Reforming curricula
through innovative co-creation of OERs and testing of the MOOC

D3.2 Working Guidelines

CHOICE

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CHOICE

Increasing Young People's Motivation to Choose STEM Careers Through an Innovative Cross-Disciplinary STE(A)M Approach to Education

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WP3 Reforming curricula through innovative co-creation of OERs and testing of the MOOC

D3.2 Working Guidelines

Non-formal education for promoting co-production of educational resources

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Introduction

The working guidelines *Non-formal education for promoting co-production of educational resources* was developed by CESIE within the CHOICE project aiming at increasing young people's motivation to choose STEM careers through an innovative cross-disciplinary STE(A)M approach to education.

This document will guide the project partners and members of Creative Leadership Teams[1] in the delivery of *A3.3 Design & Development workshops* and the co-production of **Open Educational Resources** (OER). It will provide necessary information on the theoretical concepts and methodologies adopted by CHOICE as well as practical instructions for the implementation of the co-productive process.

STEM & STE(A)M

STEM is a term used to group the following disciplines: **Science**, **Technology**, **Engineering** and **Mathematics**. Recently, there has been a rising tendency to shift from teaching the STEM subjects separately to combining some or all of the four disciplines into one class, unit or lesson based on connections between the subjects and real-world problems – so-called **integrated STEM education** (Guzey et al., 2016)[2]. STEM curriculum is therefore built on the idea of educating students in four disciplines in an **interdisciplinary and applied approach**.

STE(A)M, on the other hand, adds another dimension to STEM education. The "(A)" stands for **Arts** or, in some interpretations, it means **All** and indicates involving all other academic subjects in STEM education. In this context, STE(A)M approach allows connecting teaching and learning STEM with social and humanistic studies, language learning or artistic, creative as well as sports activities. Since STE(A)M removes the rigid distinction between disciplines and replaces them with a multidisciplinary focus on creativity, inquiry and innovation, it has a great potential to contribute to our understanding, and eventually to finding solutions to complex real-world challenges.

The complex approach to education implies aiming at the formation of cognitive and critical subjects valuing reflection, discussion, action, curiosity, uncertainty and questioning and, therefore, the reconstruction of educational practice[3] also through collaboration, co-creation and interactive content production.

Non-formal education

The defining characteristic of **non-formal education** is that it is **an addition, alternative and/or a complement to formal education**. Unlike informal education, it is, however, institutionalized, intentional

[1] 1 Creative Leadership Team (CLT) will be established in Italy, Cyprus, Greece and Spain composed of 4 students, 3 teachers, 1 tutor and 2 external role models from the STEM academic and business field.

[2] Guzey, S.S., Moore, T.J., Harwell, M. et al. STEM Integration in Middle School Life Science: Student Learning and Attitudes. *J Sci Educ Technol* 25, 550–560 (2016). https://doi.org/10.1007/s10956-016-9612-x

[3] Behrens, M. A. (2014). Transformative Education: Meetings and Convergences of the Works of Paulo Freire and Edgar Morin. In R. Barros, & D. Chotti (Eds.), *Paving the Way for a Transformative Education*. Lisbon: Chiado Editora.

and planned by an education provider. It caters for people of all ages, but does not necessarily apply a continuous pathway-structure; it may be short and/or low intensity, and it is typically provided in the form of short courses, workshops or seminars. Non-formal education can cover programmes on life skills, work skills and social or cultural development.[4] It is usually designed to improve a range of skills and competences, outside the formal educational curriculum. It is rather an open-minded education system, where exams are not mandatory.

Non-formal education should be[5]:

- voluntary
- accessible
- an organised process with educational objectives
- participatory
- learner-centred
- about learning life skills and preparing for active citizenship
- based on involving both individual and group learning with a collective approach
- holistic and process-oriented
- based on experience and action
- organised based on the needs of the participants.

In the STE(A)M context, non-formal education plays an important role since many formal curricula don't count with inter-disciplinary lessons and activities allowing the connection of knowledge, methods, and approaches of different disciplines. To fulfil the STE(A)M's potential, stronger synergies and interaction between formal and non-formal education are needed.

Non-formal education can be applied in STE(A)M education through various extra-curricular activities including experimental and creative workshops, art exhibitions or performances, learning events showcasing the real-life application of STEM, creative competitions, or sports and physical activities turned into STEM learning opportunities.

