INTEGRATING OPEN AND CITIZEN SCIENCE INTO
ACTIVE LEARNING APPROACHES IN HIGHER EDUCATION

Recommendations on integrating OS (and CS) in HE curricula

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Abstract:

This set of recommendations aims to support the readers in integrating OS activities into their higher education curricula and normalising the institution's development process. The paper begins by considering the necessity to develop new curricula by reflecting on the current uncertain, complex world. Next, potential forms of OS-integrated curricula will be considered from precedent cases of European HEIs. Besides, organisational and pedagogical viewpoints will consider possible challenges in shifting to OS-integrated curricula. Finally, we suggest ten recommendations to design and implement OS-integrated

curricula successfully by the development phase. Each suggested action is based on our experiences from the previous project activities and teaching practices. We conclude that the learning goals and evaluation system should be redesigned in OS-integrated learning activities that include diverse stakeholders. Positioning an academic library as a mediator of OS could help such diverse inclusion and be a key to the successful implementation of OS in education at an institution level.

Keyword list:

citizen science, curriculum development, higher education, open science, student-centred learning

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List of Abbreviations

The following table presents the acronyms used in the deliverable in alphabetical order.

Abbreviations	Description
CS	Citizen Science
HEI	Higher education Institution
OER	Open Educational Resource
OKA	Open Knowledge Activity
OI	Open Innovation
OIA	Open Innovation Activity
OS	Open Science

Executive Summary

This set of recommendations aims to support the readers in integrating OS activities into their higher education curricula and normalising the institution's development process. The report begins by considering the necessity to develop new learning objectives and approaches by reflecting on the current uncertain, complex world. In such an era, knowledge is no longer transmitted straight to the students from the upper level, namely a school or a teacher. Instead, knowledge is cultivated with a bottom-up approach alongside educators, peers and external experts. The INOS consortium believes that Open Science (OS), including Citizen Science (CS), has strong potential to foster new knowledge creation processes by engaging students, educators and other stakeholders in the challenge-driven learning activities.

Before going to the recommendation part, we will briefly examine a form of OS-integrated curricula. The section is a reflection of our previous work: a *State-of-the-art report on the integration of OS (and CS) in existing HE curricula* (see Nakata, 2022), which synthesises the collected examples of OS-integrated curricula in European higher education institutions (HEIs). Then, we will consider challenges in shifting to OS-integrated curriculum development and implementation from an organisational and pedagogical point of view.

Finally, we suggest ten recommended actions to design and implement OS-integrated curricula successfully. The section is divided into four phases of curriculum development: (1) Planning, (2) Designing, (3) Implementation and (4) Evaluation. Each piece of recommendation includes a description of the background and suggested actions. They are followed by some examples and lessons learnt from our experiences to help readers get insights into the implementation.

We conclude that we must reconsider setting learning goals and evaluation systems considering the open nature of OS-integrated learning activities. We argue that education needs to move from an objective criteria-based assessment focusing on individuals' measurable competencies to post-positivist approaches considering the meaningfulness of learning and OS outcomes from different stakeholders' perspectives. We also acknowledge various challenges in implementing OS-integrated curricula due to the inclusion of diverse people from various roles, departments, organisations and expert fields. Positioning an academic library as a mediator of OS could help such diverse inclusion and be a key to the successful implementation of OS in education at an institution level. The INOS consortium encourages HEIs to reconsider their current curricula and reform them step by step, but progressively, to cultivate students' competencies to take advantage of OS and formulate their futures as active citizens.

1. Introduction

The goal of 'education' should meet the current demands of society, cultivating capable and responsible citizens engaging in the co-creation of our future (Király & Géring, 2021). In other words, required competencies and knowledge constantly change, especially in this digital era. "It now seems timely to revisit the issue of curricula, for as the 21st-century advances, the meaning, purpose and nature of higher education are undergoing profound changes", said Whalley et al. (2011, p.379). The world where we are currently living is often described with the acronym of VUCA (Volatility, Uncertainty, Complexity and Ambiguity), meaning that we are facing many challenges that cannot be solved with a single, clear and straightforward solution. The age is also defined as 'supercomplexity' (Barnett, 2000), which challenges universities by requiring a structure change of knowledge function. Bartnett (2000) continues:

> in the world of the internet, everyone is a potential expert; the academics are no longer granted a status of unalloyed authority; and their frames of knowing are felt to be inadequate for a fast-changing world, replete with its own and proliferating frames for comprehending the world – the rules of which are at least a matter of process as of substance. (p. 416)

Whalley et al. (2011) also acknowledge the uncertainty of 'knowledge' and advocate that universities are no longer privileged to access it. Therefore, they need to establish their social role and goal more explicitly. This report highlights that education needs a grassroots-level change in the delivery method and aims to catch up with the global changes and needs. The traditional education in which knowledge was directly transmitted from the upper level, such as schools and teachers, to the students is insufficient in this changing and challenging world. Instead, transversal knowledge and skills should be cultivated with a bottom-up approach through which students co-create new knowledge together with teachers, peers and external experts. Accordingly, the European Consortium of Innovative Universities (ECIU) emphasises that European universities should offer opportunities that allow learners, teachers and researchers to collaborate with public sectors, industries and citizens to tackle global challenges and crises together.

Open Science (OS) can facilitate collaboration across diverse people beyond academic fields because of openness and interdisciplinarity. Open Science is an umbrella term including various types of open principles from research to education. The United Nations Educational, Scientific and Cultural Organisation (UNESCO) defined OS in their recent publication, *a UNESCO Recommendation on Open Science in November 2021,* as follows:

> open science is defined as an inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community (p.7).

Citizen Science (CS) is the involvement of the public in scientific research – whether community-driven research or global investigations (Citizen Science.org, n.d.)[1]. CS is both an aim and enabler of OS, more specifically, referring to the public participation in the research process such as data collection, data analysis, volunteer monitoring and distributed computing, as well as the use of open access data, information and journal articles (Bezjak et al., 2018). CS is a form of OS which is an inclusive concept for all

[1] Retrieved from Citizen Science.org (https://citizenscience.org/)

the open practices that share the same vision - public participation in scientific knowledge creation and utilisation.

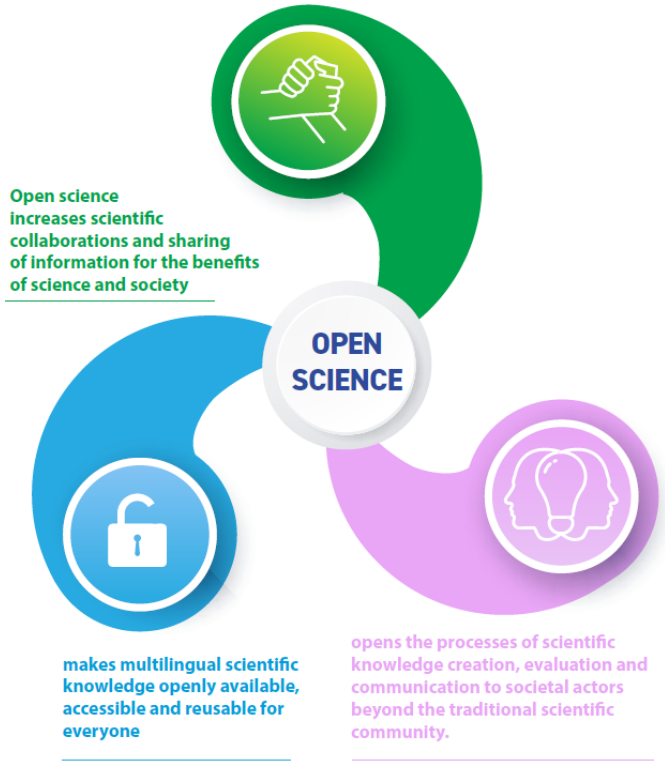

Figure 1. A broad concept of Open Science. Retrieved from UNESCO (2021).

