconomy across age groups, with all cohorts exhibiting a similar moderate level of interest. On a 4-point Likert scale, the overall average scores across all items were 2.77 for the 4-8 years group, 2.73 for the 9-13 years group, and 2.63 for the 14-18 years group, suggesting a generally positive level of fascination that remains relatively consistent across ages, with only minor variations. However, in some specific items, significant and interesting differences can be observed.

A comparison across age groups reveals notable differences, particularly between the youngest (4-8 years) and oldest (14-18 years) cohorts. The 4-8 years group consistently shows higher means in key items related to fascination with bioeconomy:

- "In general, I find bioeconomy very interesting." (4-8: 3.43 vs. 14-18: 2.65, difference = 0.78)
- "In general, when I work on bioeconomy content, I love it." (4-8: 3.32 vs. 14-18: 2.50, difference = 0.82)
- "I know what I need to learn to work in the bioeconomy." (4-8: 3.05 vs. 14-18: 2.27, difference = 0.78)

These differences, exceeding 0.5 points in several cases, suggest a potentially significant shift in perception, indicating greater fascination among the youngest group in these specific areas. This heightened fascination among younger children may be attributed to their greater openness to playful, game-based learning approaches, such as the BioHeroes: Let's Save the Plnanet! card

game used in the GenB interventions, which aligns with their developmental stage and curiosity-driven engagement, as supported by Pyle et al.[8] (2017). In contrast, the lower fascination in the 14-18 years group may reflect their stage of academic and career orientation, where many have already chosen pathways—such as humanities or social sciences—less aligned with bioeconomy, a topic not typically embedded in their curricula, as highlighted by Tai et al.[9] (2006) and Sadler et al.[10] (2012), who note that adolescents' STEM interest often declines when career aspirations diverge from science-related fields. The 9-13 years group generally falls in between, with means closer to the 14-18 years group in most items.

Table 16. Bioeconomy fascination among young people in schools – Age analysis

Question	Mean n=234	Standard deviation	Mean (4-8)	Mean (9-13)	Mean (14-18)
I wonder about how bioeconomy works every day.	2.15	1.04	2.87	1.92	1.72
In general, when my students work on bioeconomy content, I love it.	2.78	0.82	3.32	2.57	2.5
In general, I find bioeconomy very interesting.	2.91	0.79	3.43	2.68	2.65
After a really interesting bioeconomy activity is over, I look for more information about bioeconomy	2.77	0.98	2.49	3.09	2.69
I need to know how bioeconomy works.	2.13	1.06	2.41	1.89	2.10
I want to read everything I can find about bioeconomy.	2.47	0.93	2.51	2.41	2.48
I want to know everything about bioeconomy.	2.76	1	2.61	2.77	2.85
I want to know how to do everything that bioeconomists do	2.80	1.03	2.41	2.93	3.05
After a really interesting bioeconomy activity is over, I can't stop thinking about it	2.78	1.06	2.47	3.04	2.82
I talk about how bioeconomy work with friends or family	2.84	1.01	2.61	3.05	2.84
I love bioeconomy!	2.77	1.09	2.65	2.98	2.68
Bioeconomy makes me feel excited	2.92	1.05	2.68	3.17	2.91
I am interested in and want to learn more about the bioeconomy	2.79	1.07	2.65	2.90	2.80
I know the impact of the bioeconomy on the world around us	2.61	1.04	2.61	2.64	2.58
In the future, I would like to work in something related to the bioeconomy	2.69	1.02	2.69	2.77	2.61
I know what I need to learn to work in the bioeconomy	2.52	1	3.05	2.26	2.27
I want to know how to do everything related with my favourite theme on bioeconomy (biomaterials, bioenergy, farming, etc.)	2.80	1.03	2.75	2.82	2.81

[8] Pyle, A., DeLuca, C., & Danniels, E. (2017). A scoping review of research on play-based pedagogies in kindergarten education. *Review of Education, 5*(3), 311–351. https://doi.org/10.1002/rev3.3097

[9] Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. Science, 312(5777), 1143–1144. https://doi.org/10.1126/science.1128690

[10] Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education, 96*(3), 411–427. https://doi.org/10.1002/sce.21007

Degree of influence on young people in terms of competencies beliefs – Overall & Gender analysis

The results show that participants perceive themselves to have a moderate level of competence beliefs in bioeconomy, with an overall average of 2.63 on a 4-point scale.

The highest-rated statements were:

- "I can understand bioeconomy information on websites for my age." (Me = 3.07)
- "I can do the bioeconomy activities I get in class all the time." (Me = 2.66)

These values suggest that participants feel confident in their ability to understand age-appropriate bioeconomy information and perform classroom activities related to bioeconomy, reflecting a positive perception of their competence in these areas.

On the other hand, the lowest-rated statement was:

- "I think I am very good at: Figuring out how to fix a bioeconomy activity that didn't work." (Me = 2.47)

This result suggests that participants believe they can be engaged in bioeconomy activities and understand related content, while they are less confident in their ability to troubleshoot or solve problems when activities do not go as planned.

The data reflect a positive but moderate perception of students' competence in bioeconomy. While their ability to understand age-appropriate information and perform classroom activities is recognised, there is potential for improvement in problem-solving skills, as shown in Table XX.

This is not unexpected, as bioeconomy is a thematic area with which students are not typically accustomed to working in class, which may limit their familiarity and confidence in addressing challenges related to this subject.

No significant gender differences were observed, as shown in Table 17.

Table 17. Bioeconomy competency beliefs among young people in schools

Question	Mean n=234	Standard deviation	Mean (M)	Mean (W)
I can do the bioeconomy activities I get in class all the time.	2.66	0.99	2.69	2.64
If I went to a bioeconomy museum, I could figure out what is being show in all areas.	2.62	0.93	2.63	2.61
I can understand bioeconomy information on websites for my age.	3.07	1.26	3.02	3.13
If I did my own project in an after-school bioeconomy club, it would be excellent.	2.48	0.94	2.36	2.60
I think I am very good at: Figuring out how to fix a bioeconomy activity that didn't work.	2.47	0.75	2.50	2.44
I think I am very good at: Coming up with questions about bioeconomy.	2.54	0.77	2.52	2.57
I think I am very good at: Doing bioeconomy experiments.	2.59	0.81	2.62	2.56

Degree of influence on young people in terms of competencies beliefs – Age analysis

Table 18 presents the detailed results on competency beliefs among young people (n = 234), segmented by age groups (4-8 years, 9-13 years, and 14-18 years), highlighting varying perceptions of competence in bioeconomy and its applications. The results indicate that younger age groups tend to exhibit a more positive perception of their competence in bioeconomy, while older groups show a more moderate stance, potentially reflecting differences in educational focus and exposure. On a 4-point Likert scale, the overall scores across all items were 3.08 for the 4-8 years group, 2.41 for the 9-13 years group, and 2.45 for the 14-18 years group, suggesting a generally positive perception that decreases with age after the youngest group, with the 4-8 years cohort showing the highest overall confidence.

A comparison across age groups reveals notable differences, particularly between the youngest (4-8 years) and oldest (14-18 years) cohorts. The 4-8 years group consistently shows higher means in key items related to perceived competence in bioeconomy:

- "I can understand bioeconomy information on websites for my age." (4-8: 3.67 vs. 14-18: 2.79, difference = 0.88)
- "I can do the bioeconomy activities I get in class all the time." (4-8: 3.37 vs. 14-18: 2.43, difference = 0.94)
- "If I did my own project in an after-school bioeconomy club, it would be excellent." (4-8: 3.10 vs. 14-18: 2.22, difference = 0.88)

These differences, exceeding 0.5 points in several cases (e.g., 0.94 and 0.88), suggest a potentially significant shift in perception, indicating greater confidence among the youngest group. The 9-13 years group generally falls in between, with means slightly lower than the 14-18 years group in most items, reflecting a transitional phase in educational focus and possibly a dip in confidence during this developmental stage, as noted in prior studies on science learning.

The higher means among the 4-8 years group support the hypothesis that younger children exhibit a stronger belief in their competence for bioeconomy-related tasks[11]. While bioeconomy is related to the "S" of STEM (science), encompassing areas such as biotechnology and sustainability typically studied in science subjects (e.g., biology, environmental science), its lack of explicit integration into the secondary STEM curriculum may reduce older students' perceived competence due to a lack of perceived relevance to their academic or career goals, a phenomenon observed in prior research on STEM interest during adolescence (Tai et al.,[12] 2006;

[11] This can be always explained by their educational stage, where curricula are more holistic, often integrating hands-on and nature-based learning that fosters confidence in basic bioeconomy skills through practical and less evaluative learning environments, as supported by Pyle et al. Pyle, A., DeLuca, C., & Danniels, E. (2017). A scoping review of research on play-based pedagogies in kindergarten education. *Review of Education, 5*(3), 311–351. https://doi.org/10.1002/rev3.3097.
In contrast, the 14-18 years group, likely in secondary or pre-university education, may have chosen specialised tracks (e.g., sciences, humanities, or arts), which could disconnect them from bioeconomy topics if not explicitly included in their educational curricula.

[12] Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science, 312*(5777), 1143–1144. https://doi.org/10.1126/science.1128690

Sadler et al.,[13] 2012). These findings underscore the importance of early, engaging bioeconomy education through interactive methods to build lasting confidence, which may encourage younger students to pursue educational pathways related to bioeconomy or careers in sustainable fields, supporting the long-term objectives of the European Bioeconomy Strategy.

Table 18. Bioeconomy competency beliefs among young people in schools – Age analysis

Question	Mean n=234	Standard deviation	Mean (4-8)	Mean (9-13)	Mean (14-18)
I can do the bioeconomy activities I get in class all the time.	2.66	0.99	3.37	2.24	2.43
If I went to a bioeconomy museum, I could figure out what is being show in all areas.	2.62	0.93	3.21	2.26	2.42
I can understand bioeconomy information on websites for my age.	3.07	1.26	3.67	2.80	2.79
If I did my own project in an after-school bioeconomy club, it would be excellent.	2.48	0.94	3.10	2.20	2.22
I think I am very good at: Figuring out how to fix a bioeconomy activity that didn't work.	2.47	0.75	2.69	2.29	2.44
I think I am very good at: Coming up with questions about bioeconomy.	2.54	0.77	2.68	2.51	2.44
I think I am very good at: Doing bioeconomy experiments.	2.59	0.81	2.84	2.53	2.41

Degree of influence on young people in terms of knowledge – Overall and gender analysis

Now, through an adaptation of the Sulitest scale, participants are asked how they believe the GenB content taught during the intervention will impact them, specifically in sustainability-related topics. Only this scale is assessed using a 7-point Likert scale.

The results suggest that participants perceive a moderately positive influence of the GenB content on their knowledge and attitudes toward sustainability-related topics. The overall average score across all items was 4.21, indicating a perception that leans toward the positive but remains tempered, reflecting a balanced engagement with the content rather than an overwhelmingly enthusiastic endorsement.

The statements with the highest scores were:

- "We will learn a lot by completing the GenB content." (Me = 4.57)
- "The GenB content will help me reflect on my knowledge of sustainability." (Me = 4.46)

These values suggest that participants view the GenB content as a useful resource for enhancing their understanding and fostering reflection on sustainability, pointing to a solid educational foundation with room for further growth.

Conversely, the statements with the lowest scores were:

[13] Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education, 96*(3), 411–427. https://doi.org/10.1002/sce.21007

- "The content will help me understand how sustainability knowledge compares to that of other children of the same age in the same country." (Me = 3.98)
- "The content will help me understand how sustainability knowledge compares to that of other children of the same age globally." (Me = 3.98)

These findings indicate that the perceived influence of the content is less pronounced when it comes to enabling comparisons with peers, either nationally or globally, suggesting an area where the intervention's impact could be strengthened.

All details can be found in Table 19.

Table 19. Sustainability knowledge among young people in schools

Question	Mean n=234	Standard deviation	Mean (M)	Mean (W)
GenB will help me see sustainable opportunities around me.	4.30	1.73	4.19	4.42
We will learn a lot by completing the GenB content.	4.57	1.64	4.55	4.6
The GenB content will help my reflect on my knowledge of sustainability.	4.46	1.67	4.41	4.52
The content will help me understand how sustainability knowledge compares to that of other children of the same age in the same country.	3.98	1.48	3.89	4.09
The content will help me understand how sustainability knowledge compares to that of other children of the same age globally.	3.98	1.47	3.87	4.1
The content will motivate me to share sustainability-related information with other people they know..	4.21	1.57	4.15	4.27
The GenB content will motivate me to seek additional sustainability information from other people they know.	4.10	1.63	4.06	4.14
It is likely that we will voluntarily repeat the GenB content in the future to see if we have improved our knowledge of sustainability.	4.07	1.57	4.11	4.03

Degree of influence on young people in terms of knowledge – Age analysis

Regarding age, the results show significant differences in the perception of the content's impact across age groups. The overall average scores by age group were: 5.76 for the 4-8 age group, 3.48 for the 9-13 age group, and 3.50 for the 14-18 age group. This indicates a highly positive perception among the youngest participants, which contrasts with a more moderate perception, close to neutral, in the older age groups. These values reflect considerable enthusiasm among the youngest children, who perceive the content as a valuable tool for learning and reflection, approaching the upper end of the scale. However, pre-adolescents and adolescents perceive a more limited impact, particularly in the comparative dimension of the content, which could suggest lower relevance of this aspect for these age groups.

Table 20. Sustainability knowledge among young people in schools – Age analysis

Question	Mean n=234	Standard deviation	Mean (4-8)	Mean (9-13)	Mean (14-18)
GenB will help me see sustainable opportunities around me.	4.30	1.73	5.93	3.43	3.67
We will learn a lot by completing the GenB content.	4.57	1.64	6.16	3.68	4.00
The GenB content will help my reflect on my knowledge of sustainability.	4.46	1.67	6.05	3.66	3.81
The content will help me understand how sustainability knowledge compares to that of other children of the same age in the same country.	3.98	1.48	5.40	3.33	3.26
The content will help me understand how sustainability knowledge compares to that of other children of the same age globally.	3.98	1.47	5.57	3.37	3.06
The content will motivate me to share sustainability-related information with other people they know.	4.21	1.57	5.78	3.54	3.44
The GenB content will motivate me to seek additional sustainability information from other people they know.	4.10	1.63	5.67	3.40	3.36
It is likely that we will voluntarily repeat the GenB content in the future to see if we have improved our knowledge of sustainability.	4.07	1.57	5.49	3.46	3.38

Young People's engagement – Overall & Gender analysis

Table 21 presents the detailed results on engagement among young people during a GenB bioeconomy activity, highlighting their level of commitment and how they experienced the activity, allowing conclusions to be drawn about their engagement. Affective, cognitive, and behavioural engagement are assessed through the selected items. The data show a strong affective engagement and a positive cognitive engagement, with an overall average score across all items of 2.60 on a 4-point Likert scale, suggesting a highly positive experience with the activity, driven by the engaging design of the Key Exploitable Results (KERs) used, such as BioHeroes: Let's Save the Planet! and The BioRace, specifically developed for the school environment.

The highest-rated statements were:

- "During this activity: I felt happy." (Me = 3.33, SD = 0.54)
- "During this activity: I felt excited." (Me = 3.26, SD = 0.94)

These values indicate a strong positive emotional response, with students reporting high levels of happiness and excitement, reflecting robust affective engagement during the bioeconomy activity. This strong affective engagement can be attributed to the interactive and playful nature of the KERs, such as the BioHeroes: Let's Save the Planet! card game for younger students and the BioRace board game for older ones, which likely fostered a sense of enjoyment and novelty, enhancing emotional connection to the activity.

Additional insights show low levels of boredom ("During this activity: I felt bored." Me = 1.95, SD = 1.00), further underscoring the engaging quality of the KERs in maintaining student interest.

Likewise, moderate distraction was observed, as students were busy with other tasks (Me = 2.69, SD = 1.04) and talked about unrelated topics (Me = 2.46, SD = 1.04) to a certain extent. The perception that "During this activity: Time went by quickly." (Me = 2.18, SD = 1.01) suggests a moderate sense of immersion, though not overwhelmingly positive. These distractions and the moderate perception of time passing quickly may be attributed to the structured classroom setting, which can limit autonomy, particularly if the activity does not align with students' immediate interests or if external distractions are present, a phenomenon often observed in formal educational contexts (Fredricks et al[14]., 2004; Klassen & Chiu[15], 2010).

Overall, the data suggest that young people were highly engaged affectively and positively engaged cognitively during the bioeconomy activity. The results are moderately positive within the school context, and prolonged engagement with these materials, leading to their full mastery, could further enhance engagement levels, optimising their educational impact in future bioeconomy initiatives.

No significant gender differences were observed, as shown in Table 21.