Open Educational Resources

The open education concept intends information and resources to be freely shared, as well as the learning and teaching process to become more open, collaborative, participatory, flexible, and interactive giving everyone involved an opportunity to participate with freedom, autonomy, and responsibility.[6]

[4] Non-formal education. *UNESCO* [online]. ISCED 2011 [2020-12-05]. Available at: http://uis.unesco.org/en/glossary-term/non-formal-education
[5] Non-formal education. *Council of Europe Portal.* [online]. [2020-12-05]. Available at: https://www.coe.int/en/web/european-youth-foundation/definitions
[6] Torres, P. L., Boaron, D. C., & Kowalski, R. P. G. (2017). Open Educational Resources Development on Higher Education in a Collaborative Process of Co-Creation. *Creative Education*, 8, 813-828. https://doi.org/10.4236/ce.2017.86059

Open Educational Resources (OER) are teaching, learning and research materials in any medium – digital or otherwise – that reside in the public domain, or have been released under an open license that permits no-cost access, use, adaptation, and redistribution by others with no or limited restrictions.[7]

OER may include[8]:

- **Learning content:** full courses, course material, content modules, learning objects, collections, and journals.
- **Tools:** software to support the creation, delivery, use and improvement of open learning content including searching and organization of content, content and learning management systems, content development tools, and online learning communities.
- **Implementation resources:** Intellectual property licenses to promote open publishing of materials, design-principles, and localization of content.

The CHOICE OERs will be a set of **20 learning and teaching resources** providing teachers with materials and instructions enabling them to deliver 4 hours long STE(A)M sessions based on each CHOICE OER.

Each CHOICE OER will have **2 layers**. Firstly, the actual content for **students' learning** and secondly, **instructions for teachers** on how to deliver the session. The OERs are supposed to be an instrument for teachers when implementing STE(A)M approaches in their teaching – providing them with both the content and the guidance to its implementation.

Finally, each OER will indicate the **desired learning outcomes** based on **the Bloom taxonomy[9]** in order to develop an assessment tool to evaluate the learners' knowledge, skills and competences developed during each thematic session.

The Bloom taxonomy operates with the following six levels of learning[10]:

1. **Level: Remembering** – retrieving, recognizing, and recalling relevant knowledge from long-term memory.
2. **Level: Understanding** – constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. **Level: Applying** – carrying out or using a procedure for executing, or implementing.
4. **Level: Analysing** – breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
5. **Level: Evaluating** – making judgments based on criteria and standards through checking and critiquing.

[7] Open Educational Resources (OER). *UNESCO*. [online]. [2020-12-05]. Available at: https://www.coe.int/en/web/european-youth-foundation/definitions
[8] Discovering Open Educational Resources (OER). *University Libraries* [online]. [2020-12-05]. Available at: https://guides.temple.edu/OER
[9] Benjamin Bloom, 1956
[10] Shabatura J. *Bloom's Taxonomy to Write Effective Learning Objectives.* University of Arkansas [online]. 2013 [2020-12-05]. Available at: https://tips.uark.edu/using-blooms-taxonomy/

6. **Level: Creating** – putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

The taxonomy is hierarchical, learning at the higher levels is dependent on having attained prerequisite knowledge and skills at lower levels. Before students can understand a concept, they must remember it. To apply a concept, they must first understand it. In order to evaluate a process, they must have analysed it. To create an accurate conclusion, they must have completed a thorough evaluation.

When developing learning objectives based on Bloom's taxonomy, using verbs aligning with each level is the most effective way. See an overview table linking verbs to Bloom's levels and examples of learning objectives in Annex II.

The CHOICE resources will include materials for both **face-to-face** and **remote learning sessions**:

1. Face-to-face lessons and assignments designed to be carried out in the classroom with the facilitation of teachers. Each OER will cover approximately 4 hours of the face-to-face educational session.
2. Materials for remote learning such as assignments to be self-administrated by the students as homework (this is particularly suitable for preparatory and follow-up tasks).

In line with the recommendations released by UNESCO in 2019[11], the CHOICE resources will be based on the cooperation of partners from 5 European countries, designed to promote **inclusive** and **equitable** education, and to be **useful**, **practical** and **sustainable** in time.

The OERs will also pursue the objective of encouraging more **female students** to choose a STEM degree and career and facilitating access for a wide range of students to STEM field including students with a **disadvantaged background**.