HEIs can also initiate Open Innovation (OI) activities, inviting diverse professional people to create new solutions to societal problems. Like the CS concept, OI is also a form of OS as it facilitates multidisciplinary, multi-sector collaboration and open discussion to exchange expertise. By acting as regional innovation builders and educational and scientific incubator roles (Benneworth et al., 2009), universities can become a hub where people from multiple sectors can meet. HEIs can facilitate OI between academics and industry, supporting socioeconomic growth and problem-solving in the region (Benneworth et al., 2009).

Hence, we should consider how impactful HEIs contribute to our society through OS promotion and active citizenship cultivation. With the help of academic libraries, universities can reach out and involve citizen scientists and industry players in their scientific knowledge creation processes. Most importantly, universities are privileged to educate students to become responsible citizens and create a social value by cultivating their competencies and knowledge necessary in the changing world (Király & Géring, 2021). Curriculum revision is a step to promote such impact - a new learning approach can naturally engage students, educators and stakeholders in problem-solving and provoke their awareness of their important roles in society.

2. Form of Open Science-integrated curricula

Our previous project report collected existing OS-integrated curricula from European HEIs (See Nakata, 2022). In the report, we sorted out the cases and analysed which OS practices are integrated into curricula. As an overview, the concept of OS has been incorporated as learning content and method. Activity type and duration vary from a short-term study module to a one-semester course or even a degree program for one or two years. Through the review of the presented cases, we identified three main trends of OS implementation in curricula of European HEIs.

The first trend is to teach students about OS principles by providing a set of informative lectures, especially to enrich open research practices. For example, it could be a course for PhD students to learn practices of open publication and data handling issues. This type of learning activity often takes place in an online self-study mode where students take lectures whenever they like (e.g. MOOC). In the second trend, OS is applied as a learning method to study public participation processes in science and how to leverage rich data. CS approaches, including Crowdsourcing, are well integrated into the course design, encouraging students to collect, analyse and publish data as citizen scientists. In the third trend, learning activities often include OI (and CS) opportunities to let students get aware of real-world problems and tackle them by creating innovative solutions. The activities are often designed with a Challenge-Based Learning approach. Students select or define their problems based on their prior knowledge and collaborate with various external stakeholders to solve them. To realise such a diverse learning environment, a university utilises its own unique network and projects.

In the second and third trends, OS is incorporated into learning as a method and context. Students learn necessary skills and knowledge from hands-on practices during OS activities. The expected learning outcomes are not limited to OS principles but include various interpersonal competencies such as communication, problem-solving, project management and teamwork skills. Digital and technical skills, including data analysis and programming, can also be cultivated through OS activities. Students often need to communicate with stakeholders outside the university, including citizen scientists, and sometimes in a multicultural and/or multi-sector context.

Structural change at an institutional level is vital to successfully implement OS activities into curricula and mainstream new teaching practices. The institution must overcome preparing technological infrastructure enabling OS activities, building professional networks, and promoting multidisciplinary collaboration. Although such a solid foundation is a prerequisite, most importantly, cultivating collective capacity[3] among HE staff members, including researchers, educators, library staff and students, is a key to the impactful implementation. A shared understanding of the vision and recognition of the value drive people to take action; consequently, technology and network will be effectively utilised. For such collective capacity building, we highly recommend training[4] HE educators and other staff members to promote their awareness of the impact of OS and CS.

[3]Morgan (2006) sees 'capacity' "as an aspect of the collective organizational infrastructure that can house the collective skills, the ingenuity and the resolve that help people to collectively address some of the issues that affect their lives" (p. 18).
See https://ecdpm.org/wp-content/uploads/2006-The-Concept-of-Capacity.pdf

[4] Tips for training design can be found in our previous project document: Open and citizen science for enhancing skills of HE educators: A guidebook for training educators at your university
https://zenodo.org/record/6511743#.Ypm95O5Bw2x

3. Challenges in shifting to OS-integrated Curricula

Integrating OS principles into curricula has several challenges for building structure and preparing necessary resources and environments. To successfully implement OS into the educational design, curriculum developers need to understand what kind of obstacles are expected and how they can be addressed before piloting the curriculum plan. In this section, we consider potential challenges from organisational and pedagogical perspectives.

3.1. Organisational challenges

Official curricula need to comply with the institutional regulation in various ways. The first hurdle is to prepare a feasible curriculum structure that is the most practical when designing a new study programme. Specifically, the degree (what qualification will be given to the students after completion), duration (expected study hours and course periods), credit (depending on the demand of the course) are the essential elements to be determined. Since OS activities include people from different disciplines and institutions, informal participants might be in a learning activity (e.g., students attending the course from a different university). Thus, credit awarding systems for those participants need to be also considered.

Structuring the curriculum might be easier in a traditional teaching approach because the learning objectives are solid, and teachers have higher control in their classrooms. However, OS-integrated curricula have various uncertain areas, which makes planning difficult. For example, the learning objectives and expected outcomes may vary depending on the students due to the student-centred learning design. Establishing a common framework fitting different profiles may become challenging when involving people from different disciplines. These external collaborators also affect learning environments. Therefore, planning a rigid structure may be challenging, especially in the first year. When it comes to external involvement, different payment systems by institutions are also another problem. Since people already have a calculated workload in their courses, there will be some adjustment and reshare of workload among the contributors, which may be an issue to handle across institutions.

Besides these general challenges, other institutional issues must be specified, especially when preparing environments to enable OS and CS activities. Open Innovation activities often invite professionals from outside universities (e.g. private companies, civil society organisations etc.) or HE students from other countries. First, finding professionals willing to contribute and preparing payment for them might be a problem within a limited network and budget in a faculty. Also, each organisation has their internal communication channel, and in some cases, the specific system in an institute does not allow access from external people due to security reasons. Communication means for external participants and stakeholders need to be mutually decided and tested beforehand. If the planned learning activities require specific digital tools or Apps, the cost of development and installation could be a bottleneck. However, there is a lot of open access data, open-source and open educational materials on the internet that can be used for the classroom. In addition, a funded project organising CS activities and promoting OS (e.g. EU-projects by Horizon, Interreg etc.) can be used as a learning context or material free of charge. Therefore, we would like to emphasise that it is still possible to integrate OS activities into teaching without costing a lot.

3.2. Pedagogical challenges

Regarding pedagogical aspects of OS-integrated learning activity, setting learning goals and objectives may be more challenging compared to a traditional, subject-based classroom. For example, if you imagine mathematics or language class, learning topics are clearly defined and aligned with the learner's prerequisite knowledge level. These learning objectives and goals support learners' cognitive processes to accommodate new knowledge step by step. However, OS activities are open, flexible and much about capacity building, which presumes learning outcomes that go beyond one individual - collective capabilities, integration to capacities from distributed human and material assets. We are missing clear, objective ways to trace and assess such beyond individual learning outcomes.

