BioS POLICY RECOMMENDATIONS

Brussels, November 20th 2020

OVERVIEW

The BioS Erasmus+ Project and Course are mainly digital objects, aimed at the innovation and at the developments of higher ranked scientific and professional profile of the current and future health care. While enhancing knowledge, skills and interest for scientific knowledge, a valuable result is the ongoing training of contributors and developers, continuously challenged by new tasks and experiences. Future developments and the background of bioinformatics and computational methods in life and health science, with economic, social and political implications, call for appropriate consideration of Artificial Intelligence (AI) methods, namely, of deep learning and machine learning. It should include also the use of block-chain and cloud technologies and, as much as possible, should be built within a frame of an explicit theory of change. The work's effectiveness strives to show how change happens in the short, medium and long term with a trend suitable to achieve the intended impact. The goal of increasing the level of bioinformatics competence and expertise is here exemplified also in visual diagrams, infographics, and presented as a narrative report. Looking with open minds and disposition to new ideas and to the abstract, mathematical reasoning, coping with the current and forthcoming challenges and opportunities, is the key feature of the project and of the course. The major BioS results and educational tools are extensively disseminated to expert and/or interested audiences; the aim of contributing to policy-making is pursued by these Policy Recommendations, focused on exploiting the Bios VOOC together with the BioS Virtual Learning Environment (VLE). Building an inclusive community delivering information and advertisement in social networks, groups of interest and by scientific publications, calling for survey participation and ideas are some of the Bios strategy. These interventions are and will be self-maintained by the feedback of managers, contributors, followers and remote contacts after the end of the lifespan of the project.

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Bridging Gaps and Strengthening Computational Skills of Healthcare Professionals in benefit of the health of EU citizens

Despite the prolific productivity of bioinformatics researchers and engineers supporting many of the developments in biomedicine and biotechnology, there is a clear division between the bioinformatics community and the health care professionals. This situation is unfortunate as it hinders the incorporation of the latest developments of genome sequencing and genomics into the everyday medical practice. In clinical practice, big data will improve outcomes for individual patients through personalization of predictions, earlier diagnosis, better treatments, and improved decision support for clinicians in cyclic processes

During the implementation of the project "BioS: Digital Skills on Computational Biology for health-care professionals", the accumulated experiences regarding both medical personnel and bioinformatics professionals allow us to formulate recommendations on how to address these issues.

Policy recommendation for decision makers in the health care

- Enhance collaborations between the bioinformatics researchers and health professionals.
- Given the interest of such materials for the medical community, health professionals should be encouraged and allowed to dedicate some time for learning. Genomics/Bioinformatics is a clear example of an emerging field generating an emerging need. Offering further education in this field is highly recommended.

Policy recommendation for decision makers in the research funding

- Support the basic and applied research in Precision Medicine, through a blend of different programs in size and duration, which will foster different models of interaction and collaboration between partners and teammates, with the aim to forge new collective subjects bearing balanced, interdisciplinary faculties that will deliver solution prototypes for different pressing problems.
- Foster Innovation through the creation of precision medicine niches, on top of the aforementioned solution prototypes, which ideally target different links of the value chain in the "from Bench to Bedside" path. This boils down to the support through:
  - establishment and operation in innovation hubs (providing support for the operational, legal and auditing costs but also convincing diligence models for their valuation)
  - investment funding instruments (equity funding, service contracts) of the commercialization of these ideas, but also
  - their integration in international clusters envisioning the operation of the specific value chain, or more broadly
  - their assimilation in the international business ecosystem, through efficient networking, problem-driven mechanisms

Policy recommendation for decision makers in the education sector

- Integrate biology and basic bioinformatics skills in the training of medical doctors and medical students
- Teaching proposal should be flexible and adaptable to the tight schedule of health professionals. In this sense, online self-learning activities are an excellent tool.

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- Modular structure also offers this flexibility, with the participants choosing the learning activities fitting better to their needs. All the activities should be designed in a way that they can be performed both following the whole course (then activities should be related to each other) but also by itself.

