



Learning Circular Bio-economy by Hands-on Science Experiments

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Abstract

A paradigm shift towards a new industrial policy aimed at sustainability and innovation is underway in Europe. Circular Economy and Bio-economy are models to rethink the systems of production-consumption to create a waste-free future, a paradigm shift towards a new industrial policy aimed at sustainability and innovation. In particular, Bioeconomy comprises those parts of the economy that use renewable biological resources from land and sea – such as crops, forests, fish, animals and micro-organisms – to produce food, materials and energy through innovative technologies. This transition requires a cultural and structural change that can be obtained by aligning the educational programs in order to train skilled people needed to build a sustainable bio-based industry in Europe. As concern secondary schools, a promising way to introduce the Circular Bioeconomy concepts is to link them with some topics addressed by STEM disciplines, within the ministerial educational programs. In the present work, we present a learning pathway, designed for High schools, useful to introduce the basic concepts of the bioeconomy among youngsters and new career opportunities. The designed pathway was developed within the BBI-UrBiofuture project and is composed of lectures and hands-on activities. The lectures are aimed to explain the role of science within the transition from carbon economy towards Circular Bioeconomy. Hands-on activities are practical examples of Circular Bioeconomy linkable to ministerial high school curricula, suitable to be proposed to the middle and high school students. In particular, they are laboratory experiments, demonstrating how to transform some biomasses into new bio-based products. The main objective of these experiments is to show students that the bio-industry sector needs scientific knowledge, critical thinking and creativity.

Keywords: *Circular Bioeconomy, High School, Laboratory Experiments, Bio-based products, Cross-curricular learning*

1. Introduction

Our dominant economic model is still based on the logic of “take-make-waste”, and this is one of the main reasons for our current sustainability problems which imply global climate change, ecological disasters, increasing stress on non-renewable resources, geopolitical tensions and social inequity.[1] Within this framework, Circular Economy and Bio-economy have been recognized as strategic and economic models for a Sustainable Europe due to their sustainability, inclusivity and resiliency to climate change.[2] In particular, the bioeconomy is one of the largest and most important sectors in Europe, employing over 18 million people, and connecting those economic activities that use renewable bio-resources of soil and sea - such as crops, forests, animals and micro-organisms - to produce food, materials and energy.[3] The bioeconomy is not properly a new sector, but currently, it's cutting across many existing sectors with the aim to create new value chains.[4]

The transition towards circular strategies requires a cultural and structural change that can be obtained by aligning educational institutions to provide programs in order to train the skilled people needed to build a sustainable bio-based industry in Europe. In fact, in the report “A roadmap to a thriving industrial biotechnology sector in Europe” (2015)[5] identifies that the availability of skills and high-qualification staff as one of the main barriers affecting industrial biotechnology opportunities in Europe. Furthermore, the report highlights that the lack of skills is a handicap to drive the sector forward. In order to maintain Europe's competitiveness in industrial biotechnology, it was pointed out that there is a crucial need to identify skills gaps and how these can be filled. This aspect is still pending as, in order to speed up innovation, the current European bioeconomy scenario crosses the boundaries between existing and new industrial sectors and involves partners in a variety of fields entailing working in areas where different academic disciplines cross paths and in diverse teams.

Nowadays, the bioindustries are quickly evolving, and the educational systems showed some gaps and mismatches, leaving not only a youth workforce not trained for this sector, but also giving non-proper opportunities to those already working that wanted to update their knowledge. The education in



science, technology, engineering and mathematics (STEM) disciplines is a key-point to fill the gaps mentioned above; therefore, special approaches for attracting youth to STEM disciplines are needed. In this scenario, the Bio-based Industries Joint Undertaking partnership funded the UrBIOFuture project [6,7] to help Europe to gain leadership in the bio-based sector. By identifying education needs and gaps in Europe's bio-based sector, and by involving all stakeholders in a co-creation process that delivers the "UrBIOfuture experience" as a pivotal tool for attracting talent and providing professional orientation. Thus, several workshops focused on Circular Bio-economy were set up and organized for students of High Schools in order to promote interaction among industry and educational and research institutions.