In such a flexible learning environment, balancing the teacher's control and students' autonomy is another challenging aspect. With a traditional curriculum, teachers plan everything in tasks beforehand to successfully guide students towards the suggested goals. However, students' autonomy and agency[5] is a key in OS activities for them to take the initiative in their own learning path and scientific inquiry (Pata, 2021a). Thus, teachers need to give students both structural supports to assist their knowledge construction processes (e.g. by scripting, scaffolding etc.) and freedom to set their own goals, choose methods and make a decision for their learning.

It is also important to consider human resources when designing learning activities. As mentioned, OS activities often occur in an active, collaborative model. An institution may lack tutors, such as teachers and mentors who facilitate student groups due to a personnel shortage or financial problem. Consequently, a student group may not have a facilitator gaining sufficient support for their collaborative work. Not only a quantitative issue but a qualitative issue is also another concern. The prerequisites are teachers' competencies to use digital tools and facilitate students' collaborative work effectively. Additionally, teachers' open mindsets and capacity to take advantage of OS opportunities in their teaching are important to realise such learning.

Lastly, quality assurance of the course and appropriate evaluation is quite challenging due to the open structure and external intervention. It is difficult to set a concrete framework for the course design and assessment rubric because of the flexibility of learning objectives and collaborative learning approach. Each student's learning goals and contribution (engagement) to group work varies, making the evaluation process complex. Particularly, capacity building happens beyond individual capabilities (see Morgan, 2006). We have little experience and approaches to tracing these objectively within the capacity building, as well as how to evaluate these. In addition, the learning activities are facilitated by teachers and external stakeholders who may not have teaching experiences. Therefore, a teacher cannot ensure the quality of the activity. Consequently, setting firm objective evaluation criteria and sharing a common understanding among the related educators become difficult.

[5] The OECD defines student agency as "the capacity to set a goal, reflect and act responsibly to effect change" in *Future of Education and skills 2030* (n.d.) (see https://www.oecd.org/education/2030-project/).

4. Audience

This set of recommendations aims to support integrating and mainstreaming OS into HE curricula. The target audience includes curriculum developers, administration staff, teachers, and other education staff who actually organise learning activities. Besides HEIs, public organisations (e.g. NGOs) who want, together with the university, to initiate OS activities could also be our target audience. Teachers and other collaborators who will be tutoring must understand the concepts of the designed curricula to transmit the principles to the students through teaching. Therefore, we suggest teachers and other related stakeholders read this document and proactively get involved in the development process. We recommend curriculum developers invite those people and co-design the curricula by listening to both administrative and practical points of view.

5. Recommendations

In this section, we propose ten recommendations, including small action plans and noteworthy insights from our example cases. The recommendations are created by building on our prior project activities. For example, they refer to the survey results of successful factors, challenges and drawbacks reported by the participants to Open Knowledge Activities (OKAs) and Open Innovation activities (OIAs). Basic structure contains four phases of the curriculum development process: (1) Planning, (2) Designing, (3) Implementing and (4) Evaluation. Although these subsections help structure the document by showing the most relevant ones to each phase, we emphasise that the suggested ten recommendations complement each other and make one continuous flow to develop an OS-integrated curriculum successfully.

Planning Phase

Recommendation #1 | Conduct a Need analysis: why it is important, and what is needed?

The starting point is always to understand the need for the action; why does your institution need to develop a curriculum? The main purpose should come from the necessity of fulfilling societal needs and global goals. This principal need provokes another question; what societal or global objectives should be achieved with the new curricula? At the same time, we argue that universities nowadays focus heavily on external challenges and goals and start forgetting about the development of people and their identities as actors in the world. There seems to be a shift from neoliberal production of workers with specific competencies in the domain to people who act in the world and create a future as active citizens driven with high autonomy. To accomplish the goals mentioned above, HEIs should consider how they can create human value (Király & Géring, 2021) and what competencies students will need in their future working life.

OS approaches are expected to enhance students' autonomy and facilitate their active participation in society. Before designing OS-integrated curricula, you need to understand the current status of your institution from the readiness to incorporate OS into teaching. For example, you can check how much OS concepts are permeated in the institution (e.g. practices and mindsets of academic staff), what kind of

preceding cases occurred (e.g. CS projects) and what kind of infrastructures and tools are available (e.g. data repository, collaboration platform etc.). Need analysis can help the curriculum developers consider the core ideas, share the common goals, identify the necessary staff and solidify the meaning of the new educational approach.

Action

- Identify key issues and trends in the field. Global (or European) level visions can be found in public organisations' publications.[6][7]
- Evaluate the defined topic together with your collaborators
- List up the existing obstacles to realise the OS-integrated curricula in your institution
- Consider what competencies can be upskilled through the OS-integrated learning activities and how students can benefit from it.

Insights from examples

Global Engagement Module - 9 ENLIGHT partner universities

The Global Engagement Module (5ETCS) invited five participating students from each ENLIGHT[8] partner university (45 students in total) and let them work intensively together in self-steering groups to tackle the assigned challenges with support from two (junior) professors. To embark on the mission and create replicable models, the consortium of European universities has identified flagship domains[9] and framed the activities towards the challenges. The domains are related to at least 10 of the United Nations' 17 Sustainable Development Goals (SDGs), including 1) Health and Well-being, 2) Digital revolution and Impact of digitisation, 3) Climate change, 4) Energy and Circular economy, and 5) Equity. Every topic has key themes that specify the focus of action so that all the partner universities can understand the challenges and share the specific goals.

This common framework, linked to the notion of Global engagement as a combination of knowledge, skills, attitudes and values concerning global issues and intercultural situations, is a basis for creating and sharing student-centred challenges at the European University level. A basis to build some activities such as Teaching and Learning conferences and challenge-based models such as living labs or short modules

[6] European University Association. (2021). Universities without walls – A vision for 2030
[7] UNESCO. (n.d.) Futures of Education
[8] "ENLIGHT is a European University formed by nine comprehensive, research-intensive universities from nine European countries (Belgium, Estonia, France, Germany, Ireland, Netherlands, Slovakia, Spain, Sweden), training over 300,000 learners per year and sharing a deep commitment to their social responsibility. ENLIGHT aims to undertake a fundamental transformation of European higher education that empowers learners as globally engaged citizens with state-of-the-art knowledge, skills, and innovation potential to tackle major societal transitions and to promote equitable quality of life and sustainability" (ENLIGHT, n.d.). https://enlight-eu.org/university-about-us/members
[9] ENLIGHT Five Flagship Domains (n.d.) https://enlight-eu.org/index.php/university-about-us/flagship-domains

like the Global Engagement Module is associated with a common space of shared practices. The objective is the creation of a community composed of students, top academics and regional actors involved in solving some of the most complex social issues facing Europe and the World today and empowered to become engaged global citizens.

Recommendation #2 | Invite external collaborators to the planning

As aforementioned, various players often carry out OS projects from academic institutions to regional public organisations, private business entities, startups, citizen scientists, and students. OS-integrated curriculum inherently entails 'collaboration' with external people, so we recommend you invite possible stakeholders already from the curriculum development phase. The purpose of such involvement is (1) to get fresh ideas from different standpoints, (2) to figure out the practical means and procedures for the collaboration and (3) to build a diverse network to carry out the interdisciplinary education practices. External collaborators may participate in the meetings as a part of the development team or occasionally attend as an external advisory. The important thing is that the related stakeholders and HE educators can share the common concepts and goals for designing new learning approaches.