More policy recommendations focussing on the educational level are found below.

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FOREWORD

This document of Policy Recommendations is developed and completed at the end of the project, building on preceding Policy Briefs and on project results. It is targeting mainly policy-makers and is presented here, as required by the approved project, by the Dissemination Work Package Leader. We are aiming at mainstreaming the use of Computational Biology in clinical context by medical doctors. This is already a component of some specialized fields of medicine, i.e. digital health. This last concept encompasses bioinformatics, and is a component of many medical activities in Europe and worldwide, in science teaching and in its application. The wide yet targeted dissemination of BioS Policy Briefs and Policy Recommendations contributes further to the promotion of Data-Driven-Innovation in the provision of Healthcare services by increasing interest and literacy in computational approaches in medicine. Recommendations are the result of a continuous interactions with stakeholders and with a very wide audience of >2,000,000 persons reached during three years by more than 1000 posts in social media pages and groups. Moreover, >10,000 Stakeholders were reached through newsletters sent by one of the most reliable automation platform and email marketing service, suitable for assuring also information on some reaction and feedback. In addition, conceptual contributions provided by other partners are a component of this document. Target groups and potential beneficiaries of these Policy Recommendations are EACEA, medical doctors, Healthcare and Bioinformatics Sectors representatives, Policy-makers at all levels, all relevant stakeholders, public. This Project receives EU funding. Accordingly, we may share information on activities and results also on the Electronic Platform for Adult Learning in Europe - EPALE – the initiative of the European Commission funded by the Erasmus+ programme, hosting blog posts, news, events and other kinds of activities.

The key reference is The Erasmus+ Programme Guide (version 3 of 25/08/2020), incorporating the corrigendum of 25/08/2020, which is an integral part of the 2020 Erasmus+ Call for Proposals and its corrigendum, published on 26/02/2020.

A very useful reference is the survey "Adult learning and continuing vocational education and training valued by Europeans". This survey displays adult learning and Continuing vocational education and training (CVET) as any learning activities undertaken by adults (employed or not) with the intention of improving their knowledge or skills. It describes the perceived value of adult learning and CVET in producing desired outcomes and benefits for individuals (such as personal, skill and career development), society and the economy (such as lower unemployment) and for countries (such as social cohesion).

The topic of online working and learning in the coronavirus era is particularly important, and the BioS Project, as a fully digital implemented teaching and training course, is in-line with the current needs.

Science with and for Society (SwafS). The project experience and the review of the policy evolution over three years (2018-2020), at the European, national and regional level, as well as experiences from related projects were fully considered. Here we summarize the essential challenges of the implementation of educational e-learning change solutions for the delivery of new modular vocational curricula on Computational Biology & Bioinformatics. For this purpose, a key reference is Science with and for Society (SwafS), the programme. This is instrumental for addressing the societal challenges that are being tackled by Horizon 2020. The unmet needs addressed are: science education for all, gender equality in all organizations (Trovato), ethics and integrity

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embedded in research, communication we can trust, open science and ultimately how to place citizens at the core of this process. The goals are to ensure excellent Research and Innovation to tackle the challenges of today for a better future. We share the view that Europe can only thrive by matching the immense potential of science with the values, needs, and aspirations of society. Horizon Europe, the forthcoming years program, must strengthen efforts to tap into the vast potential citizens have to offer and ensure effective cooperation between science and society. The report on the Horizon 2020 Science with and for Society (SwafS) science education project portfolio is extremely relevant for a quick overview of the current situation.

The actual recommendations are presented systematically along the discussion of the different sections of this document, by a plain itemized numeration and evidence whenever specified.