Table 21. Engagement among young people in schools

Question	Mean n=234	Standard deviation	Mean (M)	Mean (W)
During this activity: I felt bored.	1.95	1	1.93	1.97
During this activity: I felt happy.	3.33	0.54	3.28	3.40
During this activity: I felt excited.	3.26	0.94	3.26	3.26
During this activity: I was daydreaming a lot.	2.75	0.92	2.78	2.71
During this activity MOOC: I was focused on the things we were learning most of the time.	2.21	0.98	2.28	2.13
During this activity: I was busy doing other tasks	2.69	1.04	2.69	2.68
During this activity: I talked to others about stuff not related to what we were learning.	2.46	1.04	2.45	2.48
During this activity: Time went by quickly.	2.18	1.01	2.12	2.24

Young People engagement – Age analysis

Regarding age, there were no significant differences in terms of engagement with the proposed activity.

[14] Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059

[15] Klassen, R. M., & Chiu, M. M. (2010). Effects on teachers' self-efficacy and job satisfaction: Teacher gender, years of experience, and job stress. *Journal of Educational Psychology, 102*(3), 741–756. https://doi.org/10.1037/a0019237

Table 22. Engagement among young people in schools – Age analysis

Question	Mean n=234	Standard deviation	Mean (4-8)	Mean (9-13)	Mean (14-18)
During this activity: I felt bored.	1.95	1	1.93	1.97	1.95
During this activity: I felt happy.	3.33	0.54	3.42	3.42	3.16
During this activity: I felt excited.	3.26	0.94	3.58	3.06	3.15
During this activity: I was daydreaming a lot.	2.75	0.92	2.74	2.78	2.71
During this activity: I was focused on the things we were learning most of the time.	2.21	0.98	2.3	2.13	2.10
During this activity: I was busy doing other tasks	2.69	1.04	2.69	2.60	2.78
During this activity: I talked to others about stuff not related to what we were learning.	2.46	1.04	2.45	2.48	2.47
During this activity: Time went by quickly.	2.18	1.01	2.34	2.065	2.14

Young People satisfaction – Overall & Gender analysis

Regarding young people's satisfaction with the GenB activities, the results indicate a moderately positive level of satisfaction among participants with the activities delivered under the GenB project. The overall average score across all items was 3.22, slightly above the neutral midpoint of 3, suggesting that young people found the activities generally acceptable and somewhat valuable, though their responses reflect a tempered enthusiasm rather than strong endorsement. The standard deviations, ranging from 1.10 to 1.42, reveal moderate-to-high variability, indicating a spread of responses with some participants highly engaged and others less so, reaching both ends of the scale.

The statements with the highest scores were:

- "I am satisfied with this activity." (Me = 3.56, SD = 1.13)
- "I am interested and want to learn more about the bioeconomy." (Me = 3.33, SD = 1.10

These values suggest a reasonable level of satisfaction and curiosity among participants, with lower variability (SD = 1.10–1.13) indicating relatively consistent positive sentiment for these aspects across the sample.

Conversely, the statements with the lowest scores and higher variability were:

- "When I grow up, I would like to work in something related to the bioeconomy." (Me = 3.04, SD = 1.23)
- "The activity motivates me to integrate the knowledge taught about bioeconomy in my daily life." (Me = 3.05, SD = 1.37)

These scores, hovering near the neutral point with elevated standard deviations, point to a polarised response: some participants felt inspired or motivated, while others showed limited interest in long-term engagement or practical application, reflecting diverse levels of connection to the bioeconomy.

The moderate-to-high standard deviations (average SD ≈ 1.28) highlight significant heterogeneity in satisfaction and engagement. This variability aligns with findings in educational research, such as Deci and Ryan (2000)[16] on Self-Determination Theory, which posits that students' motivation depends on the perceived relevance and personal connection to a subject. In a school setting, introducing bioeconomy—a relatively novel topic—may strongly appeal to students already interested in sustainability or science, while others, perhaps due to competing academic priorities or a perception of the topic as peripheral to their preferred subjects, exhibit less enthusiasm. This spread suggests both the potential of the activities to captivate certain learners and the challenge of broadening their appeal.

Regarding gender, there were no significant differences in terms of satisfaction with the proposed activity.

Table 23. Satisfaction among young people in schools

Question	Mean n=234	Standard deviation	Mean (M)	Mean (W)
The activity was fun and entertaining.	3.18	1.33	3.09	3.27
The activity is recommendable for different age categories.	3.15	1.21	3.18	3.10
I am satisfied with this activity.	3.56	1.13	3.56	3.57
The activity increases my knowledge about bioeconomy.	3.24	1.38	3.30	3.17
I catch the basic ideas of the knowledge taught about bioeconomy.	3.24	1.27	3.29	3.19
I will try to apply the knowledge learned about bioeconomy in the activity	3.21	1.35	3.23	3.18
The activity motivates me to integrate the knowledge taught about bioeconomy in my daily life	3.05	1.37	3.08	3.02
I am interested and want to learn more about the bioeconomy	3.33	1.10	3.26	3.40
When I grow up, I would like to work in something related to the bioeconomy	3.04	1.23	3.02	3.05
I am aware of the impact of the bioeconomy on the world around us	3.18	1.42	3.25	3.11

Young People satisfaction – Age analysis

The evaluation of young people's satisfaction with the GenB activities, segmented by age groups (4-8, 9-13, and 14-18 years), reveals distinct differences in their experiences and perceptions. The overall average scores were 4.49 for the 4-8 age group, 2.59 for the 9-13 age group, and 2.68 for the 14-18 age group, with a global mean of 3.22. These results indicate a notably higher satisfaction among the youngest participants, contrasting with a more moderate perception—close to the neutral point of 3—among the older cohorts, reflecting age-related variations in engagement with the bioeconomy-focused activities.

[16] Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11(4), 227–268.

The pronounced satisfaction among the 4-8 age group aligns with educational research on younger learners' preferences and developmental stages. Pyle et al. (2017)[17] highlight those children in early education, with less defined academic interests, are particularly receptive to play-based and interactive learning approaches, such as those likely embedded in the GenB activities. This openness enhances their satisfaction and perceived value, as evidenced by their high scores across multiple dimensions. Conversely, older students (9-13 and 14-18 years) may exhibit a more critical stance, as their educational focus narrows and their expectations for relevance and challenge increase, a trend supported by Deci and Ryan's (2000)[18] Self-Determination Theory. This theory posits that intrinsic motivation depends on meeting needs for competence and autonomy, which the engaging design of GenB satisfies effectively for younger children, while older learners, with more established preferences, may require content more tailored to their specific interests or developmental stage.

The high variability in responses (SD = 1.10–1.42) further underscores these differences, suggesting a spectrum of engagement within each age group, particularly pronounced among older participants. These findings affirm the GenB activities as a robust educational tool for younger learners, establishing a strong foundation for bioeconomy awareness, while indicating opportunities to adapt the approach—perhaps through increased relevance or complexity—to better resonate with pre-adolescents and adolescents.

Table 24. Satisfaction among young people in schools – Age analysis

Question	Mean n=234	Standard deviation	Mean (4-8)	Mean (9-13)	Mean (14-18)
The activity was fun and entertaining.	3.18	1.33	4.28	2.58	2.75
The activity is recommendable for different age categories.	3.15	1.21	4.55	2.43	2.50
I am satisfied with this activity.	3.56	1.13	4.47	3.11	3.17
The activity increases my knowledge about bioeconomy.	3.24	1.38	4.63	2.63	2.58
I catch the basic ideas of the knowledge taught about bioeconomy.	3.24	1.27	4.63	2.51	2.70
I will try to apply the knowledge learned about bioeconomy in the activity	3.21	1.35	4.53	2.61	2.59
The activity motivates me to integrate the knowledge taught about bioeconomy in my daily life	3.05	1.37	4.57	2.23	2.47
I am interested and want to learn more about the bioeconomy	3.33	1.10	4.38	2.81	2.88
When I grow up, I would like to work in something related to the bioeconomy	3.04	1.23	4.27	2.43	2.54
I am aware of the impact of the bioeconomy on the world around us	3.18	1.42	4.54	2.51	2.60

[17] Pyle, A., DeLuca, C., & Danniels, E. (2017). A scoping review of research on play-based pedagogies in kindergarten education. *Review of Education, 5*(3), 311–351.
[18] Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268.

7. Follow up evaluation – School results

After a few days following the completion of the KERs activity, participants complete the follow-up questionnaire. This questionnaire is identical to the pre-evaluation questionnaire, with the objective of identifying significant changes in the participants' self-knowledge and habits after taking part in the activity.

Change of knowledge in young people – Overall

The results indicate a significant improvement in participants' knowledge after completing the KERs assessment in school, with an average increase of 18% in the percentage of correct responses, achieving a 45% success rate in the final evaluation. This increase reflects a highly positive impact of the materials developed within the framework of the GenB project. the KERs BioHeroes: Let's Save the Planet! and The BioRace have been effective in clarifying key concepts and strengthening participants' understanding of bioeconomy principles, aligning with findings that game-based learning enhances knowledge retention and engagement (Hidi & Renninger, 2006)[19].

In contrast, the intervention with the test group proved successful, demonstrating that the KERs developed under the GenB project substantially enhance bioeconomy knowledge.

The questions that have demonstrated the greatest knowledge gain are the following:

- "Do you know what bioeconomy is?" (+45%)
- "Where are bio-based plastics recycled?" (+37%)
- "What is the primary goal on integrating renewable energies" (+35%)
- "Which of these processes optimize resources the bioeconomy?"(+35%)

Regarding the control group percipients, which did not engage with the KERs, achieved an average success rate of 35% in the post-test, reflecting a more modest knowledge gain of 8% from the pre-test. Both groups showed improvements in basic conceptual questions, such as:

- "Do you know what bioeconomy is?" (38% pre vs 72% post control group vs 83% post test group)
- "Can bio-based plastics be recycled?" (50% pre vs 77% post control group vs 80% post test group)
- "Bioeconomy…." (40% pre vs 60% post control group vs 64% post test group)

The control group's improvement in these questions may be attributed to a test-retest effect, where exposure to the pre-test sparked curiosity, prompting some participants to seek

[19] Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4

information independently or discuss with peers from the test group during informal settings like recess, a phenomenon observed in educational interventions (Roediger & Karpicke, 2006)[20]:

1. When completing the pre-test and being introduced to the concept of bioeconomy, this may have sparked the curiosity of the young participants, prompting them to search for information online and/or ask their family or friends what bioeconomy is.
2. Friends participating in the test group, due to their increased fascination and engagement with the activity, may have explained what bioeconomy is and shared the content of the activity with the GenB materials, thereby retaining the most basic concepts. Settings such as recess or joint extracurricular activities provide opportunities for this type of behaviour.

However, the test group's superior gains, particularly in questions requiring deeper understanding, such as "Where are bio-based plastics recycled?" (+37%) and "What is the primary goal of integrating renewable energies?" (+35%), demonstrate the added value of the KERs in fostering significant knowledge acquisition.

Nevertheless, some areas were identified where knowledge levels are lower than those observed in the pre-evaluation:

- "Are all bio-based plastics biodegradable?" (-21%) - After conducting the intervention and gaining knowledge about bioeconomy and how it relates to plastics, the young participants firmly believe that all bio-based plastics are biodegradable. This misconception has been identified as a point for future improvement. It is recommended to develop materials that, in addition to highlighting the benefits of bioeconomy, place greater emphasis on clarifying what bioeconomy cannot achieve.

- "Which of the following is an example of a green job?" (-14%) - Participants actively select the 'plastic factory worker' as an example of a green job. This choice stems from their knowledge of bioeconomy and the focus on plastics during the intervention, a theme presents in both games. This leads them to believe that a worker in a plastics factory could, for instance, contribute to producing bio-based plastics, thereby helping to create a greener world.

- The remaining questions that show a decline in knowledge pertain to highly technical topics that are not part of the KERs used in this intervention.

These misconceptions, which reflect the application of simplified mental models based on students' everyday knowledge, suggest the need to develop future materials that not only highlight the benefits of bioeconomy but also explicitly address these erroneous ideas,

[20] Roediger, H. L., & Karpicke, J. D. (2006). The power of testing memory: Basic research and implications for educational practice. *Perspectives on Psychological Science, 1*(3), 181–210. https://doi.org/10.1111/j.1745-6916.2006.00012.x

explaining why they are incorrect, as recommended by Chi (2005)[21], to ensure a more accurate understanding. The GenB Community of Practices will support the achievement of this objective, making the materials and tools of GenB and further similar projects available to the general public for at least five years after the end of GenB.

All these details can be found in Table 25.

Table 25. Bioeconomy knowledge in young people

Question	Correct answer	Pre-Accuracy %	Follow up Accuracy % (Control Group)	Follow up Accuracy % (Test Group)	Variation after implementation
Do you know what bioeconomy is?	**a) Bioeconomy is the economy based on using natural resources, such as plant and animals, sustainability to produce food, energy, and products without harming the environment** b) Incorrect answers	38%	72%	83%	+45%
Are all bio-based plastics biodegradable?*	a) Yes **b) No** c) I don´t know	32%	25%	11%	-21%
Can bio-based plastics be recycled?	**a) Yes** b) No c) I don´t know	50%	77%	80%	+30%
The dominant application for bio-based plastics is…*	a) Automotive **b) Packaging** c) Footwear d) Electronics e) I don´t know	37%	50%	64%	+27%
Where are bio-based plastics recycled?*	**a) Chemical recycling plants** b) They cannot be recycled c) They decompose in the ground d) Composing facilities e) I don't know	16%	21%	53%	+37%
You can make fuel out of...	a) Wood b) Used cooking oil c) Horse poop **d) All of them** e) I don´t know	23%	28%	52%	+29%

[21] Chi, M. T. H. (2005). Commonsense conceptions of emergent processes: Why some misconceptions are robust. *Journal of the Learning Sciences, 14*(2), 161–199. https://doi.org/10.1207/s15327809jls1402_1

Question	Correct answer	Pre-Accuracy %	Follow up Accuracy % (Control Group)	Follow up Accuracy % (Test Group)	Variation after implementation
In what forms can biofuel be presented?*	a) Solid b) Liquid c) Gas **d) All of them** e) I don´t know	32%	33%	64%	+31%
What are barriers to the development of the biofuel market?*	a) High production cost b) Lack of affordable raw materials c) Insufficient infrastructure **d) All of them** e) I don´t know	14%	9%	46%	+32%
In what areas does the bioeconomy works?*	a) Agriculture b) Production and manufacturing c) Forestry and fishing **d) All of them** e) I don´t know	33%	48%	64%	+31%
What is the primary goal on integrating renewable energies into the bioeconomy?	a) To use up non-renewable resources **b) To reduce fossil fuel use and support sustainability** c) To ignore issues in energy d) I don´t know	36%	37%	71%	+35%
Bioeconomy…*	a) Contributes to the reduction of CO2 emissions b) Reuses waste to produce new materials and energy c) Creates new jobs **d) All of them** e) I don´t know	40%	60%	64%	+24%
Which of the following best describes Life Cycle Assessment (LCA) in the context of the bioeconomy?*	a) A method to increase agricultural yield b) **A technique to evaluate the environmental impact of a product throughout its lifespan** c) A process to improve the genetic modification crops d) A strategy for marketing bio-based products e) I don´t know	27%	33%	16%	-11%

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Question	Correct answer	Pre-Accuracy %	Follow up Accuracy % (Control Group)	Follow up Accuracy % (Test Group)	Variation after implementation
Which of these processes optimize resources the bioeconomy?	a) Simply disposing of waste in landfills **b) Processing residues or by-products into raw materials** c) Burning all waste materials d) Avoiding the generation of waste altogether	32%	40%	68%	+35%
What is the difference between upcycling and downcycling in the recycling process?*	f) Upcycling creates lower quality and value materials, while downcycling improves quality and value g) Both processes create materials of the same quality **h) Downcycling produces lower quality and value materials, while upcycling enhances quality and value** i) Upcycling and downcycling are unrelated to recycling j) I don´t know	18%	10%	11%	-7%
Which of the following statements about composting is true?*	a) Composting involves burning organic waste to generate energy **b) Composting converts organic waste and improves soil quality** c) Composting is a method for recycling plastics d) All of them are true	21%	11%	7%	-14%
What does biodegradation refer to? *	a) Burning organic waste to make energy b) Making new materials with chemicals c) Recycling plastics using machines **d) Microorganisms breaking down organic materials** e) I don´t know	21%	19%	27%	+6%
What is biomimicry?*	**a) Imitating natural processes and systems to solve human problems**	13%	19%	34%	+21%

Question	Correct answer	Pre-Accuracy %	Follow up Accuracy % (Control Group)	Follow up Accuracy % (Test Group)	Variation after implementation
	b) Creating synthetic materials using biotechnology c) Breeding animals for specific genetic traits d) The study of fossils and ancient life forms e) I don´t know				
Why do non-biodegradable materials, like plastics, pose long-term environmental risks?	a) They descompose quickly but leave harmful residues b) They are easily absorbed by natural processes **c) They persist for a long time and can harm ecosystems and wildlife** d) They break down into harmless substances that benefit the environment e) I don´t know	22%	9%	37%	+15%
What is an important feature of non-renewable energy sources?	a) They are always being made by nature b) They don´t harm the environment much c) They can be used forever without running out **d) They will run out because they can´t be replaced quickly** e) I don´t know	22%	24%	25%	+3%
Which of the following is an example of a green job?	a) Coal miner **b) Solar panel installer** c) Oil rig worker d) Plastic factory worker e) I don´t know	34%	44%	48%	-14%
What is the benefit associated with bio-based plastics their recycling, and their environmental impact?	a) They increase greenhouse gas emissions **b) They reduce dependence on fossil fuels** c) They are non-biodegradable d) They contribute to ocean pollution e) I don´t know	35%	57%	57%	+22%

Question	Correct answer	Pre-Accuracy %	Follow up Accuracy % (Control Group)	Follow up Accuracy % (Test Group)	Variation after implementation
Overall		**27%**	**34%**	**45%**	+18%

Change of knowledge in young people – Gender analysis

Regarding gender, there are no significant differences.