Action

- Find stakeholders who are truly interested in collaborating with the university and HE students
- Cultivate a win-win relationship considering mutual interests and benefits of both parties
- Problematising and defining challenges with collaborators to set a mutual goal to tackle together
- Articulate the defined challenges and goals to share the core concept among different stakeholders and teachers

Insights from examples

Ocean i3 - the University of Bordeaux and University of the Basque Country

Oi3 is a project in the field of Education and Employability, initiated in the 2018-19 academic year, in which students and teaching staff from the University of the Basque Country (UPV/EHU) and the University of Bordeaux (UB) participate. The INTERREG POCTEFA programme funded it from January 2020 to December 2021.

Oi3 operates in the Euskadi-Nouvelle Aquitaine cross-border coastal area and condenses the main keys that define the Campus Bordeaux-Euskampus strategic alliance in its approach and operation: it is an inter-university, cross-border, interdisciplinary project that develops an innovative training approach with an important territorial engagement.
Indeed, Ocean i3 offers students a particular framework in which they will be able to develop different types of projects and curricular practices oriented towards a common mission (Mission Oriented), which

in this first stage is "**ocean pollution by plastics**" (theme identified and prioritised with the participation of local stakeholders).

The project is developed during the second semester of each academic year. Teachers and students work within their own curricular frameworks, carry out the work they would do anyway in their own programmes, but participate in Ocean i3 to share, contrast and enrich their projects by establishing collaborations with real actors and real problems/challenges of the cross-border coastline. All the stakeholders from an "extended project community" were involved from the planning phase. The social agents propose challenges related to the topic and their problematics at the start of the academic year (call of challenges). Teachers adjusted the proposed challenges to fit pedagogical goals. Each challenge is then presented during the first workshop in order to facilitate the appropriation by the community and to ensure its relevance to others. Involving socioeconomic agents in this way from the designing phase and throughout the process works well. Indeed, socioeconomic agents benefit from the project on several levels: the results are often transferable, the students may continue the projects with internships, and the social impact encourages the construction of lasting relationships with the university. Social actors are often the same from one edition to another because they see how they can benefit from the project, which consequently encourages and motivates them to be a part of it.

LIFE course - Tallinn university

LIFE course is a university-wide project-based course where students from different study areas collaborate with academics to carry out projects focusing on interdisciplinary problems of their own interest. The main objective of LIFE is to support the development of general competencies and teamwork skills, which would foster the development of competence in resolving interdisciplinary problems. The course offers students opportunities to collaborate with external stakeholders such as start-ups, private companies and public organisations.

A specific regulatory framework is set in LIFE projects to handle the issues when inviting external supporters. For example, there is a requirement to have interdisciplinarity at the mentoring level and a mechanism of calculating the workload at the institutional level in case of co-leadership. Students themselves take the initiative in their own LIFE projects, which leads to lessening the workload of mentors as they are taking more facilitator roles.

Recommendation #3 | Utilise an academic (research) library as a hub of network and knowledge storage

Academic (research) libraries are key actors in OS activities by being a physical place where knowledge and practice can be exchanged. They have multifaceted roles, for example, training people on how to search for information and initiate CS projects, building a bridge between citizens and academic institutes, offering a place where OS project information and practices are shared, and coordinating policy-making (Kuprienė &

Petrauskienė, 2018). Sharing best practices and awareness-raising through training are important to develop OS infrastructures, and academic libraries are central to such activities (Ayris et al., 2018)[10].

In addition to the practical expertise, libraries also can facilitate building multidisciplinary, inter-sector collaboration, which is crucial for OS and CS implementation. Such collaboration includes a research unit, faculty, IT sectors and administration, private and public organisations and citizen scientists. By serving as hubs, academic libraries can gather all the different stakeholders (e.g. researchers, technical staff, administrators, etc.), help establish strong and trusting relationships between them and provide them with essential expertise for OS and CS (Yankelevich, 2021).

An example of how academic libraries can act as hubs for the facilitation of Open Science is the BESPOC model (Broad Engagement in Science, Point of Contact) - a template for a single point of contact based at a university library for Citizen Science activities (Ignat & Ayris, 2020). Citizen Science, as one of the pillars of Open Science, improves transparency and trust between citizens and the scientific community. Research libraries are uniquely placed as community hubs to facilitate this knowledge sharing (Yankelevich, 2021). The BESPOC model offers a practical approach at an institutional level to integrating Citizen Science at higher education institutes, utilising the academic library and its role as a trusted community hub[11] to enable a dialogue between science and society.

Action

- Invite experts of OS and CS from a library network to design or implement learning activities
- Reach out to the citizens, public organisations, and private institutions via a local library network
- Ask librarians for practical advice. Holding a training session by inviting curriculum developers and related teachers fosters their awareness of the concept and strengthens the communication path to the library.
- Establish a single point of contact at the library to enable knowledge exchange and trust-building between citizens and the research community.
- Integrate research data management training by an academic (research) library into the curriculum as a mandatory course

[10] For instance, the University College London (ULC) library set up an Office for Open Science Scholarship supporting the UCL community in the adoption of Open practices and approaches. They run several Training and Skills services to upskill in Open Science principles. https://www.ucl.ac.uk/library/open-science-research-support/ucl-office-open-science-and-scholarship

[11] See LIBER (2017) *Research Libraries Powering Sustainable Knowledge in the Digital Age* https://libereurope.eu/wp-content/uploads/2020/10/LIBER-Strategy-2018-2022.pdf

Insights from examples

Integrating Citizen Science at Universities: from 'What' to 'How' - LIBER and University College Dublin Library

This extracurricular event was designed to introduce HE students and staff to CS and the challenges associated with its implementation, as well as discuss ideas and controversial aspects of CS. The event was co-organised by LIBER (Ligue des Bibliothèques Européennes de Recherche – Association of European Research Libraries) and the University College Dublin Library in an online participation mode.

The activity started with an introductory presentation by a Head of Open Spaces in TU Delft Library, The Netherlands. The presentation focused on the basics of citizen science, challenges in its implementation, the role of libraries and the benefits citizen science brings. It was followed by a presentation by a Head of the National Folklore Collection, UCD Library, Ireland, introducing their experiences based on a long-term CS project that started in the 1930s in Ireland.

The session continued with a Q&A discussion. Participants were divided into small groups and guided by organisers to engage in discussion. The discussion was so lively that the organisers needed to extend the session time and adjust the timeframe of the following activity. Most of the participants mentioned, in a post-event survey, that they were very satisfied with the opportunity to learn from the experts and to exchange opinions on CS topics with other participants.

In this event, the experts were invited from a LIBER network (members of LIBER CS Working Group). Many academic libraries belong to such a librarian community and have a unique network with other libraries, professional organisations and citizens. This case is a good example of a library's involvement in connecting HE students and staff to experts from different professional areas.