CONCEPTS AND MISSION

The BioS Project Consortium has the awareness of, and share the strong commitment to working closely with the European Parliament and Commission on defining the issues of our generation: health care promotion and equity harmonization, fighting climate change, harnessing digitalization, building a social market economy for today's world. Scientific activities require faster and effective collaborations, so that we need to strengthen the European Research Area. Such Area is embracing all of Europe, because knowledge has no territorial boundaries, scientific knowledge grows with collaborations and knowledge is trusted if there is open scrutiny of its quality. (Gabriel). We share the need for Europe to show leadership in the World to care for the things Europeans cared and care for, and to find common solutions to shared ideals and challenges. We want to take pride in our work and to find new ways to make this possible, building the world we want to live in a Union of vitality in a world of fragility (Van Der Leyen).

A sustainable roadmap of clearly defined 2030 digital targets is related to connectivity, skills and digital public services, with a focus on the right to privacy and connectivity, freedom of speech, free flow of data and cybersecurity. All these will encompass areas covering safety, liability, fundamental rights and data aspects of artificial intelligence. We recommend that all these issues be considered in any scientific course, as it is in the BioS Course, by videos, handbooks, question/answers sections aimed at empowering understanding and memory, additional reading in the virtual library and webinars. These last were formally included in the curriculum (Trovato), or suggested throughout the dissemination campaigns launched almost daily by the Bios Social Media. Overall, these policy recommendations strive to be in line with the 2021 European Commission work programme – from strategy to delivery -,

The task of building within a frame of an explicit theory of change allows a better addressing of unmet needs in Europe, suitability of e-learning for teaching bioinformatics, realistic targets. This should have a sufficient flexibility to respond to the needs of the target group as well as fostering wider developments in policy and practice (Trovato). The work's effectiveness strive to show how change happens in the short, medium and long term with a trend suitable to achieve the intended impact. The goal of increasing the level of bioinformatics competence and expertise is below exemplified also in visual diagrams, i.e. few infographics, and presented as a narrative report. Facts, barriers and fiction must be clearly detected, or debunked if needed. Building an inclusive community delivering information and advertisement in social networks, groups of interest and by scientific publications, calling for

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survey participation and ideas are some of the dissemination strategy actions. These can be self-maintained by the feedback of contributors, followers and remote contacts (Marsden). Accordingly, we recommend the most great awareness and strategy for linking together open scientific, educational and professional communities, different and independent but joined by shared ideals and interests. The instruments are, apart the Course itself, the social forum networks and pertinent webinars, either organized or participated.

THE GRAND CHALLENGES

Efficient and consequent policy recommendations may strengthen Europe's capacity to reach the sustainability goals set by culture, innovation, health and research programs.

We strive to descend from the Bios project experience into a higher-level view of the scientific and industrial landscape of MOOC change tools by e-learning teaching. We produced the identification of some "grand challenges" and policy recommendations for addressing such tasks.

These outcomes reflect the understanding of the Consortium about the critical success factors and risks of high-level science education change systems. In the intention of the authors of this deliverable, we attempt to offer to the European Policy Makers and Funding Agencies a useful insight on the areas where research and policy could act more effectively to achieve the objective of more sustainable development.

The two already above narratively itemized recommendations are:

1. RECOMMENDATION 1. In any scientific course, as it is in the BioS Course, videos, handbooks, question/answers sections are aimed at empowering understanding and memory. Additional well tailored and targeted readings and teaching, provided by linked and commented virtual libraries and webinars, should be provided, calling for comments of the trainees.
2. RECOMMENDATION 2. The developers of the courses should express strongly explicit endorsement and enhancement for linking together open scientific, educational and professional communities, different and independent but joined by shared ideals and interests. The instruments are, apart the Course itself, social forum networks, pertinent webinars, either organized or participated, wide audience publications and, mostly relevant, the active production or participation to such actions of the trainees themselves.

FEW HIGHLIGHTS ON THE BIOS PROJECT AND COURSE.

Section 1. Architecture of the Bios Project and of the Bios Course.

Looking back at the three years' experience of the Consortium, as well as at their contributions, infographics description of its architecture was disseminated for enhancing interest of stakeholders and potential users during the lifetime of the project.