Change of knowledge in young people – Age analysis

Regarding age analysis:

- The average percentage of correct responses among participants aged 4-8 who played the game BioHeroes: Let's Save the Planet was 56%. This game proves to be fully adapted to this age range, demonstrating high effectiveness in increasing young participants' knowledge.
- The average percentage of correct responses among participants aged 9-13 and 14-18[22] who played the game The BioRace was at 34%. This result can be explained since BioRace is not designed to enhance in-depth scientific and technical knowledge of all bioeconomy aspects but to provide an overview and initial approach to the processes involved. The questions used in the KER assessment required advanced knowledge that cannot be acquired solely through the game but through multiple educational activities. BioRace should be considered part of a broader learning pathway, serving as an initial or complementary component, not as a standalone educational tool.

These factors, presented as hypotheses, could serve as a foundation for future research to further justify these outcomes.

All these details can be found in Table 26.

Table 26. Bioeconomy knowledge in young people – Age analysis

Question	Correct answer	Follow up Accuracy % (Test Group)	Follow Up Accuracy % (4-8)	Follow Up Accuracy % (9-13)	Follow Up Accuracy % (14-18)
Do you know what bioeconomy is?	**a) Bioeconomy is the economy based on using natural resources, such as plant and animals, sustainability to produce food, energy, and**	83%	92%	63%	86%

[22] The analysis of the BioRace games for the 14–18 age group was carried out only in Spain, as the format was originally designed for different target audiences

		products without harming the environment				
	b)	Incorrect answers				
Are all bio-based plastics biodegradable?*	a)	Yes	11%	-	12%	10%
	b)	**No**				
	c)	I don´t know				
Can bio-based plastics be recycled?	**a)**	**Yes**	80%	84%	66%	79%
	b)	No				
	c)	I don´t know				
The dominant application for bio-based plastics is…*	a)	Automotive	64%	-	55%	68%
	b)	**Packaging**				
	c)	Footwear				
	d)	Electronics				
	e)	I don´t know				
Where are bio-based plastics recycled?*	**a)**	**Chemical recycling plants**	53%	-	39%	64%
	b)	They cannot be recycled				
	c)	They descompose in the ground				
	d)	Composing facilities				
	e)	I don't know				
You can make fuel out of...	a)	Wood	52%	34%	43%	71%
	b)	Used cooking oil				
	c)	Horse poop				
	d)	**All of them**				
	e)	I don´t know				
In what forms can biofuel be presented?*	a)	Solid	64%	-	44%	77%
	b)	Liquid				
	c)	Gas				
	d)	**All of them**				
	e)	I don´t know				
What are barriers to the development of the biofuel market?*	a)	High production cost	46%	-	32%	56%
	b)	Lack of affordable raw materials				
	c)	Insufficient infrastructure				
	d)	**All of them**				
	e)	I don´t know				
In what areas does the bioeconomy works?*	a)	Agriculture	64%	-	44%	77%
	b)	Production and manufacturing				
	c)	Forestry and fishing				
	d)	**All of them**				
	e)	I don´t know				
What is the primary goal on integrating renewable energies into the bioeconomy?	a)	To use up non-renewable resources	71%	74%	50%	79%
	b)	**To reduce fossil fuel use and support sustainability**				
	c)	To ignore issues in energy				
	d)	I don´t know				
Bioeconomy…*	a)	Contributes to the reduction of CO2 emissions	64%	-	47%	75%
	b)	Reuses waste to produce new materials and energy				
	c)	Creates new jobs				

	d)	**All of them**				
	e)	I don´t know				
Which of the following best describes Life Cycle Assessment (LCA) in the context of the bioeconomy?*	a)	A method to increase agricultural yield	16%	-	14%	11%
	b)	**A technique to evaluate the environmental impact of a product throughout its lifespan**				
	c)	A process to improve the genetic modification crops				
	d)	A strategy for marketing bio-based products				
	e)	I don´t know				
Which of these processes optimize resources the bioeconomy?	a)	Simply disposing of waste in landfills	68%	89%	39%	71%
	b)	**Processing residues or by-products into raw materials**				
	c)	Burning all waste materials				
	d)	Avoiding the generation of waste altogether				
What is the difference between upcycling and downcycling in the recycling process?*	a)	Upcycling creates lower quality and value materials, while downcycling improves quality and value	11%	-	9%	13%
	b)	Both processes create materials of the same quality				
	c)	**Downcycling produces lower quality and value materials, while upcycling enhances quality and value**				
	d)	Upcycling and downcycling are unrelated to recycling				
	e)	I don´t know				
Which of the following statements about composting is true?*	a)	Composting involves burning organic waste to generate energy	7%	-	7%	7%
	b)	**Composting converts organic waste and improves soil quality**				
	c)	Composting is a method for recycling plastics				
	d)	All of them are true				
What does biodegradation refer to? *	a)	Burning organic waste to make energy	27%	-	17%	32%
	b)	Making new materials with chemicals				
	c)	Recycling plastics using machines				
	d)	**Microorganisms breaking down organic materials**				

	e)	I don´t know				
What is biomimicry?*	**a)**	**Imitating natural processes and systems to solve human problems**	34%	-	26%	36%
	b)	Creating synthetic materials using biotechnology				
	c)	Breeding animals for specific genetic traits				
	d)	The study of fossils and ancient life forms				
	e)	I don´t know				
Why do non-biodegradable materials, like plastics, pose long-term environmental risks?	a)	They descompose quickly but leave harmful residues	37%	39%	33%	37%
	b)	They are easily absorbed by natural processes				
	c)	**They persist for a long time and can harm ecosystems and wildlife**				
	d)	They break down into harmless substances that benefit the environment				
	e)	I don´t know				
What is an important feature of non-renewable energy sources?	a)	They are always being made by nature	25%	31%	20%	24%
	b)	They don´t harm the environment much				
	c)	They can be used forever without running out				
	d)	**They will run out because they can´t be replaced quickly**				
	e)	I don´t know				
Which of the following is an example of a green job?	f)	Coal miner	48%	-	34%	58%
	g)	**Solar panel installer**				
	h)	Oil rig worker				
	i)	Plastic factory worker				
	j)	I don´t know				
What is the benefit associated with bio-based plastics their recycling, and their environmental impact?	f)	They increase greenhouse gas emissions	57%	-	39%	73%
	g)	**They reduce dependence on fossil fuels**				
	h)	They are non-biodegradable				
	i)	They contribute to ocean pollution				
	j)	I don´t know				
Overall			**45%**	**56%**	**34%**	**46%**

Self-perception of green habits change – Overall

The KERs assessment does not influence the green habits of young people. Youths in the 4-18 age range often lack decision-making capacity in many of these matters, which makes it consistent that no significant change in these habits is observed, as shown Table 27.

Table 27. Green habits in young people

Question	Pre-Mean	Follow Up Mean (Control Group)	Follow Up Mean (Tested Group)	Variation after implementation
I turn off the lights/television when I leave a room	4.34	4.28	4.39	+0.05
I unplug appliances that are left in stand-by mode*	3.25	3.14	3.25	0
I reduce the use of heating or air-conditioning to limit energy consumption*	3.40	3.16	3.47	+0.07
I reduce the time I take showers to save water	3.26	3.22	3.48	+0.22
I watch TV programs, videos or movies on environmental issues	2.53	2.63	2.55	+0.02
I have increased the amount of organic fruits and vegetables that I eat.*	3.34	3.042	3.34	0
I talk to other people about their environmentally friendly behaviors.*	2.25	2.16	2.12	-0.13
I reduce the amount of meat that I eat*	2.18	1.93	2.12	-0.06
In general, if I have to go by car, I try to carpool.	3.06	2.86	2.88	-0.18
In general, I use public transport instead of the car.	2.72	3.00	2.87	+0.15
In general, I ride a bike, scooter or walk instead of using the car	2.92	2.89	2.93	+0.01

Self-perception of green habits change – Gender & Age analysis

Regarding gender and age, there are no significant differences.

8. Lesson learnt

The KER assessment in Slovakia was conducted across various schools, including an inclusive school for Roma students. Dividing participants into three age groups was crucial, as it allowed us to observe significant differences in engagement and comprehension.

The youngest age group (4–8 years) responded best across all aspects of the activities. The BIOHEROES cards proved to be particularly engaging for them, as they quickly learned how to use them and understood the different roles within the bioeconomy. Through these role-based activities, we were able to effectively explain fundamental bioeconomy principles in a way that was both accessible and enjoyable. These children were also very active in discussions, eagerly answering questions and often arriving at correct conclusions through critical thinking. This experience strongly suggests that gamified learning and active teaching methods foster essential skills such as problem-solving, analytical thinking, and collaborative learning, while also making abstract concepts easier to grasp.

One of the major challenges observed during the assessment was the limited time available for each lesson. This issue is likely a common struggle for teachers, as bioeconomy concepts require deeper exploration than a single lesson allows. Additionally, within the same classrooms, there

were noticeable differences in students' prior knowledge, meaning that some children were able to engage with the content more quickly, while others needed more time to process the information. These disparities highlight the importance of flexible teaching strategies that accommodate different learning paces.

For older students, engagement proved more complex. However, as the activity progressed, engagement gradually increased, especially towards the end of the session. Students began forming teams, interacting more, and demonstrating genuine interest in the BioRace game's strategic elements.

A significant finding across all age groups was the lack of prior knowledge about bioeconomy as a concept. However, when we introduced related topics such as renewable energy and composting, many students recognised these ideas and could use them as a foundation to understand broader bioeconomy principles. This reinforces the interdisciplinary nature of bioeconomy education and suggests that linking it to familiar environmental topics can help make the subject more accessible to students.

Perhaps one of the most promising aspects of this assessment was the positive feedback from teachers. Several educators expressed a strong interest in integrating more bioeconomy-related lessons into their curriculum. This highlights the potential for bioeconomy education to expand in the future, but it also raises the issue of curriculum limitations. Without structured integration into existing subjects, bioeconomy may remain an isolated topic rather than a fundamental component of students' learning. Curriculum adjustments will be necessary to ensure that bioeconomy topics are given adequate attention and that they are taught in a way that maintains engagement across different age groups.

Overall, this assessment demonstrated that bioeconomy education holds great potential, particularly when delivered through interactive, engaging methods. Younger students responded especially well to gamification and hands-on activities, showing enthusiasm and strong learning outcomes. However, time constraints, knowledge gaps, and engagement challenges among older students indicate the need for curriculum adaptations and refined teaching strategies. Bioeconomy has significant educational value, but to fully leverage its potential, it is essential to rethink how it is taught, integrate it more deeply into existing subjects, and ensure that students of all ages can engage with it in meaningful ways.

The GenB workshops in Spain were conducted in two educational institutions located in Petrer and Bétera, involving three distinct age groups—4-8, 9-13, and 14-18 years—to enable a comparative analysis of the educational impact. Tailored materials, including BioHeroes for the youngest group and The BioRace for the older groups, were deployed to ensure age-appropriate engagement with bioeconomy concepts. The implementation revealed valuable insights into the delivery and reception of these activities.

Across all groups, the use of game-based learning proved effective in fostering engagement and facilitating the assimilation of bioeconomy concepts. The youngest participants (4-8 years)

quickly adapted to BioHeroes, demonstrating high interest despite initial challenges with questionnaire comprehension, which were mitigated through collective guidance and teacher support. For the intermediate group (9-13 years), the BioRace was well-received, though participants required additional time to grasp the game's dynamics, suggesting that a slightly longer session duration could enhance understanding and participation. The oldest group (14-18 years), although not specific target group for the game, exhibited strong initial engagement with The BioRace, sustaining active involvement throughout.

These findings highlight the success of interactive approaches in bioeconomy education, with minor adjustments—such as extended session lengths for the 9-13 age range—potentially optimizing outcomes. The workshops underscore the value of adapting delivery to developmental stages, ensuring effective knowledge transfer and participant satisfaction across diverse educational settings.

9. Conclusion

The GenB project's intervention, implemented through Key Exploitable Results (KERs) in school settings, aimed to assess the impact of bioeconomy-focused educational games on young people's knowledge, satisfaction, and engagement, while exploring supporting dimensions such as values, fascination, and competency beliefs. Drawing on data from participants across age groups (4-8, 9-13, and 14-18 years), this study provides a robust evaluation of the project's effectiveness. The conclusions below synthesize the findings, address the research objectives, and outline their implications, connecting them to GenB's goals.

The primary objectives—to measure changes in bioeconomy knowledge and evaluate satisfaction and engagement with the intervention—were successfully achieved. The follow-up evaluation demonstrated a significant increase in knowledge, with a notable rise in correct responses, confirming GenB's efficacy in enhancing understanding of bioeconomy concepts. Satisfaction and engagement were positive overall, with the youngest group (4-8 years) showing exceptional enthusiasm and the strongest gains in knowledge, while older groups (9-13 and 14-18 years) exhibited more moderate but still positive responses. Supporting dimensions—values, fascination, and competency beliefs—reinforced the intervention's impact, reflecting a solid foundation for bioeconomy education across all ages.

The study uncovered a clear age gradient: younger children, particularly those aged 4-8, displayed the highest levels of satisfaction, engagement, and knowledge acquisition, driven by their receptivity to interactive learning approaches. Older students, aged 9-13 and 14-18, showed more tempered responses, with the 9-13 group achieving slightly lower knowledge gains due to challenges in grasping game dynamics within the limited session time rather than any inherent flaw in the game design. Across all ages, the intervention increased knowledge about bioeconomy, sparked curiosity, and fostered a positive connection with the bioeconomy, affirming the educational potential of the games. The BioRace game, used with the 9-13 group, remains effective and well-developed, with its results attributable to session duration and evaluation structure and tool rather than material quality.

A key strength of GenB is its firm commitment to reducing the gender gap, a priority emphasized by the European Union in its policies for equitable education and sustainable development. No notable differences in responses were observed between genders across satisfaction, engagement, or knowledge outcomes, underscoring the inclusivity of the intervention. The materials, including BioHeroes and The BioRace, are meticulously designed to avoid exacerbating gender disparities, ensuring equal access and appeal for all students. This alignment with EU goals highlights GenB's role in promoting a diverse, informed, and engaged generation in bioeconomy education.

These results offer significant benefits to multiple stakeholders. Educators gain a proven tool for bioeconomy education, effective across age groups, with only slight adaptations needed for older students to enhance relevance. Policymakers can use this evidence to integrate bioeconomy into curricula, supporting the European Green Deal's sustainability objectives. Curriculum designers benefit from a model that, based on this sample of KERs, can be extrapolated to the broader suite of GenB materials, ensuring the creation of effective resources that positively influence bioeconomy knowledge and awareness. Students acquire a foundational understanding that prepares them for future engagement with sustainability challenges.

The age-related trends align with established research, such as Pyle et al.[23] findings on younger children's affinity for play-based learning, and Deci and Ryan's[24] Self-Determination Theory, which ties motivation to relevance and autonomy—effectively met for younger learners in this intervention. The positive, albeit moderate, fascination and competency outcomes resonate with Eccles and Wigfield[25] Expectancy-Value Theory, where utility drives engagement, reinforcing consistency with prior studies.

Future investigations will focus on refining BioRace, a prototype for which improvements in visual elements, continuous testing, and other aspects have already been planned for the exploitation stage by APRE. Including observational analyses by educators could provide deeper insights into engagement and learning dynamics, ensuring the game's full potential is realized across all age groups.

4.3.2 Analyse the level of change of knowledge and satisfaction – MOOC

1. Background

The GenB initiative provides a free online learning program (MOOC) titled "Bioeconomy for Educators: Cultivating a Sustainable Future." This course aims to equip teachers with the knowledge and resources needed to introduce bioeconomy concepts into various educational

[23] Pyle, A., DeLuca, C., & Danniels, E. (2017). A scoping review of research on play-based pedagogies in kindergarten education. Review of Education, 5(3), 311–351.
[24] Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268.
[25] Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109–132.

subjects. Its goal is to empower students to tackle environmental challenges and explore innovative solutions for a more sustainable future.

This training is intended for educators working with students aged 4 to 19, regardless of their prior experience with bioeconomy. It is also open to other education professionals and stakeholders in the field. Throughout the course, participants will learn how to design lesson plans integrating bioeconomy principles, discover sustainable practices to transform their schools, and develop strategies to introduce career opportunities in this sector to their students.