Creative Leadership Team in each of the implementing countries (Italy, Cyprus, Greece and Spain) will develop 5 OER – one for each of the following macro-areas (further explained and described in the *D2.5 CHOICE Framework for reforming STEM curricula*)

1. **Connecting STEM and arts** – using visual arts such as drawing, painting, printmaking, sculpturing, ceramics, photography, design or crafts, and performing arts including playing music or theatre, performing magic, dance or puppetry while applying artistic creativity and imagination in STEM education.
2. **Experiential projects** – providing hands-on experience in the field of STEM, engaging students in interactive activities and connecting STEM subjects to their application in solving complex real-life challenges and so-called wicked problems.

[11] Open Educational Resources (OER). *UNESCO* [online]. 2019 [2020-12-09]. Available at: https://en.unesco.org/themes/building-knowledge-societies/oer/recommendation

3. **Using languages in STEM lessons** – adding a linguistic dimension to the STEM education using both mother tongue and/or foreign languages to support the development of language skills but also to engage emotions and imagination for example through literature, poems or riddles.
4. **Using technology in social sciences** – using digital technologies, tools and application as well as multimedia in social research, history research, analysis of data to explain social phenomena, economic development etc.
5. **Turning sports and physical activity into a STEM learning experience** – connecting STEM education initiatives with sports and physical activity is an effective, hands-on and fun approach to teaching STEM and promoting healthy lifestyle.

The CHOICE OERs will be created in a **user-friendly** and **interactive format**. The resources will have a **form of course materials** including teachers' and learners' worksheets, written instructions with infographics, pictures, tables, interactive presentations, slide shows, quizzes, video materials and tutorials etc. ICT tools such as coding platforms, data resources, simulation tools and apps accompanied by instructions for students and teachers will be also integrated.

The final OERs will be used as a basis for 5 thematic modules of the CHOICE MOOC to be applied in STE(A)M education at schools.

The CHOICE partnership agreed on the selection of the **Attribution-NonCommercial-NoDerivatives 4.0 International** (CC BY-NC-ND 4.0) for the publication of any project materials and results.

Design & Development workshops

In each implementing country, Design & Development workshops (D&D workshops) will take place with the purpose of co-producing 5 OERs by Creative Leadership Teams.

The approach adopted within the D&D workshops will be multi-faceted: teachers will build on the support methods acquired during the training sessions, and develop the OERs with the students. On the other hand, students will build on the exchange they had with both role models and teachers during the training and brainstorming sessions and will use the collected data from the research phase in WP2. The tutor will supervise the process ensuring a balance among participants, and the appropriate use of non-formal methods.

The participants and their roles

The D&D workshops **participants**, and at the same time the creators of the OERs, will be **the members of Creative Leadership Team** (CLT). The teams will be established before the implementation of the workshops, and will be composed of at least 4 students, 3 teachers, 2 role models and 1 tutor.

Each member has their specific role important for the resources' development:

The workshops will be led by the **teachers** (including teachers of STEM subjects as well as at least one teacher with artistic/humanistic background to fulfil the requirement of multidisciplinary STE(A)M approach). They are the subject experts guaranteeing the quality of the content and academic value of the resources. At the same time, they are couches to the students leading them in their active learning process. The teachers will also take care of the practical side of the resources – making sure that those are useful and feasible to apply in class with students.

The **tutor** (coming from the core project partners) will be present during all workshops to facilitate the sessions, support teachers, and take care of the procedural and administrative issues ensuring that the OERs developed are coherent, comply with the *Framework*, are complementary to the other OERs developed in other partner countries and fit to the MOOC structure.

Students will be actively participating in the whole process of OER's development. Their role is crucial to ensure that the resources will be interesting and motivating for their peers while respecting their level of knowledge. Some participants may also contribute to peer learning and further peer tutoring of students non directly involved in the workshops.

Role models (external experts coming come from the STEM-related academic and business field) will participate in the first and the last workshop with the aim of strengthening the connection between STEM/STE(A)M education and its real-world application.

Programme of the D&D workshops

Preparations

Few weeks before the first D&D workshop, teachers and tutors from the Creative Leadership Teams will take part in **international training**, where they will be introduced to co-production, co-creation, and participatory techniques and methods, will learn about Open Educational Resources, discuss innovative content based on interdisciplinarity and combination of STEM and non-STEM subjects, and plan the D&D workshops in their country. At the end of the international training, each team should have at least drafted proposal of 5 OERs to be shared with students and role models, and further discussed during the first session.