Recommendation #4 | Prepare environments for collaboration and data handling

Owing to the nature of 'openness', OS often requires a digital environment for handling resources and communicating with multi-sector stakeholders. Open Innovation activities usually invite various people from outside of the organiser institution. Therefore, an open communication channel or collaboration platform available for third parties should be prepared beforehand. The technical infrastructure is also necessary to operate some OS/CS activities. For instance, participating in a CS (crowdsourcing) project may require a specific App or digital environment to input collected data. Preparing a digital tool and providing an instructional session would help students adapt to the new learning environment.

In terms of data management, students and teachers should be aware of data handling risks. In various OS activities, participants (students) may collect and (re)use data and eventually share it with the public on the open cloud. They may deal with personal data that could identify the data subject. Thus, both educators and students need to know the concept of data management and avoid possible risks with the right handling procedures and robust technology. A rigorous data management strategy and policy should be created in the institution, for example, complying with GDPR and FAIR data principles, writing DMP, assigning data stewards, etc. (De León & de Ferrer, 2018, Demchenko & Stoy, 2021).

Action

- Prepare a communication platform that is accessible for every participant and fills all the common needs.
- Consider the sustainability of the platform and community, and possibly make the platform open to be continuously used beyond the project period
- Give students a clear lecture on using a specific digital platform, app etc.
- Train students and teachers with data handling. GDPR and FAIR data principles are useful to understand the whole picture of data management and open data.
- Prepare ethical standards and related consents (e.g. privacy notice, risk assessment etc). A prior risk evaluation may be needed depending on the type of data.
- Get to know the data management policies in your country and institution. Your institution or faculty may have a data steward who knows the latest data management principles.

Insights from examples

Noise Pollution at Reidi Road - Tallinn University

This one-day CS problem-solving activity was designed to train secondary education in-service teachers and let them explore the practice with their students. The participants were introduced to the concepts, the idea behind citizen science as a data-based decision-making activity, and digital tools for collaborative task execution through preparation lectures. After that, they went out for an outside excursion (the Reidi road near the university) to explore the questions at the trail using the Avastusrada.ee (https://avastusrada.ee/en). They also measure the sound surrounding the road with Globises sensors and input the collected data to the citizen science crowdsourcing portal. The second activity was conducted by students from the gymnasium in Türi. The students created a trail in Türi using the same app and measured air pollution there. The measurement data were also stored in the citizen science crowdsourcing portal.

The goal of the activity was to contribute to Avastusrada.ee to test out and validate the activity trail questions' content and positions. The second activity aimed to teach how to crowdsource data with Avastusrada.ee, a geolocation citizen science tool. The participants experienced new digital environments to work on the project collaboratively throughout the event. They could also see how to contribute to CS crowdsourcing and how the collected data look on an open platform. However, the findability of data around and beyond the university is limited due to a lack of a place to share them. That could be addressed by utilising an academic library as a shared platform where the results of such generated knowledge and data from OS could be found in academia and the public.

Designing phase

Recommendation #5 | Define clear learning goals and framework

A pitfall of OS-integrated learning activities could be that students could easily get lost in their learning objectives. In our past OKAs, the participants raised several challenges such as the unpredictability of the activity, inappropriate task level, unclear instructions, less time allocation, and technical difficulties. As explained in the previous section (3. Challenges in shifting to OS-integrated Curricula), OS activities are broad and flexible, making it difficult for curriculum developers and teachers to plan well-structured learning activities and give solid instructions. Therefore, it is important to set clear learning goals and build a core framework of the activity/course to guide students and teachers to have a big picture of the OS-integrated curriculum and learning activities.

In addition, the topic of learning must be in line with the students' interests. The more relevant and important they find the content, the more proactively they are self-motivated and engage in the activity. Students' intrinsic motivation is vital for OS-integrated learning activities in which they should take the initiative in their learning. It is also important to clarify and describe the prerequisites to enrol in a course (e.g. skills, experiences or language proficiency). Clear descriptions can avoid mixing beginner and expert students in the same activity.

Action

- Consider the relevancy of the learning objectives to the participants' interests and prior knowledge
- Make sure the given learning goals underline the application of competencies in various contexts (beyond the academic context) to reach different profiles of participants (e.g. citizenship, professional environment)
- Offer some openness to students and allow them to consider their learning goals to keep student agency
- Include the activity into the proper framework/curricula depending on the learning goals and the establishment context

Insights from examples

Collaborative Problem Solving in Working-life - University of Oulu

This course is a part of the international Master's degree program (Learning and Educational Technology). Students collaborated with a local Edtech company to design a solution for their challenges by applying their knowledge about learning theories and practices. Students were divided into groups of 3-4 persons. Teachers, mentors and companies' representatives work with the students along the process as coaches. Coaches take an important role in the Collaborative Problem Solving (CPS) design as

they share expertise, provide constructive feedback, track the process, clarify the task objectives, and establish expectations.

The main goal of this course was to acquire working-life skills such as collaboration and cooperation, problem-solving, teamworking, creativity and socially shared regulation, including utilising academic experts in practical scenarios. Specific learning outcomes are listed in the course description (see https://opas.peppi.oulu.fi/en/course/413327S/11686).

The design-based approach was used to frame the concept and build a clear structure for students' CPS processes. The small steps include 1) Understanding and defining an open problem in the given context, 2) Planning group work, 3) Constructing a solution, 4) Presenting a solution, and 5) Elaborating the whole process. This structure helps students plan their goals and strategy for the task, monitor their collaboration processes and reflect on their progress as a group.

Pedagogical CPS design provides a macro script that successfully guides the cooperation and collaboration. It also helps in creating feelings of togetherness and assigning of roles in groups. Further it helps students in co-regulation of learning and facilitating adaptive ways of working as well as steers them in divergent and convergent thinking during problem-solving. (Siklander, Impiö & Rawat, 2021.)

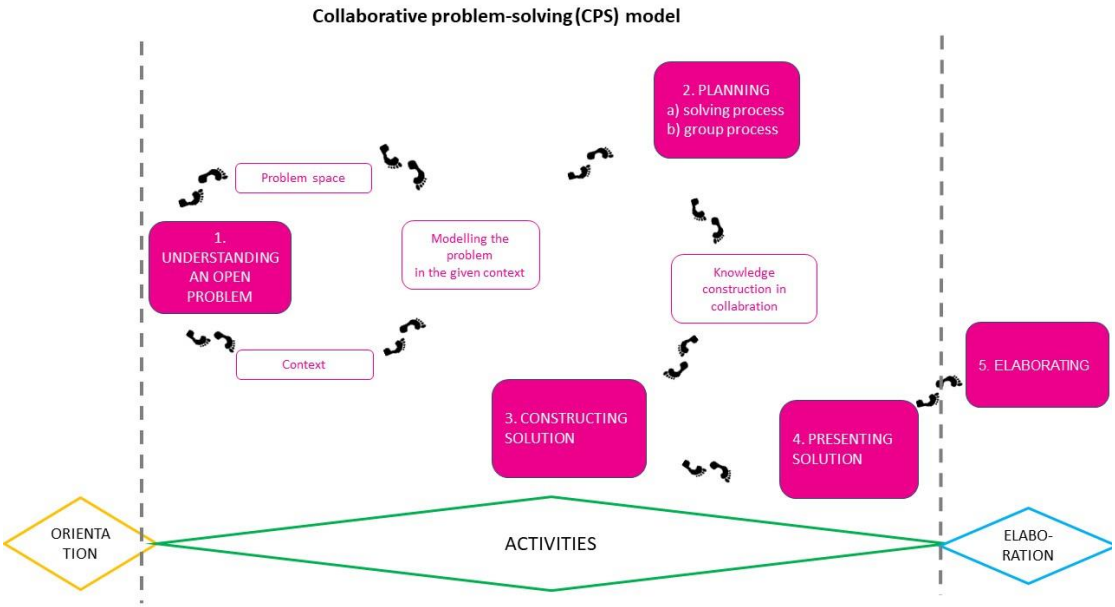

Figure 2. Collaboration Problem Solving (CPS) model

Recommendation #6 | Design student-centred learning activities with Problem-Based Learning methods