As part of the impact assessment for this activity, the objective is to evaluate educators' existing knowledge of bioeconomy to identify areas requiring further training and those adequately addressed by the course content. Additionally, the evaluation aims to gather educators' perspectives on the effectiveness of the provided materials of the MOOC in engaging students and enhancing key aspects such as knowledge, skills, and interest in bioeconomy. This feedback will be instrumental in assessing the course's potential to foster a deeper understanding and enthusiasm for sustainable practices among students.

2. Methodology

Regarding the methodology, to systematically evaluate the impact of the MOOC on educators' knowledge and perceptions of bioeconomy, the KERs assessment methodology was applied. This methodology followed a structured sequence designed to measure knowledge acquisition, satisfaction, and self-perceived learning progress.

The evaluation process consisted of three key phases:

- Pre-evaluation phase: Before commencing Module 1, MOOC participants completed an initial questionnaire to assess their baseline knowledge of bioeconomy. This involved responding to the GenB Quizzes, which served as a self-assessment tool to gauge their perception of their knowledge levels before engaging with the course material.
- Immediate post-evaluation phase: Upon completing Module 3, participants answered a second questionnaire designed to measure knowledge acquisition and satisfaction levels. This phase utilised scientific scales to ensure a robust evaluation of learning outcomes and perceived course effectiveness.
- Follow-up evaluation phase: At the end of Module 4, participants retook the GenB Quizzes (initial questionnaire) to assess potential knowledge gains and retention over the course of the training. This final assessment allowed for a comparative analysis of pre- and post-course knowledge, providing insight into the effectiveness of the MOOC in fostering bioeconomy competencies among educators.

Table 28 summarises the structured procedure for implementing the assessment methodology:

Part No.	Item adaptation	Tools and materials	Timing	Dimension of application
1	Pre-evaluation	Survey. Questionnaire – "Societal – educational impact assessment through MOOC" (Appendix 6A)	Before the module 1	Kn. through conducting quizzes as a tool to measure self-perception of knowledge change (not through scientific scales).
2	Immediate post-evaluation	Survey. Questionnaire – "Societal – educational impact assessment through MOOC" (Appendix 6B)	At the end of module 3	Kn. through scientific scales Sa. through scientific scales
3	Follow-up evaluation	Survey. Questionnaire – "Societal – educational impact assessment through MOOC" (Appendix 6C)	At the end of module 4	Kn. through conducting quizzes as a tool to measure self-perception of knowledge change (not through scientific scales)."

Table 28. Characteristics of the procedure for conducting the "MOOC Assessment"

Figure 4 shows an overview of the structure, objectives, scales and tool employed in GenB materials assessment questionnaire to assess both knowledge gain and participant satisfaction.

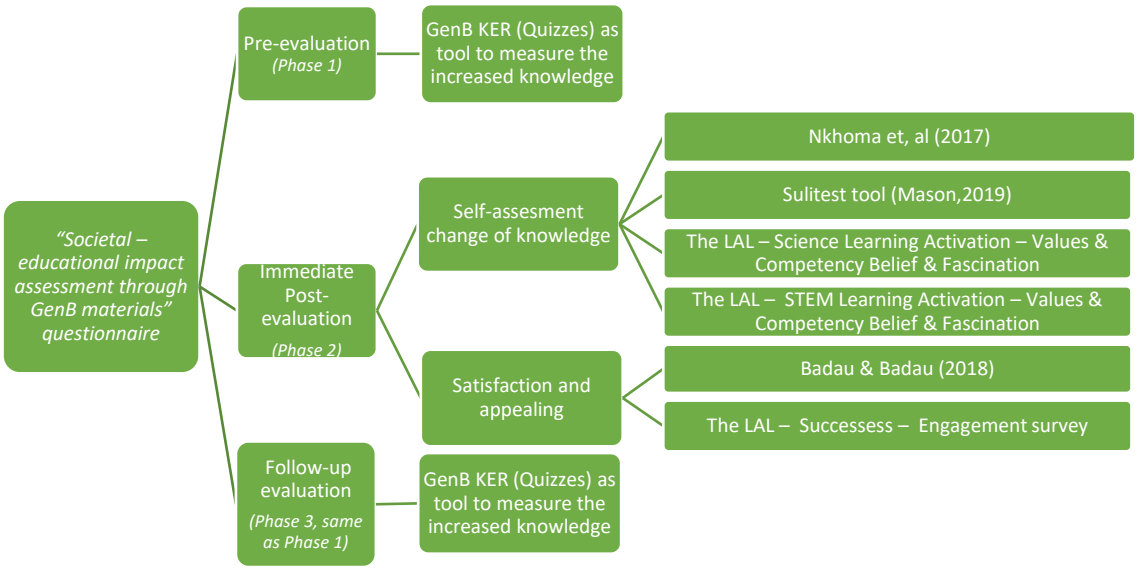

Figure 4. Measurement variables, scientific measurement scales and questionnaire structure for KERs Assessment

For more details on the methodology, see Deliverable 4.1.

3. *Data analysis*

Regarding the data analysis, bivariate analyses were conducted using Gandia Barbwin, a statistical data analysis software. To describe the results concerning knowledge and satisfaction

regarding bioeconomy across different demographic groups in the sample, several two-tailed Student's t-tests (95% confidence interval) were performed. These tests compared the results based on two demographic variables: gender (men vs. women) and age (two groups: 44 years or younger vs. 45 years or older).

4. Sample description

The quantitative study includes a sample of 139 participants (with a sampling error of +- 8,31%), consisting of teachers (men and women) from different countries which are Croatia, Czech Republic, Egypt, France, Greece, Italy, Kazakhstan, Montenegro, Poland, Portugal, Romania, Serbia, Spain, Sweden and Turkey.

Regarding gender, 73% of the survey participants are women, and 26% are men. This is due to the persistent imbalance in the teaching profession, where a gender gap remains, and it is still stereotypically perceived as a female-dominated field. This trend is supported by studies from Eurostat[26], which indicate that approximately 73% of primary and secondary education teachers are women, as well as by the OECD's *Education at a Glance*[27] report, which states that women represent around 70% of primary school teachers and 60% of secondary school teachers.

Regarding age, 52% of the participants are 44 years old or younger, while 48% are 45 years old or older.

5. Pre- evaluation – MOOC results

Before starting the MOOC, participants complete a questionnaire to assess their level of knowledge and green habits.

Prior self-perception of knowledge in teachers – Overall & Gender analysis

First, the pre-evaluation data is analysed, designed to assess the prior knowledge of teachers before participating in the MOOC, as well as their green habits.

Table 29 shows the results corresponding to the questions aimed at assessing participants' knowledge of bioeconomy in the MOOC. A total of 58% of the responses were correct. Specifically, 68% of participants correctly identified the definition of bioeconomy.

Participants demonstrated greater knowledge in questions such as "What is the primary goal of integrating renewable energies into the bioeconomy?" and "Which of the following is an example of a green job?", both with 80% correct responses, as well as "In what areas does the bioeconomy work?".

On the other hand, the main areas for improvement were identified in more technical questions, such as "What is biomimicry?" with 48% correct responses, "What is the difference between upcycling and downcycling in the recycling process?" with 35% correct responses, and "Where are biobased plastics recycled?" with only 17% correct responses.

[26] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Gender_statistics
[27] Education at a Glance 2024 | OECD

Overall, the results indicate that teachers have greater knowledge of general aspects of the bioeconomy, while more technical and/or specific aspects are less well understood

Regarding gender, a t-Student significance test was conducted to assess potential gender differences in bioeconomy knowledge. The test was configured with a 95% confidence level, a two-tailed approach, and assuming equal variances.

The results indicate that there are statistically significant differences between men and women in their accuracy percentages ($p < 0.0001$). On average, women scored 9 percentage points higher than men (60% vs. 51%), suggesting a greater familiarity or understanding of bioeconomy concepts among women.

On the other hand, the largest gender differences were found in key questions about fundamental bioeconomy concepts. Specifically:

- "Which of the following best describes Life Cycle Assessment (LCA) in the context of the bioeconomy?", where 68% of women answered correctly compared to 44% of men, a 24-percentage-point difference.
- "What does biodegradation refer to?", with 67% accuracy among women versus 47% among men, showing a 20-percentage-point gap.
- "What is biomimicry?", where 53% of women responded correctly, compared to only 33% of men, reflecting a 20-percentage-point difference.

Therefore, the data suggest that the prior knowledge of the women participating in the MOOC is higher than that of the men, as shown Table 29. Prior knowledge in teachers and educators

Table 29. Prior knowledge in teachers and educators

Question	Correct answer	Accuracy % n=139	Accuracy % (M)	Accuracy % (W)
Do you know what bioeconomy is?	**a) Bioeconomy is the economy based on using natural resources, such as plant and animals, sustainability to produce food, energy, and products without harming the environment** b) Incorrect answers	68%	61%	71%
Are all bio-based plastics biodegradable?	a) Yes **b) No** c) I don´t know	41%	36%	42%
Can bio-based plastics be recycled?	a) Yes b) No c) I don´t know	58%	61%	57%
The dominant application for bio-based plastics is…	a) Automotive **b) Packaging** c) Footwear d) Electronics e) I don´t know	55%	53%	55%

Question	Correct answer	Accuracy % n=139	Accuracy % (M)	Accuracy % (W)
Where are bio-based plastics recycled?	**a) Chemical recycling plants** b) They cannot be recycled c) They descompose in the ground d) Composing facilities e) I don't know	17%	22%	16%
You can make fuel out of...	a) Wood b) Used cooking oil c) Horse poop **d) All of them** e) I don´t know	63%	58%	64%
In what forms can biofuel be presented?	a) Solid b) Liquid c) Gas **d) All of them** e) I don´t know	52%	50%	52%
What are barriers to the development of the biofuel market?	a) High production cost b) Lack of affordable raw materials c) Insufficient infrastructure **d) All of them** e) I don´t know	44%	42%	44%
In what areas does the bioeconomy works?	a) Agriculture b) Production and manufacturing c) Forestry and fishing **d) All of them** e) I don´t know	75%	64%	78%
What is the primary goal on integrating renewable energies into the bioeconomy?	a) To use up non-renewable resources **b) To reduce fossil fuel use and support sustainability** c) To ignore issues in energy d) I don´t know	80%	69%	84%
Bioeconomy…	a) Contributes to the reduction of CO2 emissions b) Reuses waste to produce new materials and energy c) Creates new jobs **d) All of them** e) I don´t know	71%	58%	62%
Which of the following best describes Life Cycle Assessment (LCA) in the context of the bioeconomy?	a) A method to increase agricultural yield b) **A technique to evaluate the environmental impact of a product**	62%	44%	68%

Question	Correct answer	Accuracy % n=139	Accuracy % (M)	Accuracy % (W)
	throughout its lifespan c) A process to improve the genetic modification crops d) A strategy for marketing bio-based products e) I don´t know			
Which of these processes optimize resources the bioeconomy?	a) Simply disposing of waste in landfills **b) Processing residues or by-products into raw materials** c) Burning all waste materials d) Avoiding the generation of waste altogether	50%	36%	54%
What is the difference between upcycling and downcycling in the recycling process	a) Upcycling creates lower quality and value materials, while downcycling improves quality and value b) Both processes create materials of the same quality **c) Downcycling produces lower quality and value materials, while upcycling enhances quality and value** d) Upcycling and downcycling are unrelated to recycling e) I don´t know	35%	30%	36%
Which of the following statements about composting is true?	a) Composting involves burning organic waste to generate energy **b) Composting converts organic waste and improves soil quality** c) Composting is a method for recycling plastics d) All of them are true	61%	61%	61%
What does biodegradation refer to?	a) Burning organic waste to make energy b) Making new materials with chemicals c) Recycling plastics using machines	62%	47%	67%

Question	Correct answer	Accuracy % n=139	Accuracy % (M)	Accuracy % (W)
	d) Microorganisms breaking down organic materials e) I don´t know			
What is biomimicry?	**a) Imitating natural processes and systems to solve human problems** b) Creating synthetic materials using biotechnology c) Breeding animals for specific genetic traits d) The study of fossils and ancient life forms e) I don´t know	48%	33%	53%
Why do non-biodegradable materials, like plastics, pose long-term environmental risks?	a) They descompose quickly but leave harmful residues b) They are easily absorbed by natural processes **c) They persist for a long time and can harm ecosystems and wildlife** d) They break down into harmless substances that benefit the environment e) I don´t know	70%	56%	74%
What is an important feature of non-renewable energy sources?	a) They are always being made by nature b) They don´t harm the environment much c) They can be used forever without running out **d) They will run out because they can´t be replaced quickly** e) I don´t know	67%	56%	71%
Which of the following is an example of a green job?	a) Coal miner **b) Solar panel installer** c) Oil rig worker d) Plastic factory worker e) I don´t know	80%	78%	80%
What is the benefit associated with bio-based plastics their recycling, and their environmental impact?	a) They increase greenhouse gas emissions b) They reduce dependence on fossil fuels	68%	58%	71%

Question	Correct answer	Accuracy % n=139	Accuracy % (M)	Accuracy % (W)
	c) They are non-biodegradable d) They contribute to ocean pollution			

Prior self-perception of knowledge in teachers – Age analysis

Regarding age, there are no significant differences.

Prior teachers' green habits – Overall & Gender analysis

Now, an analysis of the teachers' green habits prior to their participation in the MOOC has been performed to determine whether this course can promote a change in their habits. To conduct this analysis, each item in Table 30 is evaluated using a Likert scale from 1 to 5 points with 1 being totally disagree and 5 being totally agree. For data analysis, we will consider the mean and standard deviation, as shown in Table 30.

Participants show the highest agreement with actions related to energy conservation and water saving, particularly: "I turn of the lights/television when I have a room" with 4.59 points, "I reduce the use of heating or air-conditionating to limit energy consumption" with 4.25 points and "I reduce the time I take showers to save water" with 4.19 points.

However, the lowest agreement with actions related to sustainable transportation choices, particularly: "In general, I ride a bike, scooter, or walk instead of using the car" with 3.34 points, "In general, if I have to go by car, I try to carpool" with 3.54 points and "In general, I use public transport instead of the car" with 3.56 points.

A t-Student significance test was conducted to assess potential gender differences in the Green Habits scale, which measures habits and behaviours related to sustainability. The test was configured with a 95% confidence level, a two-tailed approach, and assuming equal variances.

The results indicate that there are no statistically significant differences between the mean values of men and women ($p > 0.05$). This suggests that the observed variations in the scale may be due to random fluctuations rather than a systematic difference between the analysed groups.

Therefore, from a statistical perspective, no gender gaps are identified in the adoption of sustainable habits according to the Green Habits scale.

Table 30. Prior teachers and educators' green habits

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
I turn off the lights/television when I leave a room	4.59	1.26	4.63	4.58
I unplug appliances that are left in standby mode	4.03	0.97	3.97	4.05
I reduce the use of heating or air-conditioning to limit energy consumption	4.25	0.91	4.41	4.20
I reduce the time I take showers to save water	4.19	0.92	4.25	4.16

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
I watch TV programs, videos or movies on environmental issues	3.79	0.99	3.88	3.78
I have increased the amount of organic fruits and vegetables that I eat.	3.93	0.91	3.97	3.92
I talk to other people about their environmentally friendly behaviours.	4.08	0.82	4.08	4.08
I reduce the amount of meat that I eat	3.59	1.14	3.38	3.66
In general, if I have to go by car, I try to carpool.	3.54	1.13	3.55	3.53
In general, I use public transport instead of the car.	3.56	1.25	3.80	3.48
In general, I ride a bike, scooter or walk instead of using the car	3.34	1.33	3.66	3.23

Prior teachers' green habits by age analysis

Regarding age, there are no significant differences.

6. Immediate post evaluation – MOOC results

After completing Module 3, the MOOC participants took the second impact questionnaire. It is conducted at the end of Module 3 because it is the last module that presents content to the participants. Module 4, on the other hand, is a technical module focused on explaining the review and peer review process of their Learning Scenario, meaning that by this point, participants would have already gone through all the content in the preceding weeks.

The objective of this questionnaire is, on one hand, to assess teachers' satisfaction and engagement with the MOOC they have completed, and on the other hand, to understand how they believe the presented content may influence their students in terms of values, fascination, competencies beliefs, and knowledge regarding the bioeconomy.

This questionnaire has been adapted to a 4-point Likert scale, as its scientific basis is the Learning Activation Lab, which uses scales with this scoring system. For more details on the methodology and the scientific scales used in the development of the questionnaire, see Deliverable 4.1.

Degree of influence in students in terms of values – Overall and Gender analysis

Table 31 presents the detailed results on Bioeconomy Values, highlighting the overall positive perception of bioeconomy and its applications.

The results indicate that participants generally value bioeconomy as an important area of knowledge, particularly in its role in education and problem-solving. On a 4-point Likert scale, the overall average score across all items was 3.44, suggesting a positive perception of bioeconomy's relevance.