By this infographics, the fundamentals of the Bios Project are shown.

The Basis (5) is a good and explicit conceptualization bioinformatics and computational biology goals for increasing knowledge and skills among health professionals. The second level (4) is the detection of suitable and sustainable tools for reaching a wide target of health professionals. The third level (3), the key, refers to the rationale of the educational strategy and the curriculum topics. The fourth level (2) is the continuous spreading strategy for communicating and raising interest in the course. The last level (1) is the actual enrollment, participation and final proficiency in the course.

A clear and appropriate definition of all these steps of a pyramid is recommended at the beginning of any project or course, with the needed changes of names and concepts.

RECOMMENDATION 3. Clear and explicit visual representation of the steps and of the intermediate or final goal.

In this infographics, some components linking concept, wished impact, implementation and actual impact achieved are illustrated.

Each component is critical because 1. A robust analysis of unmet needs for teaching widely bioinformatics is not available,

2. The strategic approach, even based on the experience of other e-learning courses is a matter of ongoing development, taking into account several factors (see below).

3. The human resources, infrastructure and facilities available should be on-place or must be acquired; and, last, but not least, the impact achieved, apart the indicators of course attendance and proficiency, has not the time for including a meaningful description of career prospects or novel jobs and tasks for the trainees, but only an early or late trajectory or trend.

In addition, such analysis is needed when planning an advanced educational project, and should be explicitly recommended to include as a visual reference of tasks and goals.

RECOMMENDATION 4. The sequence of requisites needed for the development of an educational, scientific project and course should be clearly presented, with the possibility of a quick overview.

The final goal is to provide a contribution to the development and establishment of health care organization based also – or mainly – on precision medicine. In this sense, the BioS course is able to provide a comprehensive teaching and training in all these bases and pillars, as visually shown in this below shown infographics.

RECOMMENDATION 5.

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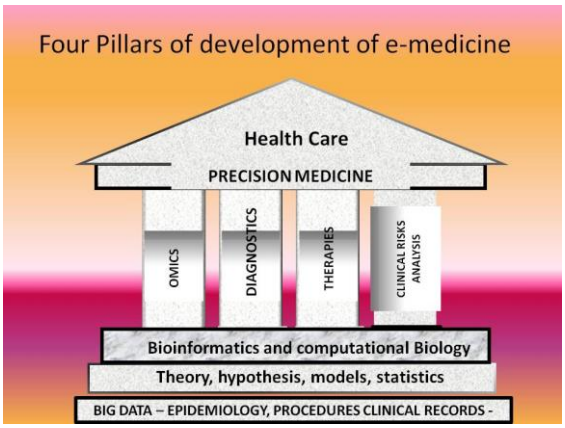
Even including statements that are more assertions than fully supported evidence, the engineered structure of the theorethical pillars of the wished outcome should be explicitly shown.



RECOMMENDATIONS. A NARRATIVE OVERVIEW.

The Architecture of the Bios Project and of the Bios Course, "some grand challenges" are above outlined. The Consortium illustrates here, below, the most critical success factors and risks of educational strategies in bioinformatics and computational biology change systems, looking at the aim of increasing knowledge and skills of health professionals in most if not all the medical specialties.

Topics which are developed also by the virtual library include applications of bioinformatics in genetics, oncology, infections, sepsis and epidemiology of contagious disease, whole organs and stem cell transplantation, and many other sectors. Such arguments and articles are aimed at opening the minds of the trainees, exploring the many possibilities and opportunities that will derive from their new skills and competences. This is a distinctive feature of this project and course and a feature to be recommended in forthcoming course aimed at the increase of science knowledge and skills, by a pro-active learning, if not by learning-by-teaching or learning-by-working.

SUPPORT AND PROMOTION BY THE EUROPEAN POLICY MAKERS, LEGISLATORS, AND RESEARCH FUNDING AGENCIES.