The problem-Based Learning (PBL) approach enables students to "use 'triggers' from the problem case or scenario to define their own learning objectives" (Wood, 2003, p. 328). In PBL, problems are appropriately used to increase students' understanding of the phenomena and gain knowledge, rather than students attempting to solve the problem (Wood, 2003). Similarly, Challenge-Based Learning[12] and Project-Based Learning[13] are also often used for designing student-centred learning from a problem-solving point of view. Such student-centred approaches enable learners to engage in their learning activities more actively by shifting the responsibilities of learning processes from teacher to students (Means, 1994 as cited in Brush & Saye, 2000). CS has great potential to design student-centred and problem-oriented learning activities because it engages students in real scientific inquiry with a hands-on approach. It is useful for improving teaching and engaging students in the topic (e.g. Borrell et al., 2016).

In many cases, student-centred learning engages students in tackling a defined problem or executing their own project with a small group of peers. Such learning promotes cultivating knowledge on the topic and problem-solving and social skills such as communication, teamwork and acceptance of diversity (e.g. Smith & MacGregor, 1992; Wood, 2003). Collaborative problem-solving requires rich interactions that effectively contribute to bringing new perspectives, knowledge and understanding (Vuopala et al., 2016) and coordinating the group learning processes. Co-regulation of learning in which peers mutually stimulate appropriation of strategic planning, performing, reflection, and adaptation creates affordances and boundaries for productive self-regulated learning and/or socially shared regulation of learning (Hadwin et al., 2017). Thus, facilitating students' productive interactions (e.g., knowledge co-construction and co-/socially shared regulation of learning) is a key to a successful collaborative problem-solving experience.

Although a positive side of student-centred learning is emphasised, researchers also pointed out that such learning approaches often lack adequate structure and guidance towards completing the activity, which disorients and frustrates students (e.g. Brush & Saye, 2000; Kirschner et al., 2006). Thus, balancing the level of the structure by considering a student's proficiency and experience in collaborative problem-solving learning is important.

Action

- Design learning activities and form groups by considering the level of students' proficiencies, experiences and prior knowledge
- Provide well-structured pedagogical sequences to assist students' collaborative problem solving process

[12] "Challenge based learning is a multidisciplinary approach to education that encourages students to leverage the technology they use in their daily lives to solve real world problems. By giving students the opportunity to focus on a challenge of global significance and apply themselves to developing local solutions, CBL creates a space where students can direct their own research and think critically about how to apply what they learn" (Johnson & Brown, 2011, p.4)

[13] "Project-Based Learning (PBL) is a student-driven, teacher-facilitated approach to learning" (Bell, 2010, p.39).

- Modify real open problem in which the solution possibilities are not defined, and collaboration is needed to find the solutions
- Give the student groups partial freedom to co-lead and redefine the learning outcomes in the projects to increase their agency
- Design learning to trigger peer interactions and student autonomy to engage in their own project
- Incorporate gamification aspects, outdoor explorations and digital environment use into learning to make students excited
- Make a common ground among the students regarding content knowledge, task understanding, collaborative work process etc. Ice-breaking sessions, pre-event knowledge sharing, and scripting of the activity help form a common ground within a group.

Insights from examples

Technology and Migration: Interdisciplinary Project - Aalborg University

This intra-curricular activity was a part of the Aalborg University Megaproject[14] and targeted Bachelors' and Masters' students from Techno-Anthropology & bachelor's students from Medialogy. The students created their own problem formulation under a shared "Technology and Migration" theme. They worked in groups to tackle the problem within the scope of each group's focused interests and the program's curriculum. The collaboration across education offered the opportunity for interdisciplinary collaboration and peer-learning through several online meetings with supervisors and researchers from different backgrounds and institutions that fostered peer-to-peer support beyond the specific degree.

Open innovation is further incorporated by involving the UN Refugee Agency Copenhagen (UNHCR) as an external expert. The coordinators hosted weekly meetings for students to support the collaboration with the UNHCR. However, such activities are not compulsory, and the students themselves decide to participate. Students were also free to initiate other collaborative activities inspired by their project work, such as interest group meetings.

The post-activity survey revealed that the students liked the idea of connecting two different disciplines and collaboratively learning the topic from different perspectives. The specific issue noted was the lack of clarity in expectations and instructions at the start of the activity, including the project scope, problem description and external mentor's intervention. Considering their voices, although a student-centred learning environment gives students higher autonomy, well-structured pedagogical sequence and structuring support for collaborative problem-solving processes are still necessary.

[14] See https://www.megaprojects.aau.dk/what-is-a-megaproject/
'A megaproject is an ambitious umbrella project addressing one or more significant societal problems. A megaproject is part of a collaboration with at least one external partner. The megaprojects consist of several subprojects, all of which contribute to solving the grand challenge set in the megaproject. The students involved are thus working in their own disciplines and as part of their curricular activities' (retrieved from Schwalm & Brini, 2021).

Implementation phase

Recommendation #7 | Include mentoring support and reflection moments

We have repeated the importance of the 'student-centred' learning approach in the previous sections; however, it does not mean leaving the students to let them study independently. The qualitative feedback from the participants in the past Open Knowledge Activities shows that they appreciated the group interactions, the possibility of asking questions and the experts' explanations and involving the public in the reflection (see Pata, 2021a).

An external mentor/expert plays a key role in knowledge provision and practical facilitation. They can guide students when they feel stuck or have questions on the topic, methodology, etc. Setting a check-up motivates students to prepare questions and summaries of their work, helping structure their study project. If it is a long-term project (e.g. one-semester course), setting several checkpoints throughout the project can help students reflect on their progress and reconsider their strategic plan for their learning from time to time.

Action

- Clarify the goal and process of mentoring at the beginning of the student group formation phase
- Make sure the mentors and students share the goal and process of mentoring support. The common understandings between the two parties help them take advantage of the opportunity, especially encouraging students to seek support from their mentors.
- Promote active engagement of expert mentors, not just observing but discussing with students (keep the door open for students)
- However, mentors should not take the lead in the students' collaboration. Students must take the initiative and responsibility for their own projects.
- Set a reflection moment at different phases of the project (beginning, middle and finalisation)

Insights from examples

Civic engagement projects - Tallinn University

This ten-day project was conducted as a part of the Tallinn University Winter School 2021. The project has been conducted twice and realised with the help of external collaborators such as local partners, consultants, freelancers and experts from the field. This winter session invited experts from the civic engagement technology area and design thinking approach.