The highest-rated statements were:

- "Do you think it would be important for your students to learn about bioeconomy?" (Me = 3.72, SD = 0.51)
- "Do you consider it important for your students to develop the ability to think like a bioeconomist?" (Me = 3.71, SD = 0.50)
- "Bioeconomy makes the world a better place to live." (Me = 3.68, SD = 0.47)

These results suggest that participants strongly recognize the value of bioeconomy education and its potential impact on students. This aligns with Expectancy-Value Theory[28] (Eccles & Wigfield, 2002), which highlights those individuals are more likely to engage in learning when they perceive its utility for personal and societal goals.

On the other hand, the lowest-rated items indicate that while participants acknowledge the importance of bioeconomy, they do not see it as the single most important subject:

- "I think bioeconomy is more important to know than anything else." (Me = 2.98, SD = 0.75)
- "I think bioeconomists are the most important people in the world." (Me = 3.21, SD = 0.69)
- "Bioeconomy is the most important thing in the world for me to learn." (Me = 3.21, SD = 0.73)

From a theoretical perspective, these findings align with research suggesting that individuals develop science-related values based on their personal and social experiences (Eccles, 2005[29]; Lyons, 2006[30]). According to Identity Development Theory[31] (Tan & Barton, 2007), the extent to which learners integrate science-related values into their identity depends on their exposure to and understanding of the subject. Thus, while the majority of participants view bioeconomy positively, their personal prioritization of the field may be shaped by external factors such as curriculum structure, professional backgrounds, or previous exposure to bioeconomy-related topics.

No significant gender differences are observed, as shown in Table 31.

Table 31. Bioeconomy values among young people in teachers and educators in MOOC

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
Do you think it would be important for your students to learn about bioeconomy?	3.72	0.51	3.69	3.73

[28] Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109-132.
[29] Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. En A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 105-121).
[30] Lyons, T. (2006). Different countries, same science classes: Students' experiences of school science in their own words. *International Journal of Science Education, 28*(6), 591-613.
[31] Tan, E., & Barton, A. C. (2007). Unpacking science for all through the lens of identities-in-practice: The stories of Amelia and Ginny. *Cultural Studies of Science Education, 2*(2), 361-392.

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
Do you consider it important for your students to develop the ability to think like a bioeconomist, that is, thinking about how to make things work better?	3.71	0.50	3.71	3.71
Bioeconomy makes the world a better place to live.	3.68	0.47	3.66	3.69
I think bioeconomists are the most important people in the world.	3.21	0.69	3.11	3.23
Bioeconomy is the most important thing in the world for me to learn.	3.21	0.73	3.07	3.26
Knowing bioeconomy is important for being a good citizen.	3.54	0.54	3.45	3.55
I think bioeconomy is more important to know than anything else.	2.98	0.75	2.78	3.05
I think bioeconomy ideas are valuable.	3.55	0.51	3.52	3.55
Learning about bioeconomy help my students understand how the world works.	3.44	0.61	3.38	3.46
Thinking like a bioeconomist will help my students do well in all classes.	3.43	0.54	3.35	3.45
Knowing bioeconomy is important for all jobs.	3.36	0.57	3.28	3.38

Degree of influence in students in terms of values – Age analysis

Regarding age, there are no significant differences.

Degree of influence in students in terms of fascination – Overall & Gender analysis

About the fascination, the items that provide the most information when asking teachers about students have been selected. The results show that participants perceive a moderate-to-high level of fascination from their students towards bioeconomy. On a 4-point Likert scale, the statement with the highest score was:

- "In general, when my students work on bioeconomy content, they love it." (Me = 3.34, SD = 0.50)
- "In general, my students will find bioeconomy very interesting." (Me = 3.32, SD = 0.51)

These values indicate a positive perception of the topic's appeal, though not at the highest possible levels. On the other hand, the statement with the lowest score was:

- "My students will wonder about how bioeconomy works every day." (Me = 2.96, SD = 0.78)

This result suggests that while bioeconomy is seen as an interesting subject, it is not necessarily perceived as a daily concern or curiosity for students. Additionally, the highest standard deviation (0.78) in this item reflects a greater variability in responses, indicating that while some teachers perceive a high level of curiosity among their students, others do not observe the same pattern.

No significant gender differences are observed.

All these results can be found in Table 32.

Table 32. Bioeconomy fascination among teachers and educators in MOOC

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
My students will wonder about how bioeconomy works every day.	2.96	0.78	2.97	2.96
In general, when my students work on bioeconomy content, they love it.	3.34	0.50	3.31	3.35
In general, my students will find bioeconomy very interesting.	3.32	0.51	3.26	3.34

Degree of influence in students in terms of fascination – Overall & Gender analysis

Regarding age, there are no significant differences.

Degree of influence in students in terms of competencies beliefs – Overall & Gender analysis

The results show that participants perceive their students as having a moderate-high level of competence in bioeconomy, with an overall average of 2.99 on a 4-point scale.

The highest-rated statements were:

- "If my school offers extracurricular activities on bioeconomy, my students will find them excellent." (Me = 3.15, SD = 0.74)
- "I think the majority of my students are very good at: Coming up with questions about bioeconomy." (Me = 3.14, SD = 0.60)

These values suggest that participants trust their students' ability to actively engage in extracurricular activities and generate questions about bioeconomy.

On the other hand, the lowest-rated statement was:

- "My students will be able to understand bioeconomy in books meant for adults." (Me = 2.65, SD = 0.82)

This result suggests that while participants believe their students can understand bioeconomy content adapted to their age, they face more difficulties with advanced materials.

Data reflect a positive but not outstanding perception of students' competence in bioeconomy. While their ability to conduct practical activities and ask questions is recognized, there is room for improvement in understanding more complex content, as shown Table 33.

No significant gender differences are observed, as shown in Table 33.

Table 33. Bioeconomy competency beliefs among teachers and educators in MOOC

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
My students will be able to do the bioeconomy activities they get in class all the time.	3.01	0.67	2.95	3.03
If my students go to a bioeconomy museum, they will be able to figure out what is being shown.	3.03	0.65	3.07	3.01

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
My students will be able to understand bioeconomy information on websites suitable for their age.	2.91	0.62	2.92	2.90
If my school offers extracurricular activities on bioeconomy, my students will find them excellent.	3.15	0.74	3.02	3.19
My students will be able to understand bioeconomy in books meant for adults.	2.65	0.82	2.85	2.60
I think the majority of mi students are very good at: Figuring out how to fix a bioeconomy activity that didn´t work.	2.97	0.67	3.09	2.92
I think the majority of my student are very good at: Coming up with questions about bioeconomy	3.14	0.60	3.21	3.11
I think the majority of my student are very good at: Doing bioeconomy experiments	3.08	0.64	3.11	3.06

Degree of influence in students in terms of competencies beliefs – Age analysis

Regarding age, there are no significant differences.

Degree of influence in students in terms of knowledge – Overall and gender analysis

Now, through an adaptation of the Sulitest scale, participants are specifically asked how they believe the GenB content taught during the MOOC will impact their students, specifically in sustainability-related topics. Only this scale is assessed using a 7-point Likert scale.

The results show an average of 6 points, with no significant differentiation between the proposed items, indicating that the professors are mostly in agreement with the GenB content and its applicability to students, promoting sustainable values and increasing awareness and knowledge on this topic.

No significant gender differences are observed, as shown in Table 34.

Table 34. Sustainability knowledge among teachers and educators in MOOC

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
The knowledge my students will gain from the GenB content will help them see sustainable opportunities around them.	6.08	1	6.09	6.07
My students will learn a great deal by completing the GenB content.	6.04	1	6.02	6.04
The GenB content will help my students reflect on their knowledge of sustainability.	6.02	1.05	6.04	6.01
The GenB content will help my students understand how their knowledge of sustainability compares to other children of the same age in my country.	6.00	0.95	6.04	5.99
The GenB content will help my students understand how their knowledge of sustainability compares to other children of the same age globally.	6.00	1	6.07	5.97
The GenB content will motivate my students to share sustainability-related information with others they know.	6.06	1	6.00	6.07

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
The GenB content will motivate my students to seek additional sustainability information from others they know.	6.01	0.94	5.97	6.01
My students will likely retake the GenB content voluntarily in the future to see if they have improved their sustainability-related knowledge.	5.85	1	5.90	5.83

Degree of influence on students in terms of knowledge – Age analysis

Regarding age, there are no significant differences.

Teacher's engagement – Overall and Gender analysis

Now, it shows how the participants in the MOOC engage during the activity and their overall level of commitment to it, allowing conclusions to be drawn about how they felt during the activity. Affective, cognitive, and behavioural engagement is assessed through the selected items.

The data show a high level of emotional and cognitive engagement, as participants felt happy (3.44) and excited (3.41), and they did not feel bored (1.73). Additionally, distraction was low, as they were focused most of the time (3.31) and were not busy with other tasks (2.03) or talking about unrelated topics (2.11). However, the result for daydreaming (2.60) is moderate, so it could be useful to identify small areas that might be difficult to follow during the course and improve them. Overall, the data suggest that participants were highly engaged, both emotionally and cognitively, and had a positive experience with the MOOC.

No significant gender differences are observed, as shown in Table 35.

Table 35. Engagement among teachers and educators in MOOC

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
During this MOOC: I felt bored.	1.73	0.93	1.67	1.74
During this MOOC: I felt happy.	3.44	0.54	3.40	3.45
During this MOOC: I felt excited.	3.41	0.58	3.38	3.41
During this MOOC: I was daydreaming a lot.	2.60	0.91	2.61	2.58
During this activity MOOC: I was focused on the things we were learning most of the time.	3.31	0.60	3.21	3.34
During this MOOC: I was busy doing other tasks	2.03	0.90	1.97	2.04
During this MOOC: I talked to others about stuff not related to what we were learning.	2.11	0.97	2.26	2.04
During this MOOC: Time went by quickly.	3.24	0.64	3.26	3.23

Teacher's engagement – Age analysis

Regarding age, there are no significant differences.

Teachers' satisfaction – Overall & Gender analysis

Finally, questions are asked to assess the overall satisfaction with participation in the activity, aiming to determine if the MOOC was effectively focused and to identify potential improvements for the future. Only this scale is assessed using a 5-point Likert scale.

All the statements have a high level of agreement, with an average of 4.33 points. The data conclude that the MOOC is enjoyable, recommended for different age groups, increases knowledge in bioeconomics, motivates participants to apply what they have learned in their daily lives, and encourages them to share that knowledge with students. Therefore, participants perceive the MOOC as a success, as shown in Table 36

No significant gender differences are observed, as shown in Table 36.

Table 36. Satisfaction among teachers and educators in MOOC

Question	Mean n=139	Standard deviation	Mean (M)	Mean (W)
The activity was fun and entertaining.	4.28	0.70	4.31	4.26
The activity is recommendable for different age categories.	4.32	0.68	4.28	4.33
I am satisfied with this activity.	4.28	0.70	4.28	4.28
The activity increases my knowledge about bioeconomy.	4.41	0.65	4.42	4.40
I catch the basic ideas of the knowledge taught about bioeconomy.	4.37	0.73	4.33	4.38
I will try to apply the knowledge learned about bioeconomy in the activity	4.42	0.63	4.28	4.26
The activity motivates me to integrate the knowledge taught about bioeconomy in my daily life	4.42	0.68	4.35	4.41

Teachers' satisfaction – Age analysis

Regarding age, there are no significant differences.

7. Follow up evaluation – MOOC results

After completing Module 4 and concluding the MOOC, participants complete the follow-up questionnaire. This questionnaire is identical to the pre-evaluation questionnaire, so the objective is to detect significant changes in the participants' self-knowledge and habits after participating in the MOOC developed within the framework of the GenB project.

Self-perception of knowledge change in teachers – Overall & Gender analysis

The results indicate a significant improvement in participants' knowledge after completing the MOOC, with an average increase of 14% in the percentage of correct responses, reaching a 72% success rate in the final evaluation. This increase reflects a positive impact of the course on the acquisition of bioeconomy knowledge and suggests that the content has been effective in clarifying key concepts and strengthening participants' understanding.

Moreover, the fact that all items showed a positive gain reinforces the idea that the MOOC has contributed to improving teachers' bioeconomy literacy. This is particularly relevant, as a greater understanding of the topic not only benefits course participants but also has the potential to transfer into their teaching practice, influencing the instruction and awareness of their students regarding bioeconomy and its applications in everyday life and sustainable development.

The highest-increased statements were:

- “Can bio-based plastics be recycled?” (+33%)
- " Do you know what bioeconomy is?" (+21%)
- " What is the difference between upcycling and downcycling in the recycling process?" (+20%)

On the other hand, the lowest-increased statement was:

- " You can make fuel out of..." (+1%)
- “Are biobased plastics biodegradable? (+3%)

All these details can be found in Table 37.

Table 37. Bioeconomy knowledge in teachers and educators

Question	Correct answer	Pre-Accuracy %	Follow Up Accuracy %	Variation %
Do you know what bioeconomy is?	**a) Bioeconomy is the economy based on using natural resources, such as plant and animals, sustainability to produce food, energy, and products without harming the environment** b) Incorrect answers	68%	89%	+21%
Are all bio-based plastics biodegradable?	a) Yes **b) No** c) I don´t know	41%	44%	+3%
Can bio-based plastics be recycled?	**a) Yes** b) No c) I don´t know	58%	91%	+33%
The dominant application for bio-based plastics is…	a) Automative **b) Packaging** c) Footwear d) Electronics e) I don´t know	55%	69%	+14%
Where are bio-based plastics recycled?	**a) Chemical recycling plants** b) They cannot be recycled c) They descompose in the ground d) Composing facilities e) I don’t know	17%	27%	+10%
You can make fuel out of...	a) Wood b) Used cooking oil c) Horse poop **d) All of them** e) I don´t know	63%	64%	+1%
In what forms can biofuel be presented?	a) Solid b) Liquid c) Gas **d) All of them**	52%	71%	+19%

Question	Correct answer	Pre-Accuracy %	Follow Up Accuracy %	Variation %
	e) I don´t know			
What are barriers to the development of the biofuel market?	a) High production cost b) Lack of affordable raw materials c) Insufficient infrastructure **d) All of them** e) I don´t know	44%	60%	+16%
In what areas does the bioeconomy works?	a) Agriculture b) Production and manufacturing c) Forestry and fishing **d) All of them** e) I don´t know	75%	90%	+15%
What is the primary goal on integrating renewable energies into the bioeconomy?	a) To use up non-renewable resources **b) To reduce fossil fuel use and support sustainability** c) To ignore issues in energy d) I don´t know	80%	90%	+10%
Bioeconomy…	a) Contributes to the reduction of CO2 emissions b) Reuses waste to produce new materials and energy c) Creates new jobs **d) All of them** e) I don´t know	71%	82%	+11%
Which of the following best describes Life Cycle Assessment (LCA) in the context of the bioeconomy?	a) A method to increase agricultural yield b) **A technique to evaluate the environmental impact of a product throughout its lifespan** c) A process to improve the genetic modification crops d) A strategy for marketing bio-based products e) I don´t know	62%	78%	+16%
Which of these processes optimizes resources the bioeconomy?	a) Simply disposing of waste in landfills **b) Processing residues or by-products into raw materials** c) Burning all waste materials d) Avoiding the generation of waste altogether	50%	65%	+15%
What is the difference between upcycling and downcycling in the recycling process	a) Upcycling creates lower quality and value materials, while downcycling improves quality and value b) Both processes create materials of the same quality **c) Downcycling produces lower quality and value materials, while upcycling enhances quality and value** d) Upcycling and downcycling are unrelated to recycling e) I don´t know	35%	55%	+20%
Which of the following statements about composting is true?	a) Composting involves burning organic waste to generate energy **b) Composting converts organic waste and improves soil quality** c) Composting is a method for recycling plastics d) All of them are true	61%	72%	+11%

Question	Correct answer	Pre-Accuracy %	Follow Up Accuracy %	Variation %
What does biodegradation refer to?	a) Burning organic waste to make energy b) Making new materials with chemicals c) Recycling plastics using machines **d) Microorganisms breaking down organic materials** e) I don´t know	62%	77%	+15%
What is biomimicry?	**a) Imitating natural processes and systems to solve human problems** b) Creating synthetic materials using biotechnology c) Breeding animals for specific genetic traits d) The study of fossils and ancient life forms e) I don´t know	48%	66%	+18%
Why do non-biodegradable materials, like plastics, pose long-term environmental risks?	a) They decompose quickly but leave harmful residues b) They are easily absorbed by natural processes **a) They persist for a long time and can harm ecosystems and wildlife** b) They break down into harmless substances that benefit the environment c) I don´t know	70%	76%	+6%
What is an important feature of non-renewable energy sources?	a) They are always being made by nature b) They don´t harm the environment much c) They can be used forever without running out **d) They will run out because they can´t be replaced quickly** e) I don´t know	67%	75%	+8%
Which of the following is an example of a green job?	a) Coal miner **b) Solar panel installer** c) Oil rig worker d) Plastic factory worker e) I don´t know	80%	90%	+10%
What is the benefit associated with bio-based plastics their recycling, and their environmental impact?	a) They increase greenhouse gas emissions **b) They reduce dependence on fossil fuels** c) They are non-biodegradable d) They contribute to ocean pollution	68%	76%	12%

Self-perception of knowledge change in teachers – Age analysis

Regarding age, there are no significant differences.