The set of some interconnected policy recommendations, which collectively embody the retrospective considerations of the Consortium about which directions could benefit more from a sustained support and promotion by the European Policy Makers, legislators, and Research Funding Agencies, is the core topic of this section.

The Bios Project was planned, approved, developed and now concluded delivering the wished live instrument for teaching and learning bioinformatics by a vocational scientific e-learning course, hosted by a friendly and comprehensive edX platform. The Bios course has several interactive features, and implies blended components with instructors, tutors, external webinars, practical training webinars and social media networks (BIOS Twitter, Facebook and LinkedIn pages and groups). All these are allowing interactions with the responsible dissemination managers, followers participating to the BioS course, other followers interested in Bioinformatics and in the course itself. Such forums strive to be a flywheel for facilitating or triggering interest and knowledge in science, namely in the most related fields i.e. computational biology, genetics and multiomics, molecular biology and epidemiological models, AI and deep learning,

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Block-chain and clouds, with practical applications in any fields of medicine (Trovato)

The overall participation reached followers, interacting and engaged by one thousand posted document and information in the three years (2018-2020).The fallout in related groups is great, mostly in LinkedIn and Facebook, reaching repeatedly more than one millions of individual contacts.

The main effects of this intense campaign of dissemination are:

1. Information of the steps of development of the BioS Course, flagging since December 2019 the opening of enrolments with a sufficiently friendly submission procedure, encouraging some of them exclusively by this way.
2. Stepwise increasing interest and literacy of the followers, with daily information on the most attractive advancements in the above listed field and in the societal and ethical implications.
3. Enhancement of the public awareness of the interest and commitment of the European Commission, namely of the Erasmus Plus actions, in the topics of advanced education in Science and of innovative teaching tools.These actions were professionally managed by the dissemination partner in charge, with some contributions from the other Partners.

Participation and interactions of learners with BioS social media networks are limited, seemingly due to a rigid educational roadmap of the course for outreach learning. By the comparison with a parallel institutional national academic LinkedIn page, >50.000 followers with the same page-manager, we can claim a good success for the BioS pages, considering the narrow focus of the topics involved.

OVERVIEW OF CHALLENGES AND SOLUTIONS: PLANNING FORTHCOMING INITIATIVES

The overlap between advanced training courses in science and Horizon Europe calls that incorporate research and innovation missions be wide. The shared need is to increase the effectiveness of funding by pursuing clearly defined targets analyzing and forecasting, as much as possible, how a mission-oriented policy approach will work. The Digital Education Action Plan (2021-2027) outlines the European Commission's vision for high-quality, inclusive and accessible digital education in Europe. It is a call to action for stronger cooperation at European level to:

- learn from the COVID-19 crisis, during which technology is being used at an unprecedented scale in education and training
- make education and training systems fit for the digital age.

Similarly, in this case the overlap with EU policy in the field of vocational education and training is present.

This key element of lifelong learning systems aims to equip citizens with knowledge, skills and competences required in particular occupations and on the labor market.

When dealing with healthcare work-forces, and in general with actual services or industries, the need of planning and operating inside the real world is extremely important. A different, abstract approach will build systems adherent with some formal requirements, but essentially no more than empty boxes. Very comprehensive approaches are needed for managing big-data for the health of great

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populations, such as all Europe and individual member States health systems. This vision is currently used and developed, and requires a good understanding of the general concepts of neural networks, i.e. basically non-linear statistical data modeling or decision making tools. They can be used to model the complex relationships between inputs and outputs or to find patterns in data. In other words, the use of artificial intelligence tools is a need. The implicit step forward relies on deep learning algorithms, which can implicitly learn the distribution function of the observed data. Learning in neural networks is particularly useful in applications where the complexity of the data or task makes the design of such functions by hand impractical.

In addition, the widespread use of Artificial Intelligence (AI) could have unintended consequences that are dangerous or undesirable. This is one of the reasons of the AI winter, i.e. is a period of reduced funding and interest in artificial intelligence research and application, cyclically appearing, from one decade to the other, happening when it fail to fulfill the very public promises it was making. Nonetheless, this is not influential on the trend toward a greater scientific, technological and societal networking that needs interpretation and drive in a very comprehensive and expert way.