The mentors' expected role was to share advice, give insight into their specific expertise, provide guidance, and facilitate group collaboration. They were also involved in the activity preparation, the pre-training (tool) and the activity evaluation (assessment phase). As facilitators, the mentors helped

participant students choose the tools and methods for collaboration from the beginning of the activity. In the end, student groups (3-5 students in a group) pitched their outcomes with Pecha Kucha presentations, and mentors asked constructive questions to the team. These experts were part of the course teaching activities but also helped us run the discussions, and they had tasks in leading and evaluating design groups.

Recommendation #8 | Open the learning resources and outcomes

While we emphasise the use of open resources, contributing to enriching them is also another important aspect of OS-integrated curricula. Students' output could be generated data, documentation of the research process, or knowledge artefacts during learning activities. For instance, in the case of Jekel et al. (2020), students re-analysed the original empirical studies' data they picked up from the university's database and examined the replicability of the study. After writing reports (theses) in which students reflected on the applied theories and discussed the results of the original studies, they uploaded the documents on the Open Science Framework platform (OSF: https://osf.io/) to make them accessible.

Through publishing their work, students can participate in the cycle of OS and understand practical procedures to make open resources. Consequently, they can learn how to engage in OS activities and cultivate mindsets to become an active citizen contributor even after graduation.

Action

- Explain the concept of OS and the impact of making open resources to the students
- Encourage students to share their knowledge contents (including the research process, data, practice etc.) openly with the public. One critical thing that is missing in OS, especially in OKAs, because students' created knowledge is often not accessible to external people
- Guide students with structured procedural steps to upload their knowledge contents to an open platform
- Comply with the data management policies (e.g. GDPR and FAIR principles)

Insights from examples

Edit-a-thon – "My thesis, Wikipedia and I" - University of Bordeaux

This extracurricular event aimed to introduce the philosophy of Wikipedia and the idea of scientific enquiry and integrity to doctoral students. PhD students contributed to enriching open knowledge resources from their research work by editing Wikipedia. The event was organised by the University of Bordeaux's library department and welcomed members of a local Wikipedia users group (association "La Cubale") as external mentors.

The activity is organised in 2 phases: a 1-on-1 preparatory meeting as a training for Wikipedia and one-day activity in a plenary session. During the plenary session, in an introduction phase, students learn the principles and core philosophy of Wikipedia and its relationship with science and research by reflecting on source citation and plagiarism avoidance. Then, participants performed their activities with help from Wikipedians/library staff by adding or enriching some pages. The editathon finished with an open exchange with the Wikipedians as an informal "audit" of Wikipedia in the students' area of knowledge.

The Edit-à-thon organised by the University of Bordeaux was designed as experimentation: the next steps would be to integrate Wikipedia contribution to university courses to debunk prejudices about the platform and encourage the production of sourced information within the scholarship.

The data produced was published on Wikipedia. It is Findbable, Freely Accessible, and Reusable as Wikipedia follows a copyleft paradigm. As this is editorial data, the "Interoperable" part of FAIR principles does not apply here. The same applies to documenting the project and guidelines as it is available as a project page on Wikipedia.

Learning Environments and Technology course - University of Oulu

This example is a 10 ETC course of the Learning and Educational Technology Master's degree program at the University of Oulu. The course aims to introduce the most important research areas, methods and tools in technology-enhanced learning, computational thinking and digital fabrication. During the course, students were tasked with designing learning materials using introduced digital tools and makerspace equipment. Students also had a short lecture about the concept of Open Educational Resources (OER) and its impact on education.

After making their own digital products, students published them in Open Educational Resource repository OER Commons[15] by applying a Creative Commons[16] licence to the work.

Their learning materials are openly available (with the most open licence type), and even external people can edit and advance their work. Students can also upload teaching manuals of the material for teachers (only visitors from teacher view can download it). Teachers can easily use the open learning materials in their own classroom by using a Google classroom integration function embedded in the OER repository.

According to the teacher who designed and operated the course, students were positive about the concept of OER and understood how OERs could enhance the accessibility of education. One challenge the teacher sees is that the learning environment for the students (in this case Microsoft Teams) is closed. It is open only to course participants. Microsoft tools are designed for organisations and institutions that often want to regulate activities and content sharing. However, teachers are planning to use different tools to better facilitate ideas of open educational resources.

[15] "OER Commons is a public digital library of open educational resources. Explore, create, and collaborate with educators around the world to improve curriculum" (OER Commons, n.d.; see https://www.oercommons.org/).

[16] "Creative Commons is a nonprofit organization that helps overcome legal obstacles to the sharing of knowledge and creativity to address the world's pressing challenges" (Creative Commons, n.d.) (see https://creativecommons.org/)

Evaluation phase

Recommendation #9 | Implement an adaptive evaluation structure

The more a learning activity becomes adaptive to each student, the more evaluation becomes difficult. In traditional education systems, the scores of subject-based tests were the main source of evaluation for students. Nowadays, collaborative learning methods are often used, especially in HE scenarios. Students choose the topic of study depending on their interests and work on it as a group. In such learning situations, the evaluation criteria become more implicit and complex. A teacher must consider various aspects of students' learning, for instance, the final quantitative outcome and the students' qualitative contribution to a group learning process. However, students' collaboration processes sometimes occur outside the classroom; therefore, they are often not visible to the teacher. Hence, other evaluators, including a mentor, group members, and a student him/herself, should be involved in evaluation to help teachers picture their learning processes and outcomes.

Action

- Combine different evaluation methods (e.g., mentor's feedback, peer evaluation, self-evaluation etc.)
- Prepare an assessment framework (rubric) for non-teacher evaluators (e.g. mentor, peer, individual student etc.)
- Set reflection and evaluation points during different phases of the course. The process to the final outcome is important in collaborative learning, and having several evaluation points can avoid assessment only based on the final learning artefact.

Insights from examples

Education Technology Projects course – University of Oulu

This course is a part of the international Master's degree program (Learning and Educational Technology). Students collaborated with a local primary school and designed technology-enhanced classroom lessons for 4th-grade pupils by applying their knowledge about learning theories and practices. The assessment framework evaluated the project plan, implementation and evaluation of the team and individual level. Teachers' and external mentors' feedback and students' self-evaluation were included.

Students reflect on their collaboration processes and claim their learning outcomes and acquired skills through Open Badge (see https://openbadges.org/). The website says, "Open Badges is not a specific product or platform, but a type of digital badge that is verifiable, portable, and packed with information about skills and achievements" (n.d.). Badge labels and detailed criteria are introduced at the beginning of the course. In this context, the assessment criteria focused on elements related to project work, collaborative learning process, individual reflection and participation in each course phase. The open

badge allows for breaking learning outcomes into small chunks and recognising students' achievements visually, helping teachers picture students' collaborative learning processes.