Self-perception of green habits change – Overall & Gender analysis

Regarding green habits, the average in the follow-up evaluation is 4.3 points, indicating an increase of 0.3 points compared to the pre-evaluation (4.0). This data suggests that the

participants in the MOOC have shown an improvement in their behaviour related to environmental issues, whether in terms of energy saving, organic food consumption, or reduced car usage.

The highest-increased statements were:

- “I watch TV programs, videos or movies on environmental issues” (+0.49)
- " In general, I ride a bike, scooter or walk instead of using the car” (+0.34)
- "I reduce the amount of meat that I eat" (+0.33)

On the other hand, the lowest-increased statement was:

- " I turn off the lights/television when I leave a room " (No increase)

The lack of variation in "I turn off the lights/television when I leave a room" indicates that this behaviour is already so well-established that no significant change was recorded. Participants already had a strong tendency towards this energy-saving behaviour before participating in the MOOC.

Regarding gender, there are no significant differences.

All the details can be found in Table 38.

Table 38. Green habits in teachers and educators

Question	Pre-Mean	Follow Up Mean	Follow Up Standard Deviation	Variation
I turn off the lights/television when I leave a room	4.59	4.59	1.02	0
I unplug appliances that are left in stand-by mode	4.03	4.33	1.05	+0.30
I reduce the use of heating or air-conditioning to limit energy consumption	4.25	4.52	0.89	+0.27
I reduce the time I take showers to save water	4.19	4.45	0.95	+0.26
I watch TV programs, videos or movies on environmental issues	3.79	4.28	1.00	+0.49
I have increased the amount of organic fruits and vegetables that I eat.	3.93	4.23	1.02	+0.30
I talk to other people about their environmentally friendly behaviours.	4.08	4.31	0.99	+0.23
I reduce the amount of meat that I eat	3.59	3.92	1.10	+0.33
In general, if I have to go by car, I try to carpool.	3.54	3.88	1.24	+0.34
In general, I use public transport instead of the car.	3.56	3.66	1.35	+0.10
In general, I ride a bike, scooter or walk instead of using the car	3.34	3.71	1.36	+0.35

Self-perception of green habits change – Age analysis

Regarding age, there are no significant differences.

8. Lesson learnt

Implementation of the GenB 'Bioeconomy for Educators: Cultivating a Sustainable Future' MOOC highlights that the interdisciplinary nature of bioeconomy enhances learning by connecting its' concepts with different subjects, such as science, economics, and social studies. Integration of various perspectives on the topic makes it more engaging and relevant for students, helping them understand the real-world implications of bioeconomy. Additionally, the course demonstrated that innovative teaching methods, such as problem-solving activities and practical applications, play a crucial role in improving student engagement and comprehension.

Insights from the MOOC also emphasise the value of collaboration in strengthening educational impact. The MOOC facilitated networking opportunities that allowed educators to exchange ideas, best practices, and resources, reinforcing the role of peer learning in enhancing bioeconomy education. Access to structured teaching materials, such as the GenB toolkits and library, also boosted educators' confidence, providing them with practical tools to effectively teach bioeconomy concepts. By deepening their understanding of bioeconomy, teachers became better equipped to pass this knowledge on to students, shaping their behaviours, career choices, and attitudes toward sustainability. This reinforces the idea that empowering educators is a crucial step in fostering long-term environmental awareness and sustainable practices in society.

9. Conclusion

The GenB project's Massive Open Online Course (MOOC), designed to train teachers and educators in bioeconomy, aimed to enhance participants' knowledge of the subject while assessing their perceptions of its influence on students across values, fascination, competency beliefs, and knowledge.

The primary objectives—to measure changes in teachers' and educators' bioeconomy knowledge and evaluate their perceptions of the MOOC's impact on students—were successfully achieved. The follow-up evaluation revealed a significant 14% increase in knowledge, rising from 58% to 72% correct responses, affirming the MOOC's efficacy in enhancing understanding of bioeconomy concepts. Participants' satisfaction averaged 4.33 on a 5-point scale, reflecting high approval of the course's design and content, while their engagement reached 3.24 on a 4-point scale, indicating strong emotional and cognitive involvement. Perceptions of student impact were exceptionally positive, with an average of 6.0 on a 7-point scale across values, fascination, competencies, and knowledge, demonstrating confidence in the MOOC's transferability to classroom settings. These outcomes confirm GenB's success in equipping educators with both expertise and optimism for student learning.

The MOOC significantly increased participants' bioeconomy literacy, with notable gains in understanding key concepts such as recycling bio-based plastics and distinguishing upcycling from downcycling. Teachers and educators universally perceived bioeconomy as a valuable and engaging subject for students, predicting high levels of fascination and competence, particularly in practical and inquiry-based activities. Across all ages, the intervention increased knowledge about bioeconomy, sparked curiosity, and fostered a positive connection with the subject,

affirming the educational potential of the MOOC's content. The course also prompted a modest improvement in participants' green habits, rising by 0.3 points to 4.3, particularly in sustainable transport and media engagement. The lack of variation by gender or age underscores the MOOC's broad applicability, ensuring its relevance across diverse educator profiles.

GenB's MOOC exemplifies a steadfast commitment to reducing the gender gap, a core priority of the European Union's policies for equitable education and sustainable development. No notable differences emerged between men and women participants in knowledge gains, satisfaction, engagement, or perceptions of student impact, highlighting the course's inclusivity. The materials are expertly crafted to avoid reinforcing gender disparities, offering equal opportunities for all participants to engage with and benefit from the content. This alignment with EU objectives reinforces GenB's dedication to fostering a diverse, informed, and inspired teaching workforce capable of advancing bioeconomy education.

These findings benefit a wide range of stakeholders. Teachers and educators gain a robust, accessible resource to deepen their bioeconomy expertise, enhancing their capacity to inspire students across all educational levels. Policymakers can leverage this evidence to promote bioeconomy integration into teacher training programs, supporting the European Green Deal's sustainability goals. Designers of professional development programs benefit from a scalable model that, based on this MOOC, can be adapted to other sustainability topics, ensuring effective knowledge transfer to educators and, subsequently, students. The high satisfaction and positive student impact perceptions suggest that GenB's approach can elevate classroom instruction, amplifying bioeconomy awareness among future generations.

The MOOC materials, delivered as a complete and structured course across multiple sessions, demonstrated remarkable effectiveness, significantly enhancing participants' knowledge and engagement. This absolute success reflects the course's profound impact on bioeconomy literacy, with no need for further improvements. The comprehensive design and high participant approval affirm its robustness, positioning it as a powerful tool for educator training and classroom application.

The MOOC's success in boosting knowledge aligns with Darling-Hammond[32] research on effective professional development, emphasizing the role of content-focused training in improving educator competence. The high perceived student impact resonates with Eccles and Wigfield[33] Expectancy-Value Theory, where participants' belief in the utility of bioeconomy drives their enthusiasm for its classroom application. Engagement findings echo Deci and Ryan[34] Self-Determination Theory, linking intrinsic motivation to autonomy and relevance, both well-supported by the MOOC's interactive design.

[32] Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective Teacher Professional Development*. Learning Policy Institute.
[33] Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109–132.
[34] Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11(4), 227–268.

Future investigations should focus on analysing the participating teachers and educators in classroom settings, examining how their use of GenB's KERs influences students' bioeconomy knowledge and satisfaction. Such studies would assess the real-world transfer of MOOC content, ensuring its full potential is realized in educational practice and amplifying its impact on student learning.

These findings matter because they establish GenB's MOOC as a transformative tool in teacher education, equipping educators to foster bioeconomy awareness among students. The earlier teachers instil these concepts, the more ingrained they will become in students by the time they reach pivotal life stages, such as choosing careers or studies. This long-term vision promises to nurture a "Generación Bioeconomía"—committed, informed, and inspiring—whose understanding will drive sustainable progress aligned with Horizon 2020 and EU goals. GenB's success lays a scalable foundation for future educational initiatives, extending its influence beyond the teaching community.

4.3.3 KERs Assessment Conclusions

The KERs Assessment within the GenB project evaluates the combined outcomes of two interventions: a Massive Open Online Course (MOOC) and the deployment of educational games (BioHeroes: Let's Save the Planet! and The BioRace). These interventions aimed to enhance bioeconomy knowledge, satisfaction, and engagement among educators and students, providing a comprehensive assessment of the Key Exploitable Results (KERs) developed under the project.

The results indicate a clear advancement in bioeconomy understanding for both groups. Teachers achieved a 14% increase in knowledge through the MOOC, demonstrating its effectiveness in strengthening their grasp of bioeconomy concepts. They expressed high satisfaction with the course and a strong belief in its potential to positively influence students across values, fascination, competencies, and knowledge domains. Students, meanwhile, recorded a 16.9% knowledge gain, with younger learners showing particularly strong engagement and receptivity to the games, while older students exhibited more moderate outcomes influenced by session constraints rather than deficiencies in the materials. The alignment between teachers' confidence in the KERs' educational value and the tangible progress observed in students underscores the robustness of these resources, designed to support both educator training and student learning.

Gender inclusivity is a consistent feature across both interventions, with no significant differences observed, aligning with European Union priorities for equitable education. This ensures the KERs' applicability to diverse participants, enhancing their utility in varied educational contexts.

The findings carry significant implications for educational stakeholders. Teachers are equipped with effective tools—the MOOC and games—to integrate bioeconomy into their practice, while policymakers can utilize this evidence to advocate for its inclusion in curricula and professional development programs, supporting broader sustainability goals. The KERs' demonstrated quality, as validated by teachers' positive perceptions and students' knowledge gains, suggests

a reliable framework for future educational efforts. Even where student results appear neutral, particularly among older age groups, teachers' optimism indicates that consistent application will amplify impact over time.

The KERs Assessment confirms the success of GenB's approach in delivering high-quality educational resources. Beyond the project's duration, these KERs are poised to endure, offering a sustainable model that will continue to shape bioeconomy education. Their long-term societal impact lies in their capacity to foster a generation of informed educators and students, gradually embedding bioeconomy principles into educational systems and contributing to a more sustainable future.

5 Scientific impact

5.1 Scientific KIPs Assessment

The articles developed within the framework of the GenB project aim to advance knowledge on bioeconomy. These studies offer an innovative perspective and evidence-based solutions to address contributing to the existing scientific literature. Additionally, the proposed articles will serve as a foundation for future research, providing a reference framework for scholars and professionals in the field. Through the dissemination of these works, the project seeks to generate a lasting impact on the scientific community, fostering the exchange of ideas and promoting the development of new strategies and policies based on the results obtained.

Four non-peer-reviewed articles has been published, and this is related to KIP 1 – Generation of new knowledge through publications:

- C. Blasco-López, P. Busó, L. Mentini, S. Silvi, F. Fusconi, C. Pocaterra, S. Marinelli, S. Albertini, V. Vavassori, L. Ferrini, J. Vos, B. Davidis (2025) Educational games for bioeconomy learning: Insights from the Horizon Europe GenB project, INTED2025 Proceedings, pp. 4640-4649. https://doi.org/10.21125/inted.2025.1158
- Castellari, M., Mentini, L., Pocaterra, C., & Jurkiewicz, K. (2024). Addressing environmental challenges through innovative and engaging education approaches: Insights from Horizon Europe projects. In ICERI2024 Proceedings: https://library.iated.org/view/CASTELLARI2024ADD.
- Mentini, L. (2023). Preparing students to be agents of change through active and experiential learning activities: Examples from Horizon Europe projects. In ICERI2023 Proceedings. Retrieved from [https://library.iated.org/view/MENTINI2023PRE
- Pocaterra, C., & Mentini, L. (2023). Development of new approaches to bring research and research results to the large public through education and engagement. *ICERI2023 Proceedings*, 16th annual International Conference of Education, Research and Innovation, 7509-7517. https://doi.org/10.21125/iceri.2023.1861

Non-scientific publications based on the GenB project, such as blog posts, magazine articles, radio/TV broadcasts, videos, podcasts, and others, play a crucial role in disseminating the project's results to a wider audience. Although they do not follow the rigorous standards of scientific publications, these accessible formats allow the project findings to be translated into language that is comprehensible and engaging for the general public, including educators, professionals, and interested citizens. These types of content have the potential to endure over time due to their availability on digital platforms and their ease of distribution, ensuring that the key messages of the project reach diverse audiences for years to come.

Furthermore, these non-scientific publications serve as a valuable tool for scientific impact, as they help increase the visibility and recognition of the project's results outside the academic community. By making the information accessible in a more informal and appealing way, they foster the exchange of ideas and reflection on the subject matter, contributing to public debate. Therefore, while not considered scientific in the strict sense, non-scientific publications play an

essential role in the dissemination and sustainability of the knowledge generated by the project, ensuring that its results remain relevant and useful in the future.

More than 1000 non-scientific publications based on GenB, such as blog posts, articles in magazines, radio/TV broadcastings, videos, podcasts, etc. have been published and this is related to KIP 2 – Diffusion of knowledge through non-scientific outputs.

6 Economic impact

To evaluate the economic impact of the GenB project, the methodology outlined in Deliverable D4.1 was employed. A questionnaire (Annex 8 of Deliverable D4.1) based on the Key Impact Pathways (KIPs) of the European Commission was designed by AIJU and completed by the project coordinators in collaboration with AIJU.

Since GenB project is a Coordination and Support Action (CSA), generating a direct economic impact through commercialized products is not its primary objective. However, a direct economic impact has been observed through the hiring of one Slovak GenB Ambassador as project manager at one of the GenB Partners. Finally, indirect economic impact has also been identified in several key areas and described in the following Section 6.1.

6.1 Economic KIPs Assessment

The application of the Economic KIPs in the GenB project identified two relevant KIPs from the Horizon Europe framework: KIP 5 (Creating More and Better Jobs) and KIP 6 (Leveraging Investments in R&I). The KPIs are detailed below and linked to specific actions within the GenB project.

1. Initiatives such as the Youth2Policy workshops, Bioeconomy Career Info Days, the format of the "School project to grow future bioeconomy entrepreneurs, the development of policy recommendations for Ministries of Education, and the organization of mobilization and mutual learning workshops have also helped bridge the gap between education and future labour market opportunities in bioeconomy, fostering interest in bioeconomy among younger generations and potentially leading to increased specialization and employability in this sector. This is related to KIP 5 – Creating More and Better Jobs.

2. Influence on the development of public policies and strategies GenB has contributed to the update of the European Bioeconomy Strategy by organizing workshops and events involving policymakers, including representatives from the European Commission. This is related to KIP 6 – Leveraging Investment in R&I.

    a. The inclusion of bioeconomy in policy agendas can promote investments and new regulatory frameworks, which may drive economic growth in the long term.
    b. Additionally, the project has transformed the GenB educational model into actionable knowledge for educational communities, Ministries of Education, and policymakers (T4.2), and has supported governance modernisation by providing policymakers with accessible information (T4.3).
    c. The Partners are willing to participate in the public consultation to finalise the new EU Bioeconomy Strategy.

3. Generation of synergies with other projects and sectors. Although the project has not been directly aimed at commercial stakeholders, its dissemination and awareness-raising efforts have laid the groundwork for future initiatives with economic impact, contributing to a fair and just transition. This is related to KIP 6 – Leveraging Investments in R&I.

    a. By increasing the visibility of bioeconomy, GenB has facilitated the attraction of investments and funding for projects with commercial applications, contributing to the growth of the innovation ecosystem in Europe.

By raising awareness and engaging policymakers, GenB supports the European Bioeconomy Strategy and the preparation of a new version, fostering long-term economic growth. Its educational initiatives enhance employability in the bioeconomy, while synergies and resource mobilisation strengthen the innovation ecosystem. These effects align with the European Green Deal, positioning GenB as a catalyst for sustainable economic development.

7 Environmental impact

To evaluate the environmental impact of the GenB project, the methodology outlined in Deliverable D4.1 was employed. A questionnaire (Annex 7 of Deliverable D4.1) based SDG and Consumer Footprint Calculator was designed by AIJU and completed by APRE and AIJU.

The GenB project, as a Coordination and Support Action (CSA), does not generate a direct environmental impact, as it does not involve the production of goods or industrial processes with an immediate ecological footprint. However, its focus on educating, raising awareness, and inspiring young people about sustainable and circular bioeconomy holds significant potential for indirect environmental impact in the medium to long term. This impact stems from the transformation of attitudes, knowledge, and behaviours among young people, who can influence more sustainable consumption patterns and contribute to the development of a bio-based economy.