The social and political control relies greatly in the trust of most persons in the work of true experts: this may not counteract the widespread hostility based also on the Dunning–Kruger effect. People are typically overly optimistic when evaluating the quality of their performance on social and intellectual tasks. In particular, poor performers grossly overestimate their performances. The expertise in the use of social medias and of validated e-learning platforms as strategic tools must be empowered, particularly in the current scenario of possible European shortages of resources and findings. The requests of easy to understand proof of the evidence for the benefits of modern technology often hidden a true hostility vs. evidence based medicine and science. The best answer is to spread actively well-supported information and studies within the culture of frankly acknowledging the need of expertise, research and ethics (Trovato).

EXPLOITATION OF A COMPREHENSIVE STRATEGY: PERFORMANCE AND SCENARIO

It is getting evident globally that the predictive approach, targeted prevention and personalization of medical services are the optimal paradigm in healthcare, demonstrating a high potential to save lives and to benefit the society as a whole. It is based on bioinformatics and on established, innovative, advanced or experimental evidences: such approach is rich in achievements (Costigliola). Robust culture, knowledge and skills in Computational Sciences – namely in medicine and suitable strategies for disseminating validated information are cornerstone pillars against anti-science social and economic-driven activities and against fake-beliefs. The BioS Course is a paradigm of basic open educational resource. It has translational implications in all science domains and in all fields of life, health and medical sciences (Trovato) Knowledge of and about science are integral to preparing our population to be actively engaged and responsible citizens, creative and innovative, able to work collaboratively, and fully aware of and con-versant with the complex challenges facing society. It helps us to explain and understand our world, to guide technological development and innovation, and to forecast and plan for the future. The report to the European Commission of the expert group on science education is a detailed roadmap in this regard.

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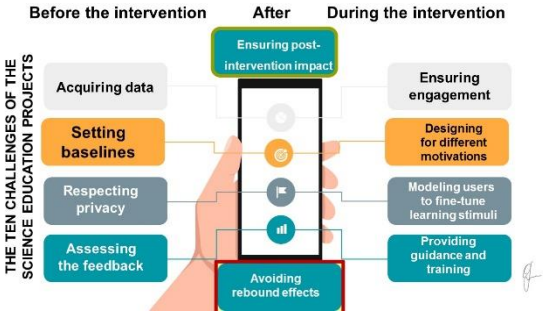
The EU funding and proposal of future e-learning courses in science and, namely, in Computational Life and Medical Sciences application are hoped for. The effective BioS course opportunities would ultimately contribute to enhance quality of health-care, professional attractiveness to service providers, industry, and applied research and innovation.

Ten new technologies are deemed to greatly promote scientific and economic progress and the level of civilization and social justice. In particular: Artificial intelligence, Blokchain, Open-source technologies, Telemedicine technologies. Three-dimensional printing, Gene editing technologies, Nanotechnologies, Synthetic biology, Drones and Robots (Mihalis Kritikos). Synergy and overlap are evident, but more important, we have the need of looking with open minds and disposition to new ideas and to the abstract, mathematical reasoning as a resource for coping effectively with the current and forthcoming challenges and opportunities.

The Bios Project, experiencing and searching solutions to obstacles and various limitations, and with the different performances of the single actions, assessed by narrow but at last appropriately flexible indicators, may become a reference for the development of the forthcoming actions with similar goals and resources.

THE TEN CHALLENGES OF A PROJECT AND AN EDUCATIONAL COURSE with the goal of being effective for providing by a vocational e-learning course knowledge and skills in bioinformatics and computational biology to health professionals, are presented below.

We identified the ten most frequent social, technical, and design challenges, which might affect the effectiveness of demand-side management interventions targeting resource saving. Such analysis may be regarded as a base for suggestions to policy makers on how to overcome the social, technical, and design challenges of building demand management systems.