The learning pathway proposed by the workshops aimed to link some concepts of circular bioeconomy with the ministerial programs of chemistry, biology and technology. The two main objectives were the following: (a) to aware youngsters about the Circular Bioeconomy; (b) to interest youngsters to address an educational career towards circular bioeconomy by showing them that the bio-industry sector needs scientific knowledge and creativity.

2. Methodology

2.1 Sample and procedure

The main aim of the workshops was to link the bio-based issues with the STEM disciplines defined as crucial enabling technologies offering skills and solutions to increase the Circular Bioeconomy approach in our society.

The learning workshops' contents and the eventually previous knowledge needed, had been discussed before with the teachers in order to link it with the national school programs and consequently raise their interest.

From the practical point of view, the workshops were organized in two sessions as described below.

The first session mainly consisted of a frontal lesson dedicated to an introduction about Circular Economy and Bio-economy as strategic economic models for a Sustainable Europe.

The aim was to point out that transition towards a circular bio-economy leads to more sustainable resource use while developing new income streams, favouring the growth of new sectors, adding value to products and increasing jobs.

The second session was organized following a learning-by-doing method. Some practical examples of Circular Bioeconomy were shown. The purpose of this phase was to demonstrate that the Bio-Industry sector requires knowledge and creativity to develop new value-chains and to establish new cross-sector interconnections. Therefore, the students were involved in some hands-on activities, that can offer them some examples of how to transform biomasses into new bio-based products. The hands-on laboratory activities have been all designed to support further learning about critical concepts of circular bioeconomy and how to links different values chains, i.e. by transforming biomasses (wool and milk) into new bio-based products, such as respectively, soap and filter for water purification (Fig. 1(A) and 1(B)), and bioplastic and flexible films (Fig.1(C)).

Along the educational pathway, the students were stimulated to work in a group with minimal guidance (student-centred learning), and they were encouraged to acquire knowledge through active exploration of real challenges (project-based-learning).