GenB outcomes - such as learning materials, online courses, and interactive formats – help facilitate education and awareness raising about the bioeconomy and the adoption of a responsible lifestyle. A circular bioeconomy aligns with many of the UN's Sustainable Development Goals (**Errore. L'origine riferimento non è stata trovata.**), contributing to the achievement of global sustainability goals and targets in a broader sense.

7.1 Assessment through the Consumer Footprint Calculator and Sustainable Development Goals

The indirect environmental impact of the GenB project lies in its ability to foster a "Bioeconomy Generation" committed to sustainability, as reflected in its educational resources and awareness-raising activities. The alignment with the SDGs demonstrates its contribution to education, responsible consumption, and climate action, while its relation to the Consumer Footprint Calculator highlights a potential influence on the variables Climate Change, Resource Use – Energy Carriers, Land Use, Human Toxicity – Non-Cancer Effects Health Risk, and Water Scarcity, driven by the promotion of bio-based products, sustainable agricultural practices, efficient resource use, and responsible water habits. These prospective effects align with the objectives of the European Green Deal and the EU Bioeconomy Strategy, positioning GenB as a catalyst for a transition towards a more sustainable economy.

8 Monitoring of the achievement of Key Performance Indicators and Specific Objectives

8.1 Review of the Specific Objective 1

According to the DoA, the SO1 involves co-creating innovative approaches, formats, materials, and tools through collaboration among children, young adults, parents, teachers, and other formal and non-formal education professionals, to offer educational and informational toolkits on bioeconomy in general and bio-based sectors.

GenB defines measurable, verifiable, realistic, achievable KPIs to fulfil this objective. In this case, all the KPIs are related to WP1.

The specific Tasks to achieve "Specific Objective 1" are as follows:

- Task 1.1 Collection of bioeconomy awareness, information and education contents
- Task 1.2 GenB resources Library
- Task 1.3 Co-creation of the awareness, information and education innovative approaches
- Task 1.4 Toolkits for young people, teachers and other multipliers

Detailed information about WP1 tasks and results are available in D1.2, D1.3 and D1.4.

The GenB project has partially achieved the KPIs established for Specific Objective 1 (SO1). The details of these achievements are presented in Table 39.

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
1.1	Information and education contents	Achieved	>100 contents	239 contents
1.1	Information and education contents	Achieved	>50 sources in several languages	>50 sources in 24 languages
1.2	GenB Resources Library	Achieved	1 library	2 libraries
1.2	GenB Resources Library	Achieved	5.000 users	26.234 users
1.3	European GenB Common Ground Camps	Achieved	40 participants	74 participants
1.3	Focus Group	Achieved	90 young people	1002 young people
1.3	Living Labs	Achieved	180 participants	689 participants

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
1.4	Toolkits for young people, teachers and other multipliers	Achieved	4.000 users; 9 languages	12.666 users; 9 languages
1.4	Additional language (FR) of "What's bioeconomy"	Achieved	1	1
1.4	"What's bioeconomy" book	Partially achieved	12000 kids; 3000 teachers; 45000 kids indirectly	12.530 kids; 866 teachers; 17.320 kids indirectly.
1.4	Printing of #1,500 copies per language (EN)	Partially achieved	1500 copies	1000 copies
1.4	Printing of #1,500 copies per language (IT)	Partially achieved	1500 copies	800 copies
1.4	Printing of #1,500 copies per language (NL)	Partially achieved	1500 copies	400 copies
1.4	Printing of #1,500 copies per language (PT)	Partially achieved	1500 copies	400 copies
1.4	Printing of #1,500 copies per language (SK)	Partially achieved	1500 copies	400 copies
1.4	Printing of #1,500 copies per language (AT)	Partially achieved	1500 copies	400 copies
1.4	Printing of #1,500 copies per language (SP)	Partially achieved	1500 copies	600 copies
1.4	Printing of #1,500 copies per language (MT)	Partially achieved	1500 copies	400 copies

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
1.4	Printing of #1,500 copies per language (FR)	Partially achieved	1500 copies	400 copies
1.4	Printing of #1,500 copies per language (EL)	Partially achieved	1500 copies	400 copies
1.4	Printing of #1,500 copies per language (UA)	Partially achieved	1500 copies	500 copies
1.4	Game or gamified educational experience	Achieved	3000 users, 9 languages	4,638 users, 9 languages
1.4	Quizzes and Educational Cards	Achieved	10000 views, 9 languages	16.548 views; 9 languages
1.4	Video teasers and Educational Videos	Achieved	4000 views, 9 languages	13.258 views; 9 languages
1.4	Online factsheet “bioeconomy job profiles”	Achieved	400 students, 9 languages	3243 students; 9 languages
1.4	Educational and information packages	Achieved	1000 young people, 9 languages	4243 young people; 9 languages
1.4	Lesson plans for teachers and training contents	Achieved	400 teachers, 6000 kids (indirect), 9 languages	1278 teachers; 25.560 kids indirectly; 9 languages

Table 39. Summary table SO1

Although the KPIs haven’t been reached completely, through the development and implementation of innovative educational and informational tools—such as videos, games, social media content, among other resources—GenB has strengthened cooperation among teachers, parents, and young people, fostering a more engaged and informed society on bioeconomy-related topics.

The analysis of the KPIs not only demonstrates the project's effectiveness in executing its planned activities but also lays the foundation for a long-term positive impact. The tools and

methodologies developed under SO1 will continue to enhance public awareness and education, contributing to a more sustainable and circular bioeconomy in Europe and supporting the EU's vision of achieving climate neutrality by 2050.

8.1.1 Strategic plan for achieving outstanding KPIs

The following section outlines the deviations encountered by the GenB project in meeting SO1, along with the underlying reasons for these deviations.

- "What´s bioeconomy book – Number of copies, Partially achieved

The KPI target was 13,500 copies, but only 4,900 were achieved. This shortfall is due to a significant increase in paper costs since 2021 (approximately 60%).

- "What's bioeconomy" book – Teachers and kids indirectly, Partially achieved

The KPI related to the distribution of physical copies to approximately 2200 teachers will not be met within the project's timeframe, due to the reduction of the distributed copies. However, the GenB consortium remains committed to sending the physical copies to teachers after the project's completion, ensuring the KPI will be achieved in a subsequent phase. Given that this delay does not compromise the ultimate goal of reaching teachers and the variation is temporary, it does not negatively impact the overall success of the KPIs established for the GenB project.

The partners are developing a distribution plan for printed copies to relevant stakeholders. For instance, APRE, as project coordinator, plans the following actions:

- June 2025 European Circular Bioeconomy Fund - ECBFORUM2025 https://www.ecbf.vc/ - 200 books in English
- 13-14 May 2025 - Place Stéphanie 20, 1050, Brussels European Rural Circular Bioeconomy Conference Collaboration of six Horizon Europe projects: MainstreamBIO, ROBIN, SCALE-UP, BioRural, BIOMODEL4REGIONS, RuralBioUP - 120 books in various languages
- 13 May 2025 - Rue Du Champ De Mars 21, 1050, Brussels BIOBASEDCERT cluster event (STAR4BBS, SUSTCERT4BIOBASED, HARMONITOR) - 65 books in various languages
- 20 May 2025 - European Commission Representation in Italy, Rome Bioeconomy Day, organized by APRE and UNITELMA - 100 books in Italian
- 26 June 2025 - Place Stéphanie 20, 1050, Brussels Sustainable Futures Conference, co-organized by Bluerev, Engage4Bio, BlueBioClusters, SKILLBILL - 65 books in various languages
- September 2025 – I.C. Guicciardini – 85 books in Italian will be distributed to four primary first-grade classrooms since the school has hosted the pilot of the BioRace game.
- October 2025 - Brussels ALFA Project Final Conference - 65 books in various languages

The distribution plan for the printed copies of the book What's Bioeconomy?, developed by AIJU, will be as follows:

A total of 600 copies in Spanish will be distributed among educational centres, individual teachers who have participated in the project, and institutions involved in the activities of Work Packages 2, 3, and 4.

Specifically, copies will be sent to schools that took part in WP2 activities such as: “Hands-on lab” and playful activities in partners’ countries, the “Inside the Bioeconomy” experiential exhibit, “BioArtGallery”, role-play games on bioeconomy-related professions in schools, “Bioeconomy talks/seminars”, informative webinars in partners’ countries, and individual meetings with multipliers organised in collaboration with FEBiotec, Surfrider, and the National Toy Museum. Additionally, a copy of the book will also be sent to each participating GenB Ambassador.

Regarding the actions under WP4, 25 copies in Spanish will be sent to the 25 teachers who participated in the workshop on the GenB educational model. Additional copies will be distributed to the two educational centres involved in the KER assessment and one school that participated in the BioArt competition.

Lastly, 5 Spanish copies will remain at AIJU’s ToyLab Experience to be used in future awareness-raising activities for children on topics related to the bioeconomy and environmental sustainability.

As for the 75 English copies, 60 will be distributed among international English-speaking schools as well as mainstream schools that are part of AIJU’s collaborating schools network in Spain. The remaining 15 copies will be retained by AIJU for use in future initiatives and projects.

The distribution plans for the copies of the remaining partners will be included in the technical report.

8.2 Review of the Specific Objective 2

According to the DoA, the second specific objective (SO2) of the GenB project aims to raise awareness, interest, and knowledge among young people at pre-school, elementary, and high school levels about the environmental, social, and economic benefits of a sustainable and circular bioeconomy, with a particular focus on bio-based sectors. This objective is pursued through inspirational activities designed to capture the imagination of future generations and sensitise them to the importance of sustainability and circularity, fostering a “Bioeconomy Generation” (GenB) deeply committed to these principles.

To achieve this goal, GenB established measurable, verifiable, realistic, and achievable Key Performance Indicators (KPIs) within Work Package 2 (WP2), specifically under Task 2.1: “Inspire and inform young people on sustainable and circular bioeconomy and bio-based sectors”. The following activities were identified within this task, each accompanied by its corresponding code from deliverable D2.2 for easy reference:

- "Hands-on labs" and playful activities (2.1a)
- Bioeconomy Village (2.1b)
- Inside the Bioeconomy Experimental Exhibit (2.1c)
- BioArt Gallery (2.1d)

Detailed information on the WP2 tasks can be found in deliverable D2.2.

This section presents the progress of SO2 through the KPIs established for Task 2.1, with results detailed in the table below. The details of these achievements are presented in Table 40.

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
2.1	"Hands-on labs" and playful activities in partners' countries	Achieved	400 young people	4.224 young people
2.1	"Bioeconomy Village" at large scale events	Achieved	40.000 people	56.928 people
2.1	"Inside the bioeconomy" exhibit experiential exhibit in existing public spaces e.g. museums	Achieved	4.000 people	17.032 people
2.1	"BioArt Gallery"	Achieved	40.000 people	56.928 people

Table 40. Summary table SO2

These outcomes illustrate how the implemented actions have contributed to the broader goals of the GenB project, supporting Europe's transition to a sustainable and circular bioeconomy in line with the priorities of the European Green Deal, the "Decade of Action" for the Sustainable Development Goals, and the EU's vision of achieving climate neutrality by 2050.

These activities, crafted with innovative approaches and tailored to the target age groups, have enabled the GenB project to make significant strides in educating young people and shaping public perceptions of the bioeconomy. They address the complexity and unfamiliarity of the concept—highlighted in the updated EU Bioeconomy Strategy as a key barrier—while also building trust and engagement. This has been further supported by involving SMEs, industries, and researchers who share their "bioeconomy stories", bridging the gap between innovation and civil society.

8.3 Review of the Specific Objective 3

According to the DoA, the SO3 aims to increase interest among new generations to join education and training on bioeconomy at large and create new ways of attracting talent in the life science, technology and bioeconomy opportunities.

GenB defines measurable, verifiable, realistic, achievable KPIs to fulfil this objective. In this case, all the KPIs are related to WP2. The specific Tasks to achieve "Specific Objective 3" are as follows:

- Task 2.2 Inspire and inform students in bioeconomy careers
- Task 2.3 Educate young people to promote the bio transition
- Task 2.4 Educate teachers in teaching bioeconomy
- Task 2.5 Inform and educate other multipliers

Detailed information about the tasks is available in D3.2.

The GenB project has partially achieved all the KPIs established for Specific Objective 3 (SO3). The details of these achievements are presented in Table 41.

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
2.2	"Role-play game" on bioeconomy jobs in schools	Achieved	150 students	188 students
2.2	TEDx pitches	Achieved	240 students	1050 students
2.2	Bioeconomy careers infodays	Achieved	300 students	293 students
2.2	"A day in a biorefinery" study visit	Achieved	100 students	336 students
2.2	"Schools´projects" to grow future entrepreneurs	Achieved	5.000 participants	6.000 participants
2.3	Educational activities using the toolkits	Achieved	720 young people	9.468 young people
2.3	Bioeconomy talks / seminars inquiry-based learning	Achieved	400 young people	4.328 young people
2.3	Online bio educational village	Achieved	5.000 young people	6.000 young people and teachers
2.4	"What´s bioeconomy MOOC", "How to use GenB toolkits", "Bioeconomy job profiles"	Achieved	800 teachers and 12000 students (indirect)	1.457 teachers and 25.215 students (indirect)
2.5	Informative webinar in partners' countries	Achieved	80 multipliers and 4000 young people (indirectly)	124 multipliers and 6200 young people (indirectly)
2.5	Individual meetings with three multipliers in each partners' country	Achieved	80 multipliers	1.038 multipliers

Table 41. Summary table SO3

Progress on SO3 was assessed through the KPIs defined for Tasks 2.2 to 2.5, with results outlined in the accompanying table. These indicators reflect the success achieved in boosting interest in bioeconomy education, the effectiveness of talent attraction strategies, and the breadth of the educational initiatives. In doing so, SO3 supported the broader aims of the GenB project, aligning with the priorities of the European Green Deal, the Sustainable Development Goals, and the EU's target of climate neutrality by 2050.

The achievement of these KPIs underscores a tangible impact that goes beyond the numbers. By inspiring young people to pursue educational and professional paths in the bioeconomy and by equipping teachers and multipliers with the tools to spread this vision, GenB has established a generation that now consumes more responsibly and is ready to lead innovation in bioeconomy sectors. This work has expanded opportunities for skilled employment and laid a stronger foundation for sustainable policymaking, positioning Europe as a global leader in a circular economy that respects the planet's ecological limits.

These tasks were crafted with innovative approaches tailored to diverse target audiences, ranging from students to educators and other influential stakeholders such as museums, science communicators, and youth organisations. Task 2.2 delivered initiatives that showcased career opportunities in the bioeconomy to students, underlining their relevance to sustainability. Task 2.3 focused on educating young people about the principles of the bioeconomy transition, encouraging shifts in consumption habits and a stronger commitment to circularity. Meanwhile, Tasks 2.4 and 2.5 empowered teachers and non-formal multipliers with resources and knowledge, enabling them to integrate bioeconomy concepts into their educational and outreach activities.

Through these activities, GenB tackled the lack of familiarity with the bioeconomy —a key barrier to its uptake— and built trust and enthusiasm among younger generations. By engaging educators and other civil society actors, the project amplified its reach, forging a vital link between bioeconomy innovation and the wider public. This not only nurtured a generation committed to sustainability but also contributed to innovation-driven growth and job opportunities, particularly in rural and coastal regions.

8.4 Review of the Specific Objective 4

According to the DoA, the SO4 contributes to the transition of the new generations towards more sustainable and circular behaviours, consumption and lifestyles through the empowerment of the young generations to assume their role.

GenB defines measurable, verifiable, realistic and achievable KPIs. In this case, the following KPIs from WP3, to fulfil this objective.

The specific Tasks to achieve "Specific Objective 4" are as follows:

- Task 3.1 Engage GenB Ambassadors
- Task 3.2 Empower the GenB Ambassadors

- Task 3.3 Support GenB Ambassadors to take a role
- Task 3.4 European Youth forum on bioeconomy

The expected impact is: Preparing the younger generation to assume their role in the transition to a circular and sustainable bioeconomy, for example, through the uptake of innovative solutions. Nomination of "Bioeconomy Youth Ambassadors" campaigns for children and young adults in high schools.

Detailed information about the tasks available in D3.2.

The GenB project has achieved most of the KPIs established for Specific Objective 4 (SO4). The details of these achievements are presented in Table 42.