The background of the best fitting expertise of developers is not considered here, because in this, as in other projects, the developers are reaching higher levels of competence while focusing on the tasks of the project. These challenges are divided into three sections, briefly itemized.

RECOMMENDATION 6 – it is needed to explicitly define and share with all Partners the challenges of science education projects in three groups: challenges to be addressed before the start of the intervention, challenges related to the intervention itself, and challenges to be addressed after the intervention, displaying them clearly.

A. Before the intervention and the actual development of the project and the course
   1. Acquiring data
   2. Setting baselines
   3. Respecting privacy
   4. Assessing the feedback

B. During the intervention and the actual development of the project and the course

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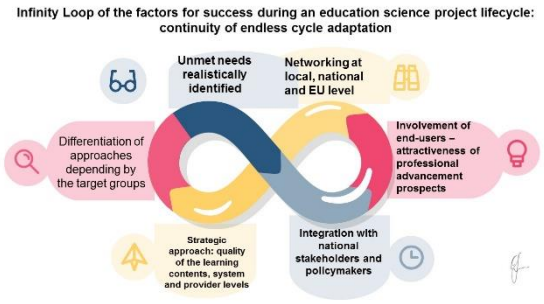
5. Ensuring engagement
6. Designing for different motivations
7. Modeling users to fine-tune learning stimuli
8. Providing guidance and training

C. <u>After the intervention and the actual development of the project and the course</u>
9. Ensuring and assessing post-intervention impact
10. Avoiding rebound effects.

LESSONS LEARNED – WAYS FORWARD

The implementation of the projects by the 13 National Partners which participated in the funding provides information on the key issues or strategic criteria that facilitate success:

1. Unmet needs realistically identified and managed: raising awareness of such context and developing a quality assurance and risk analysis and management culture is a long-term ambition suitable for long-term returns.
2. Strategic approach: quality of the learning contents, system and provider levels, both by Top-down and bottom-up planning, this second still scarcely sustainable.
3. Integration with national stakeholders and policymakers.
4. Involvement of end-users, i.e. of VET providers or representatives of other stakeholders – and activities of teachers and learners in the production of materials, enhanced by the attractiveness of professional advancement prospects.
5. Differentiation of approaches, adopting appropriate language and training depending by the target groups (schools, research institutions, industries, other service or productive organizations)
6. Networking at local, national and EU level, with the task of implementing initiatives and materials linked to the innovation of national education policies.



Each learning outcome should be attributed ECVET credits (the volume of learning based on the defined learning outcomes and their associated workload). This is a critical point, which regards the mutual recognition of vocational credits by the Member States, and in the same State, by different Schools, University, teaching organizations.

Procedures on recognition of non- formal and informal learning are not sufficiently transparent and clear. Policy makers should engage in a broader sector consultation and in dialogue with people who today do not have official accreditation of their competencies in these procedures achieved by on-line resources, mainly MOOCs, well integrated inside e-learning platforms characterized by flexibility and affordability. Students and workers can learn at the preferred time and pace and do not have to pay for the courses.

There is a role to play by professional associations, which, in the case of bioinformatics, is currently very limited. Active communication and information of bioinformaticians (Costigliola-Trovato) by the social networks may contribute to the promotion of the acquisition of green and digital skills, so important in today's and

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tomorrow's economy and working environment.

This is the **Policy Recommendation 7**: It is necessary to display and increase the awareness that the key issues or strategic criteria that facilitate success are a model of infinity loop process. Such a model implies and assures self-maintenance and trajectory corrections by the negative/positive feedback of all the contributors, users and stakeholders. The concurrent study and research comparison with other ongoing similar or contrasting approaches is continuously needed.

Even if currently there are only limited mutual certificate recognition of non-academic science education courses and training, the opportunities that the fully recorded individual e-learning courses and associated training webinars could be the live supporting evidence of the formal certificates. This prospect – respectful of the personal right to the privacy but also calling for an optimal visibility and transparency of the actual competences acquired – deserves further pilot study.