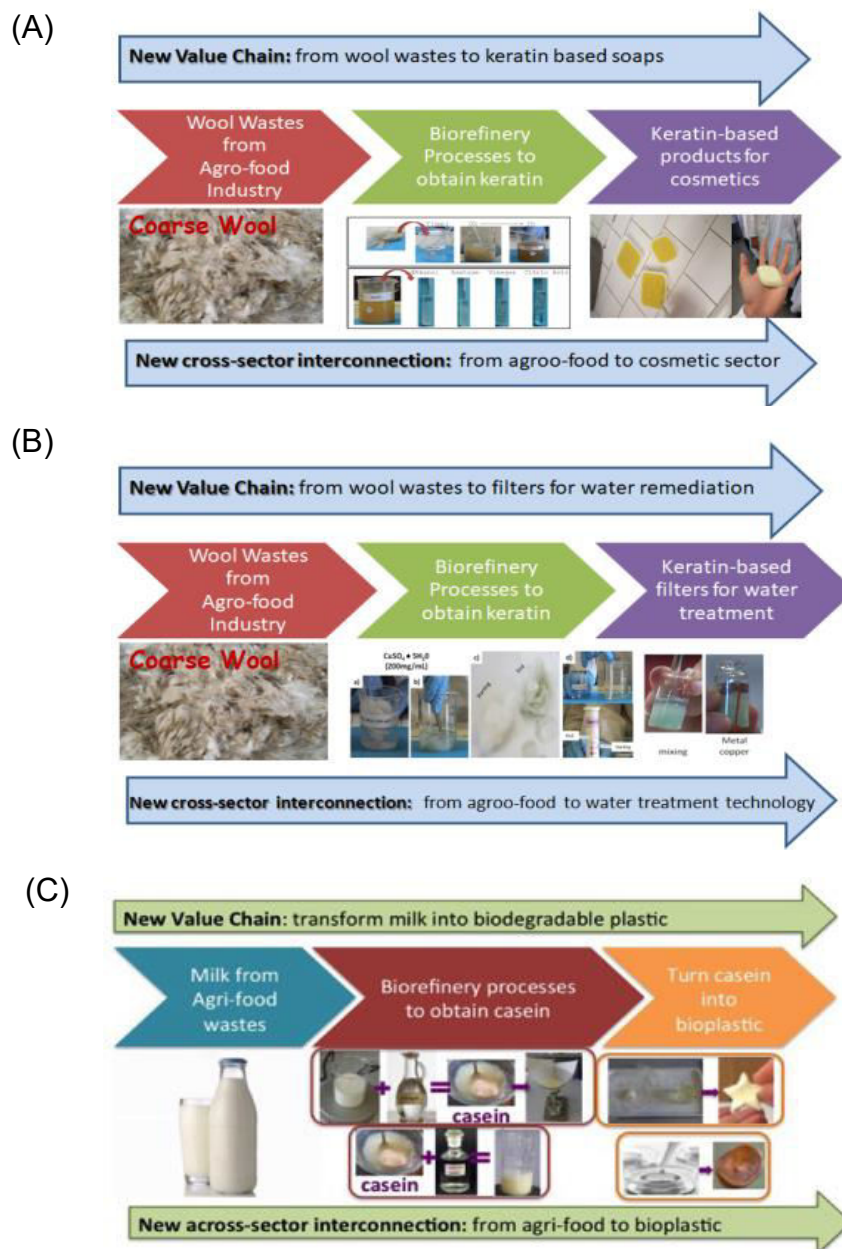


Fig. 1. Schematic descriptions of hands-on laboratory activities and their connections with critical concepts of the circular economy.

2.2 Impact assessment

In order to evaluate the impact of these workshops, a short survey has been given to the students before and after the workshop. 131 students of high school (15-18 years old), divided into 9 classes with different curricula addresses, from humanistic to scientific and to more technical curriculum, were involved in this study

The aim of the survey was to evaluate the awareness of students about the Circular Bioeconomy as an economic model to address the problem of Climate Change and to investigate about their interest to address an educational career in the field of Bioeconomy.

A brief questionnaire has been given to the students to evaluate their knowledge before and after learning workshops (Table 1).



Table 1. Questions contained in the survey and asked students who participated in the workshops on Bioeconomy

Questions before the workshop	Questions after the workshop
Have you ever heard about the problem of Climate Change?	Do you think that the workshop has clarified the concepts of Circular Economy and Bioeconomy?
How may you define Circular Economy and Bioeconomy?	Would you address your educational career towards the bioeconomy after attending the event?
Have you ever heard about the Bio-based sector and new career opportunities in this sector?	

3. Results

The overall results are that all students are fully aware of the global climate change problem. This topic is addressed in depth at school within the disciplines of chemistry, physics, geography and technology. Nowadays the climate change is considered to have a significant impact on their life and planet, and the students discussed a lot about it also on social media. Many of them followed the "Fridays for future" movement, which organized some global demonstrations to demand action from political leaders to take action to prevent climate change and to transition to renewable energy. However, before the workshop, only the 25% of the students were able to define the concepts of Circular Economy, and Bioeconomy (Fig. 2) and only the 31% of them have heard about the bio-based industry sector and were aware that this is a growing sector in which a significant increase in the employment level is expected.

After the workshop, the number of students able to define the circular economy and the bioeconomy increased to 78%, but only the 28% of them showed interest in addressing the educational career towards the bioeconomy.

The students most interested in addressing career in the bio-based sector were those from a Technical Technological Institute, followed by those of the Commercial Technical Institute and the Scientific High School. As expected, the less interested in addressing a career in this sector resulted in being the students of Human Science.