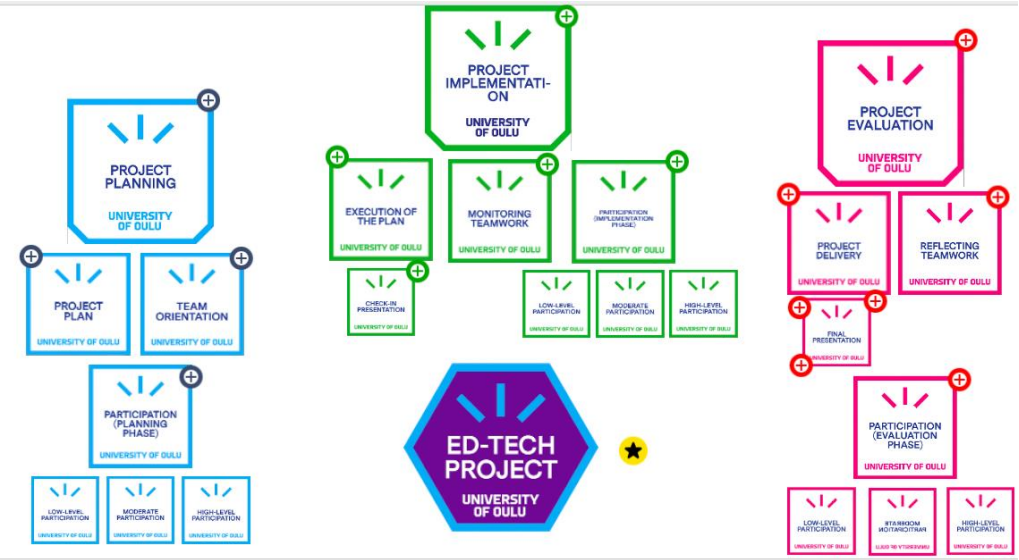

Figure 3. Open Badge Criteria for Ed-Tech Project

Recommendation #10 | Collect feedback and record the lessons learnt for the next round

Lastly, OS-integrated curriculum design does not completed at once but takes an iterative process. The activities need to be well evaluated and updated for the next round, not only topic-wise but also its activity format. As reported by the participants of our past OKAs and OIAs, there are many unpredictable challenges during learning activities, ranging from technical issues to participants' diverse profiles and expertise. Getting feedback from all the related stakeholders, including students, is important to overcome these challenges and improve the operation for the next round.

In addition to collecting feedback, we highly recommend keeping a record of the curriculum development process from designing to implementation. Specifically, how you found out the collaborators, which organisation and who cooperated with (including name and contact details), how they participated in the development or implementation process etc., is very useful information for the future. By recording and sharing the best practices open to other staff, they can refer to the lessons learnt from the precedent cases and build on them, fostering to create other OS-implemented learning practices at an institutional level. Ideally, a central information point such as a library or university web portal takes care of curating the records and related information and making them openly available for all the university staff.

Action

- Pilot a learning activity and collect feedback from the participants (including students, stakeholders and other supporters) via survey or interview
- Collect feedback right away after the activity was conducted
- Use the INOS Learning Design Framework (LDF) to capitalise on the feedback
- Build a sustainable information-keeping structure within the unit or faculty (ideally for a whole institution)

Insights from examples

Ocean i3 - the University of Bordeaux and University of the Basque Country

The Ocean i3 project (see description pp.16-17) comprises a broad community including students, teachers and external socioeconomic actors who propose challenges and act as experts throughout the learning process. It also includes coordinators from each university who form an active community of teachers that concentrates the link between teaching and student teams, the project team and the university organisation (addresses, services, vice-chancellors, etc.). The role of this "core community" is crucial regarding the evaluation phase and, more importantly, the evaluation of the project, which must constantly adapt to the permanent evolution of the community's needs and interests: indeed, each year, even if partners and teachers tend to stay the same, the Oi3 community welcomes new ones, but also new students. A "circular evaluation process" is implemented to ensure continuous monitoring from one year to the next. After each edition, a great deal of attention is given to conducting a full assessment of the project by interviewing the community and distributing surveys. The objective is to have an overview of the strengths and the challenges (cf. Learning Design Framework) with which to deal.

Then, during the semester preceding the activity (the activity takes place only during the second semester), a meeting with the teaching community is planned to map the updated community and to understand the topics to keep and the new topics and disciplines to include. This question can also be explored during the summer schools of the cross-border community every two years. This meeting, organised like a workshop, identifies the adjustments to make and opens up the community to new topics which will motivate socioeconomic actors to propose new challenges.

Finally, the workshop 0 is decisive: aiming to create the collective project, it reunifies all the community with the objectives of getting to know each other and defining a collective project which will evolve thanks to the continuous mentoring provided by teachers and socioeconomic partners at some key points: at the beginning (problematisation of the socioeconomic challenge), at the middle (to confront the project) and at the end (communication phase and evaluation phase) of the learning process. It is useful to value the experience and confirm the socio-professional empowerment of the learners. This monitoring completes the whole evaluation circle and shows the importance of co-designing the activity with communities each time.

6. Conclusion

This set of recommendations aimed to help the readers integrate OS activities into HE curricula and normalise the development process. The document emphasises the role of HEIs and future forms of knowledge creation from the perspectives of active citizenship cultivation, starting with pondering the changing world and the necessity of updating the educational approaches. The INOS consortium believes that OS and CS have strong potential to promote active engagement of citizens, including students, educators and external stakeholders, in collective knowledge creation and problem-solving on a societal level.

The core nature of OS-integrated learning activities is that the learning objectives can vary among the participating students, and therefore, various adaptive approaches are required to support each student. In addition, learning outcomes will depend not only on an individual student but will also be a collective output of groups of students and external stakeholders. From that perspective, we need to reconsider the way of setting learning goals and also evaluation systems. In education, we need to move from an objective criteria-based assessment that focuses on individuals and their measurable competencies toward post-positivist evaluation approaches that consider the meaningfulness of learning outcomes and OS outcomes from different stakeholders' perspectives.

We acknowledge various challenges in designing and implementing OS-integrated curricula from organisational and pedagogical viewpoints. Preparing a robust environment to conduct OS learning activities is the first hurdle, but more than that, cultivating collective awareness of values towards OS among HE staff and encouraging them to implement OS in their work is challenging. Institutional change requires different action levels - we need to consider what university administration, academic curators, technical staff and educators can do from their perspectives. For example, administrators may start reaching out to faculty staff and collect their views on OS. They can further consider the institution's new organisational structure and branding strategies. Educators start considering the feasibility of this new teaching practice together with technical staff and academic curators. From our experiences, the mediation place of initiating OS activities and sharing OS outputs (e.g., generated data and knowledge) is still weak in all universities. Positioning an academic library as a single point of contact to mediate OS activities can facilitate the inclusion of diverse people and successful OS implementation at an institution level.

This set of recommendations is not yet enough to enable an institution to mainstream such new teaching practices. However, we hope this paper could trigger a discussion among the versatile HEI staff, encouraging them to consider what action they can take. OS-integrated curricula can promote new knowledge creation practices and increase shared values towards OS among all the concerned people beyond an institution, which will help increase the joint capacities for building better futures (Pata, 2021b). The INOS consortium encourages HEIs to reconsider their current curricula and reform them step by step, but progressively, to cultivate students' competencies to take advantage of OS and formulate their futures as active citizens.

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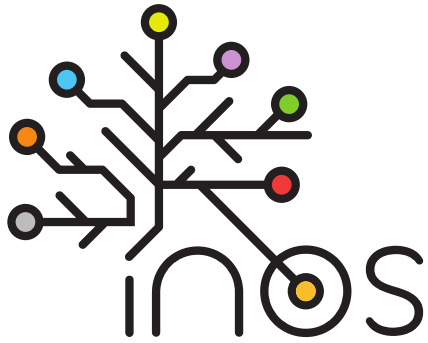

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