SUMMARY. ITEMIZED POLICY RECOMMENDATIONS

RECOMMENDATION 1. In any scientific course, as it is in the BioS Course, videos, handbooks, question/answers sections are aimed at empowering understanding and memory. Additional well tailored and targeted readings and teaching, provided by linked and commented virtual libraries and webinars, should be provided, calling for comments and personal contributions of the trainees.

RECOMMENDATION 2. The developers of the courses should express strongly explicit endorsement and enhancement for linking together open scientific, educational and professional communities, different and independent but joined by shared ideals and interests. The instruments are, apart the Course itself, social forum networks, pertinent webinars, either organized or participated, wide audience publications and, mostly relevant, the active production or participation to such actions of the trainees themselves.

RECOMMENDATION 3. Clear and explicit visual representation – not only narrative - of the steps and of the intermediate or final goal.

RECOMMENDATION 4. The sequence of requisites needed for the development of an educational, scientific project and course should be clearly presented, with the possibility of a quick overview.

RECOMMENDATION 5. Even including statements that are more assertions than fully supported evidence, the engineered structure of the theoretical pillars of the wished outcome should be explicitly shown.

RECOMMENDATION 6. It is needed to explicitly define and share with all Partners the challenges of science education projects in three groups: challenges to be addressed before the start of the intervention, challenges related to the intervention itself, and challenges to be addressed after the intervention, displaying them clearly.

RECOMMENDATION 7. It is necessary to display and increase the awareness that the key issues or strategic criteria that facilitate success are a model of infinity loop process. Such models imply and assure self-maintenance and trajectory corrections by the negative/positive feedback of all the contributors, users and stakeholders. The concurrent study and research comparison with other ongoing similar

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or contrasting approaches is continuously needed.

SUGGESTION OF DIRECTIVES BEHIND THE EDUCATIONAL MISSION.

Healthcare facilities, industry and research already make use of computational approaches and bioinformatics professionals worldwide. Nowadays the challenge is to provide European workforces with digital and computational skills that are competitive with those available in other parts of the world, namely in US and in China. It would be a rather naïve approach to imagine being able to determine with European or National directives and laws the use of bioinformatics tools in healthcare organizations or industries. The feasible strategy is to foster the development of advanced knowledge and skills, with appropriate encouragement of support funds, innovation, teaching and research, with benefits for universities, medical schools, public and private health facilities, enterprises and industries. It is certainly difficult to promote quality of study and research by law. The sustainable tool passes through the deliberate promotion of expert professionals' willingness to develop and improve themselves. At the same time, it is necessary to discourage the persistence of worst practices in medicine and life science.

As we may be aware of, the rise of artificial intelligence (AI) driven technologies in healthcare has really been tremendous over the past few years. Devices and technological ensemble already available are a way to gather data for a more refined and truly powerful predictive personalized medicine. Moreover, and mostly, AI will allow (and is already allowing) to build intelligent systems that are robust and resilient to fake and targeted attempts to denigrate experimental medicine credit and actions in the contemporary scientific world, debunking misleading and detrimental scenarios. The link between bioinformatics and AI is great. It will change everything: Deep Mind's AI makes gigantic leap in solving protein structures. Google's deep-learning program for determining the 3D shapes of proteins stands to transform biology. The operational challenge is now to strive for encouraging, supporting and maintaining the quality of high-level scientific training and to discourage and neutralize anti-scientific approaches or methods that are distant from evidence-based medicine. This implies the management of funding policy and strategies with the awareness that definition, detection and recognition of competence include great ethical and deontological rigor and extreme transparency of intent and means. Focus on avoidance of the risk of wasting resources by funding and supporting amateur approaches to research, education, training or, worse, to medicine, must be as much as possible accurate and responsible (Trovato-Russo).

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BioS at a glance

Project Name:
BioS: Digital Skills on Computational Biology

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