Teachers and tutors should agree on an approach to be adopted during the workshops delivery including their efforts to empower and support students to come up with their own ideas, balancing creativity and innovativeness with the orientation to the result to be achieved and between going according to the plan and reacting to what emerges on the spot.

1 introductory session

In the first introductory meeting, all members of Creative Leadership Teams will participate in order to get to know each other, learn more about the purpose of the workshops and discuss the creative process ahead.

The session can start with an ice-breaking activity or a thematic energiser[12], making the atmosphere relaxed and rather informal. Followed by the introduction of all the participants, including their background and their expectations for the workshops.

Then the facilitator (usually the tutor) will repeat the aim of the workshops (development of 5 OERs) and the context of the activity (CHOICE project, organising partners, hosting school etc.).

Subsequently, the facilitator will present the 5 macro-areas (***D2.5 Framework for reforming STEM curricula***) and go through the **Guidelines** (*D3.2 Non-formal education for promoting co-production of educational resources*) with a view to provide practical instructions to the co-creation process, and to make sure that all CLT members are on the same page.

The frame within which all the interactions and processes of the participants will take place should be set during the first meeting, asking all the participants to agree on some ground rules, such as:

- Everyone will participate actively in the workshops and contribute with their ideas and feedback.
- All ideas and suggestions, coming either from students, teachers, role models or tutor, count and will be treated with the same respect.
- Participants are encouraged to listen to the opinions of others, react to them and raise questions in order to assure continuous and fruitful debate
- No fear of wrong answers or examination.

The teams can create their own rules in the opening session.

After the introduction, the Creative Leadership Team will **brainstorm the ideas** of the resources to be developed within the five macro-areas. At the point of the first session, there should be already some drafts or proposals of the OERs. Share them with the group and discuss further details regarding the topic, methodologies and expected results. During a group brainstorming, full advantage of the experience and creativity of all team members can be taken, and original ideas can be developed in greater depth.

> ***Brainstorming*** *combines a relaxed, informal approach to problem-solving with lateral thinking. It encourages people to come up with unusual suggestions, thoughts and ideas that can, at first, seem a bit crazy. Attention, no idea shouldn't be criticized. Judgment and analysis at this stage stunts idea generation and limit creativity.*[13]

[12] E.g. Zombie Survival

[13] Brainstorming: Generating Many Radical, Creative Ideas. *MindTools* [online]. [2020-12-05]. Available at: https://www.mindtools.com/brainstm.html

To make the discussion outcomes clearly arranged, it's recommended to place the ideas written on post-its to a whiteboard. Afterwards, each participant should clarify their point and summarize their ideas. The final assumptions can be challenged and questioned by all CLT members. Each member has an important role within the group and is responsible for another quality of the output (see the roles' overview above). At the end of the session, the post-its can be sorted to thematic groups which will help evaluate all ideas systematically. The team will make the final decisions together taking into account the local context which may affect the OERs' development process.

Finally, wrap up what the team has decided and planned the next meeting: which OER will be the first to develop, when and where the team will meet, plan the resources needed and assign tasks related to the next sessions.

Sessions on developing the OERs

Based on the first session, teachers and tutor will prepare a programme for the up-coming workshops and decide the objectives of each meeting. To facilitate the implementation of the workshops, the teachers will prepare teaching materials such as factsheets, a summary of session-relevant theory (including mathematical formulas, physical laws etc.), lists of resources and other instructions if applicable.

It is suggested to dedicate **two 4-hours-long workshops to the development of one resource**. However, the time spent on each OER's creation can differ based on the topic and methodologies used. It is suggested that the meetings of the Creative Leadership Teams are organised bi-weekly.

Each session should follow a common structure:

1. Introduction to the topic and the objective of the session.
2. A brief review of the OERs produced in the previous section including the ones of other countries' CLTs to avoid replications.
3. Training session on the topic to be addressed by the new OER, go through the theory behind the OER to be developed.
4. Students' observation of real-world-problems, and conduction of related research.

NOTE: In the pandemic circumstances, the training session including theory and background can be done **online**. As well as students can be assigned with homework, for example doing related bibliographic, desk-top, or field research for the contents that would make up the OERs, search for images, music, software, and other open resources that could contribute to the production of the material.

5. Group work on solutions to use knowledge across disciplines.
6. Assembling the resources developed using a common template (to be found in Annex I).