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
3.1	Young multipliers engaged to play as frontrunners	Achieved	20 multipliers to play as frontrunners	20 multipliers to play as frontrunners
3.1	Young career testimonials	Achieved	8 young career testimonials taking a role in GenB activities	9 young career testimonials taking a role in GenB activities
3.1	Green sensitive young influencers and activists	Achieved	8 activists	110 activists
3.1	Environmental young journalists engaged	Achieved	8 environmental young journalists	11 environmental young journalists engaged
3.1	“GenB in Action” recruitment campaign on social media	Achieved	10.000 views	82.796 views
3.2	Capacity building webinars	Achieved	180 participants	287 Ambassadors empowered
3.2	Social media profiles @GenBvoices	Achieved	3.000 followers	5.604 followers
3.2	Online mutual learning workshop	Achieved	25 GenB Ambassadors	22 GenB Ambassadors
3.2	GenB Ambassadors hosted in 5 events, conferences,	Achieved	5 GenB Ambassadors in 5 events	10 GenB Ambassadors in 6 events

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
	other youth groups meeting			
3.3	GenB driving the transition" International Competition	Achieved	50 participants and 2500 young people invited	500 participants and 24500 young people invited
3.3	GenB Ambassadors engaged in promotional activities as “Students2Students” testimonials	Achieved	10 GenB Ambassadors engaged; 3000 views and 5000 indirect	108 GenB Ambassadors engaged; 5300 views and 8834 indirect
3.3	Social media campaigns by green sensitive young influencers as GenB Ambassadors	Achieved	3 social media campaigns reaching 50000 views	5 social media campaigns reaching more than 5400 views
3.3	Young journalists publishing on GenB	Achieved	5 environmental young journalists	11 environmental young journalists
3.3	Items published by young journalist on GenB social media	Achieved	15 new items	16 new items
3.4	Thematic online debates on topics relevant for young people	Achieved	3 debates and 300 participants	3 and 304 participants
3.4	Cross-contamination online workshop with other youth green communities	Achieved	1 workshop and 50 participants	1 workshop and 45 participants
3.4	“Our GenB future” international online workshop to generate ideas and	Achieved	1 workshop and 100 participants	1 workshop and 133 participants

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
	recommendatios "Youth2Policy			

Table 42. Summary table SO4

The impact of SO4 was measured through KPIs set for Tasks 3.1 to 3.4, with outcomes detailed in the accompanying table. These metrics highlight the extent of youth engagement, the growth of their skills, and their influence on those around them, cementing the achievements of WP3. In doing so, SO4 bolstered the overarching goals of the GenB project, aligning with the ambitions of the European Green Deal, the Sustainable Development Goals, and the EU's vision of climate neutrality by 2050.

The success of these KPIs reveals a profound impact that extends beyond the figures. By motivating young people to lead the bioeconomy transition and equipping them and their communities with the means to act, GenB established a generation that now actively drives change and promotes sustainable practices in their surroundings. This work has created a ripple effect, heightening collective awareness and laying a robust foundation for a circular bioeconomy that benefits both Europe and the planet.

These activities are built on insights gained from earlier EU-funded projects like Transition2Bio, Biobridges, and BIOVOICES, which tested various approaches to spark young people's interest in the bioeconomy. Using a structured approach, Task 3.1 rallied children and teens across age groups, from the youngest (4-8 years) to older students, through efforts like the selection of "Bioeconomy Youth Ambassadors". Task 3.2 equipped them with essential skills and practical know-how to spearhead change. Task 3.3 provided platforms for action, such as leading local efforts to promote sustainable habits among family and neighbours, while Task 3.4 elevated their voices in youth discussions across Europe.

Through these efforts, GenB overcame the initial lack of awareness many young people had about how to contribute to a bioeconomy, redirecting their passion—seen in global movements like FridaysForFuture or Youth4Climate—into meaningful action. The project enabled even the youngest participants, such as pre-schoolers, to play a part, like convincing grandparents to embrace responsible practices. Collaboration with initiatives like the Bioeconomy Youth Champions, supported by the Global Bioeconomy Summit, further amplified this work by spotlighting these young leaders.

8.5 Review of the Specific Objective 5 and Specific Objective 6

According to the DoA, the SO5 is maximise the project's impacts towards behavioural and socio-economic changes by sparking multipliers and GenB networks and ensuring exploitation, replicability and sustainability of project's outcomes and the SO6 contribute to the Destination 'Innovative governance, environmental observations and digital solutions in support of the Green Deal' by supporting the public Administrations and schools in the implementation of initiatives promoting the green transition process.

These two objectives are evaluated together because they have a common impact: contribute to the Destination 'Innovative governance, environmental observations and digital solutions in support of the Green Deal' by supporting the public administrations and schools in the implementation of initiatives promoting the green transition process.

GenB defines measurable, verifiable, realistic and achievable KPIs to fulfil these objectives. In this case, the following KPIs from WP4 and WP5 are considered.

The specific Tasks to achieve the specific objectives are the following:

- Task 4.2 GenB Education Model
- Task 4.3 Ministries of Education policy recommendations
- Task 5.2 Ecosystem building

Detailed information about the tasks available in D4.5.

The GenB project has partially achieved all the KPIs established for Specific Objective 5 (SO5) and Specific Objective 6 (SO6). The details of these achievements are presented in Table 42.

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
4.2	Online mobilisation and Mutual Learning Workshops in partners' countries involving the education community	Achieved	200 participants	237 participants
4.2	Factsheet with GenB educational model	Partially achieved	1000 downloads, 24 EU official languages	778 downloads, 24 languages
4.3	Ministries of education (online) requirements workshop,	Achieved	20 people from Ministries of Education	30 people from Ministries of Education
4.3	Ministries of education (online) recommendations workshop	Achieved	20 policy makers	50 people from Ministries of Education

Nº Task	Task	KPI Current Status	Target to be engaged	Reached
4.3	Policy Recommendations	Partially achieved	1000 downloads, 24 EU official languages	923 downloads, 24 languages
5.2	Projects and initiatives engaged in collaboration	Achieved	6 EU funded projects	21 EU funded projects
5.2	Online mobilisation and mutual learning workshops	Achieved	2 workshops and 100 participants	3 workshops with 126 participants

Table 43. Summary table SO5 and SO6

The impact of SO5 was assessed through KPIs defined for WP4 and WP5, with results presented in the accompanying table. These metrics demonstrate the success in spreading best practices, improving governance accessibility, and enabling stakeholders to adopt project outcomes, solidifying GenB's achievements. In doing so, SO5 advanced the broader aims of the GenB project, directly supporting the European Green Deal and an inclusive shift towards sustainability.

The realisation of these KPIs underscores a meaningful impact beyond the numbers. By equipping public administrations and schools with actionable resources and transforming GenB's outputs into accessible tools, the project empowered these actors to lead the green transition effectively. This work has positioned the bioeconomy as a cornerstone of political and educational agendas, fostering a more equitable society ready to address global challenges with innovative solutions.

These activities were implemented to elevate the bioeconomy's prominence across national, regional, and local agendas, drawing inspiration from the Coordination and Support Actions of the Horizon Europe Governance call. Task 4.2 fostered the exchange of successful experiences among educational communities at national and European levels, tailoring the GenB educational approach to meet the needs of ministries of education, policymakers, and other stakeholders. Task 4.3 ensured decision-makers had access to critical resources and insights, enhancing governance practices. Meanwhile, WP5 turned project outputs—such as public reports, articles, and conference contributions—into practical tools that encouraged broad uptake by relevant parties.

8.5.1 Strategic plan for achieving outstanding KPIs

The following section outlines the deviations encountered by the GenB project in meeting SO5 and SO6, along with the underlying reasons for these deviations.

- Factsheet with GenB educational model and Policy recommendations – Partially achieved

The KPI related to the number of downloads of the *Education Model Factsheet* and Policy Recommendations have not yet been reached. This is due to the fact that the elaboration and upload of all language versions of the results took longer than anticipated, which delayed the start of the promotion campaign. Now that all versions are available, the dissemination activities are fully ongoing, including targeted outreach to educators. The KPI is expected to be reached by June 2025.

Through these efforts, GenB bolstered the bioeconomy's visibility in public policy and education, aligning with EU priorities and global challenges. The project not only amplified the role of science and technology in the bioeconomy but also nurtured a new "social compact" that embraced the Sustainable Development Goals and tackled social disparities, ensuring knowledge was widely accessible.

8.6 Review of the Dissemination and Communication activities

GenB defines measurable, verifiable, realistic, and achievable KPIs. In this case, the following KPIs from WP5, specifically T5.1 is taken into account.

Detailed information about the tasks available in D5.2.

The GenB project has successfully achieved all the KPIs established for Dissemination and communication activities. The details of these achievements are presented in Table 44.

Nº Task	Task	KPI Current Status	Material to be developed	Reached
5.1	Brand Identity Kit	Achieved	1 Brand Identity Kit: Logo & Templates	1 Brand Identity Kit: Logo & Templates
5.1	GenB Websites	Achieved	1 website, > 3000 visits and > 25 countries reached	1 website, >9700 views and 27 countries reached
5.1	Flyers, Posters and Roll-Ups	Achieved	2 flyers, > 2 posters, 2 roll-ups and 500 flyers distributed	3 flyers, 8 posters, 2 roll-ups and 5000 flyers distributed

Nº Task	Task	KPI Current Status	Material to be developed	Reached
5.1	Infographics	Achieved	> 10 promotional banners, 6 Toolkits 20 Quizzes and Educational cards 1 factsheet "bioconomy job profiles" 1 factsheet "GenB educational model" in 24 EU languages > 6 infographics, 1 booklet "GenB Policy recommendations for Ministries of Education", 1 booklet "Our GenB future" recommendations "Youth2Policy"	6 infographics, and 3 booklets produced ("Youth2Policy") 40 promotional banners, 6 Toolkits 20 Quizzes and Educational cards 1 factsheet "bioconomy job profiles" 1 factsheet "GenB educational model" in 24 EU languages 6 infographics, 3 booklet "GenB Policy recommendations for Ministries of Education", 3 booklet "Our GenB future" recommendations "Youth2Policy"
5.1	Multimedia Material	Achieved	1 GenB promotional video, 2 video teasers and 1 educational video	1 GenB promotional video, 2 video teasers and 1 educational video with > 4000 views
5.1	Conferences & Events and publication	Achieved	> 10 speeches at events and conferences, > 1 publication and 1 final event	19 speeches, 2 publications and 1 final event
5.1	Dissemination Webinars and presentations	Achieved	8 informative webinars (> 80 participants), > 24 engaged multipliers in informative webinars	12 informative webinars and 112 participants, +1000 multipliers
5.1	Email campaigns, Newsletters and Press releases	Achieved	40 email campaigns, > 4 newsletters and 4 press releases	10 email campaigns, 4 newsletters and 4 press releases

Table 44. Summary table Dissemination and Communication activities.

The dissemination and communication activities of the GenB project have successfully met their established objectives, ensuring the broad outreach of the project's results and bioeconomy-related messages to the intended stakeholder groups. The development of a consistent visual identity, the establishment of a functional and regularly updated website, and the production of graphic and multimedia materials have enabled access to project content for young people, educational communities, multipliers, and other relevant actors. Furthermore, participation in significant events, the delivery of webinars and stakeholder meetings, and the dissemination through newsletters, email campaigns, and press releases have ensured effective communication, supported by the networks of partners and external collaborators.

These efforts have significantly advanced the promotion of the bioeconomy as a cornerstone of sustainability, enhancing its visibility and understanding among current generations while laying a robust foundation for its continued uptake in the future. In doing so, GenB has raised awareness among a wide and diverse audience, ensuring that the principles of the bioeconomy endure and reach the greatest possible number of people, both now and in the long term.

8.7 Conclusion

The Specific Objectives of the GenB project, built upon the partners' extensive experience in bioeconomy awareness, communication, and education, have been largely achieved, establishing a comprehensive methodological approach that has effectively contributed to Actions 2.3 and 2.4 of the updated EU Bioeconomy Strategy, the priorities of the European Green Deal, and the "Decade of Action" for the Sustainable Development Goals (SDGs). Through a diverse set of innovative approaches, activities, and tools, GenB has heightened public awareness and educated younger generations, accelerating the transition to a sustainable and circular bioeconomy across Europe.

Despite minor deviations, the collective impact of these objectives has been transformative for society. However, these deviations do not compromise the overall objectives, as the majority of KPIs were met or exceeded. By inspiring and equipping young people to lead change, enhancing the capacities of public administrations and educational communities, and broadly disseminating bioeconomy principles, GenB has cultivated a more informed and engaged citizenry committed to sustainability. This work has laid the groundwork for a circular economy that addresses social inequalities and leverages science-based solutions, aligning seamlessly with the goal of a climate-neutral Europe by 2050. In doing so, GenB has not only tackled present-day challenges but has also created a lasting legacy that ensures the ongoing adoption of sustainable practices, making a substantial contribution to the Green Deal objectives and long-term global well-being.

9 Conclusions

Deliverable 4.3 of the GenB project cements its role as a benchmark in advancing the bioeconomy, delivering a comprehensive evaluation of its transformative impact during the second reporting period. Anchored in Work Package 4, this analysis underscores the project's ability to inspire, educate, and empower diverse audiences—from young people to educators and policymakers—in full alignment with the European Green Deal and the EU Bioeconomy Strategy.

The societal impact of GenB shines through its success in fostering a deep and lasting understanding of the bioeconomy, embedding its principles into everyday life and cultivating sustainable attitudes among new generations. The project's activities have proven highly effective in inspiring, informing, and engaging, creating an initial positive connection with the bioeconomy that translates into significant knowledge gains and sustained interest in further exploration. The Key Exploitable Results (KERs), with their innovative and practical design, have amplified this impact by empowering both educators and students, demonstrating exceptional potential to endure over time. This approach has laid the groundwork for an inclusive and transformative societal shift, supporting European priorities of sustainability and equity, and preparing an active citizen to contribute to a circular future.

In the scientific realm, GenB has advanced bioeconomy knowledge through publications offering innovative perspectives and evidence-based solutions. The non-peer-reviewed articles produced within the project have enriched existing literature, providing a valuable reference framework for future studies and fostering the exchange of ideas within the academic community, in line with KIP 1 (generation of new knowledge). Concurrently, numerous non-scientific publications, such as blog posts, magazine articles, and audiovisual formats, have broadened the dissemination of results to wider audiences, aligning with KIP 2 (diffusion of knowledge). Their accessibility and permanence on digital platforms ensure that the generated knowledge remains relevant, encouraging an ongoing and sustainable dialogue about the bioeconomy.

Economically, GenB has established itself as a strategic driver of sustainable growth through significant direct and indirect impacts. Its GenB Ambassador Programme has facilitated job opportunities, bridging the gap between education and future labour market prospects in the bioeconomy, promoting greater specialisation and employability in this sector, in harmony with KIP 5 (creating more and better jobs). Likewise, by influencing public policy through workshops, events with policymakers, and participation in consultations for the new Bioeconomy Strategy, the project has contributed to updating key strategies, fostering environments that attract investment and strengthen the innovation ecosystem, aligning with KIP 6 (leveraging investments in R&I). These efforts, combined with the generation of synergies across sectors, position GenB as a facilitator of a fair and prosperous economic transition in the long term.

The environmental potential of GenB lies in its ability to transform attitudes and promote sustainable behaviours. By encouraging the responsible use of resources and bio-based solutions, the project contributes to a positive environmental footprint, aligning with the Sustainable Development Goals and reinforcing its role as a driver of a circular bioeconomy. This approach ensures that today's lessons yield tangible benefits for the planet in the future.

In terms of its specific objectives, GenB has executed its mission to inspire, educate, and empower with excellence, demonstrating a coherent and effective global strategy, despite minor challenges overcome through strategic planning. The integration of the bioeconomy into educational and societal contexts, alongside community mobilisation, reflects a holistic impact that resonates with European strategic priorities. While deviations occurred in the distribution of educational materials, participation in certain online workshops, and career-oriented events, these were minimal or temporary, addressed through measures such as post-project distribution plans, and do not compromise the overall success, as the majority of objectives were met or exceeded. This achievement, inclusive and free of gender disparities, validates the robustness of the project's approach and its capacity to deliver high-quality results, strengthening education and engagement toward a sustainable bioeconomy.

As a final reflection, GenB emerges as a transformative project that transcends its role as a Coordination and Support Action to become a cornerstone of sustainability through the bioeconomy. Its integrative vision connects generations and sectors around a shared purpose, leaving a legacy that drives a Europe committed to bioeconomy principles and a more sustainable tomorrow

10 References

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute. https://learningpolicyinstitute.org/product/effective-teacher-professional-development-report

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01

Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 105–121). Guilford Press.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, 53, 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59–109. https://doi.org/10.3102/00346543074001059

Klassen, R. M., & Chiu, M. M. (2010). Effects on teachers' self-efficacy and job satisfaction: Teacher gender, years of experience, and job stress. *Journal of Educational Psychology*, 102(3), 741–756. https://doi.org/10.1037/a0019237

Lyons, T. (2006). Different countries, same science classes: Students' experiences of school science in their own words. *International Journal of Science Education*, 28(6), 591–613. https://doi.org/10.1080/09500690500339676

Pyle, A., DeLuca, C., & Danniels, E. (2017). A scoping review of research on play-based pedagogies in kindergarten education. *Review of Education*, 5(3), 311–351. https://doi.org/10.1002/rev3.3097

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, 96(3), 411–427. https://doi.org/10.1002/sce.21007

Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science*, 312(5777), 1143–1144. https://doi.org/10.1126/science.1128690

Tan, E., & Barton, A. C. (2007). Unpacking science for all through the lens of identities-in-practice: The stories of Amelia and Ginny. *Cultural Studies of Science Education*, 2(2), 361–392. https://doi.org/10.1007/s11422-007-9065-8

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