Moreover, the majority of students appreciated the proposed hands-on activities, since they found the laboratory experiments very useful to understand the role of science on the Circular Bioeconomy.

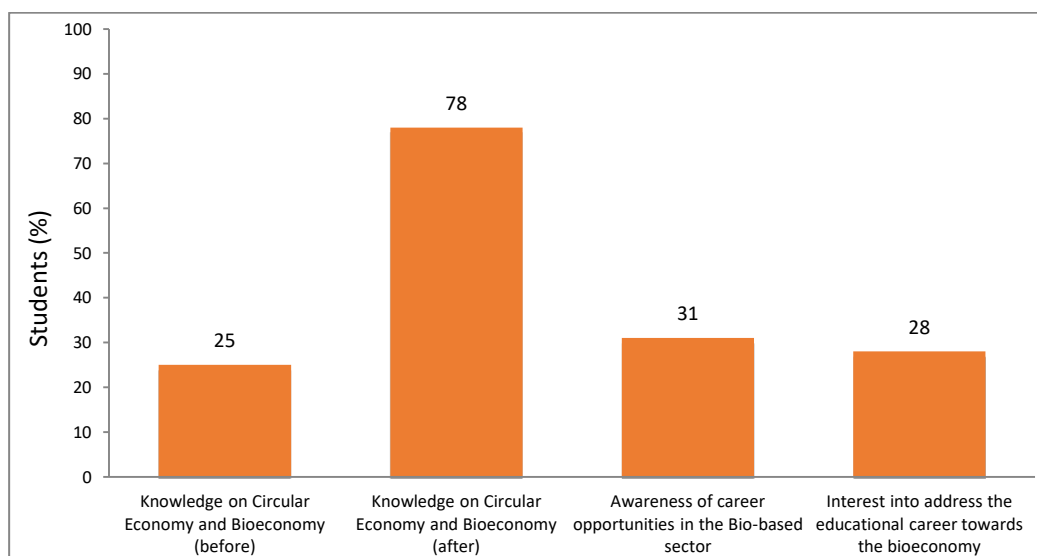


Fig. 2. Results from the students' survey

4. Conclusion

In order to boost the emerging bio-industry sector, an alignment of the educational programs is needed at all educational levels. Is for that reason that is fundamental to train young people for the new professional figures that are emerging in this sector, as well as for other professional profiles that



we still don't know. That's why the coordination between educational institutions and bio-based industries is highly needed.

In this scenario, introducing the concepts of the Bioeconomy into the programs of the STEM disciplines, mainly through hands-on laboratory activity is a functional approach both to foster young people to undertake training in this area, and to develop critical thinking, a precious skill considered fundamental not only in this sector but also in other sectors where innovation and customer approaches are getting more and more important.

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References

- [1] Vainio A, Ovaska U, Varho V, Not so sustainable? Images of bioeconomy by future environmental professionals and citizens, Journal of Cleaner Production (2018), <https://doi.org/10.1016/j.jclepro.2018.10.290>.
- [2] Food, bioeconomy, natural resources, agriculture and environment https://ec.europa.eu/info/sites/info/files/research_and_innovation/knowledge_publications_tools_and_data/documents/ec_rtd_factsheet-food-bio-resources-agri-envi_2019.pdf
- [3] Stegmanna, P., M. Londob, M. Junginger, The circular bioeconomy: Its elements and role in European bioeconomy clusters, Resources, Conservation & Recycling-x, 2020 <https://doi.org/10.1016/j.rcrx.2019.100029>
- [4] <https://www.ifpri.org/event/bioeconomy---new-transformation-agriculture-food-and-bio-based-industries---implications>
- [5] A roadmap to a thriving industrial biotechnology sector in Europe; 2015; BIO-TIC Team; www.industrialbiotech-europe.eu
- [6] <https://www.urbiofuture.eu/>
- [7] <https://www.bbi-europe.eu/>