Final session

The final session serves for debriefing and reflection on the co-creation of the OERs and collaborative learning process. It should be organised partly online in order to connect all Creative Leadership Teams and review the OERs produced in each country, and define a common framework to embed the OERs into the MOOC, and prepare its technical development.

In case of higher number of people involved in the OERs' development, it is suggested that each team have their national final debriefing meeting. Afterwards, representatives of each team participate in an international online session.

Methodologies for the D&D workshops

During Design & Development workshops, it's suggested to adopt the methodologies and approaches that encourage a support **active participation of the learners**, promote rather a **non-formal frame of learning**, **collaborative approach** and focus on the development of **transversal skill and competencies** applicable in a **real-world context**. Examples of such methodologies are briefly described below.

Project-based learning

Project-based learning (PBL) is a highly relevant method for STE(A)M education and many intersections may be observed. Indeed, PBL is a **student-centred** teaching method in which **students learn by actively engaging in projects** dealing with **real-world challenges and phenomena**, or answering **complex questions**.[14]

Because real-world problems are rarely solved using information or skills from a single subject area, one of the main PBL characteristics is **interdisciplinarity**. Students have to connect knowledge and skills from multiple academic domains to engage in inquiry, solution building and product construction.[15]

Students in PBL are also engaged in **inquiry-based learning** leading to deeper learning often going beyond the academic content towards the real-world applications.

Inquiry-based learning *is a form of active learning that starts by posing questions, problems or scenarios which is often assisted by a facilitator rather than a lecturer. Inquirers will identify and research issues and questions to develop knowledge or*

[14] What is PBL? *Buck Institute for Education.* [online]. [2020-12-05]. Available at: https://www.pblworks.org/what-is-pbl
[15] A Guide to using Project-Based Learning in the classroom. *True Education Partnership.* [online]. [2020-12-05]. Available at: https://www.trueeducationpartnerships.com/schools/a-guide-to-using-project-based-learning-in-the-classroom/

solutions. Inquiry-based learning includes problem-based learning and is generally used in small scale investigations and projects, as well as research.[16]

Based on new knowledge and skills, original solutions addressing complex challenges can be achieved. At the end of the project, learners are supposed to demonstrate their knowledge and skills by **creating a public product** (the OERs in our case) or presentation for a real audience (during the CHOICE Open days at schools and at the Final conference).

Teachers provide feedback during the whole process to facilitate and foster the students' learning, and development of skills such as critical thinking, problem-solving, collaboration and communication skills.[17] In this process, teachers haven't got the monopoly of knowledge, they take over the role of a partner, helping students to question, critic and reflect on their learning, encouraged and motivate them to transform information into meaningful knowledge.[18]

The following infographics provide an overview of the core components of project-based learning[19]:

[16] What is Enquiry-Based Learning (EBL)? *The University of Manchester.* [online]. 2010 [2020-12-05]. Available at: http://www.ceebl.manchester.ac.uk/ebl/

[17] Lamer, J., Mergendoller, J. Seven Essentials for Project-Based Learning. *Educational Leadership: Giving Students Meaningful Work* [online]. September 2010, 68(n. 1), Pages 34-37 [2020-12-05]. Available at: http://www.ascd.org/publications/educational_leadership/sept10/vol68/num01/Seven_Essentials_for_Project-Based_Learning.aspx

[18] Torres, P. L., Boaron, D. C., Kowalski, R. P. G. (2017). Open Educational Resources Development on Higher Education in a Collaborative Process of Co-Creation. *Creative Education*, 8, 813-828. https://doi.org/10.4236/ce.2017.86059

[19] What is project-based learning? *Magnify Learning* [online]. [2020-12-05]. Available at: https://www.magnifylearningin.org/what-is-project-based-learning

Although the desired **learning objectives** many vary, some are common to all project-based learning activities:[20]

- Integration of knowledge and skills from various areas through more complex investigations and multi-disciplinary projects.
- Autonomous learning encouraged through independent research of unstructured problems.
- Teamwork, which helps prepare students for a social environment.
- Self-evaluation and self-criticism, which encourages students to see beyond their ideas and knowledge.

Experiential Learning Cycle

In traditional education, information is usually transferred from the teacher to a passive learner. On the other hand, within the Experiential Learning Cycle[21] concept, learners are **equipped with the necessary knowledge** and **coached to express** what they've learnt in highly skilled ways. Students **receive information through experience,** and abstract conceptualization and transform it through reflective observation and active experimentation. In this way, **learners are both receivers and creators** of information, and the new

[20] A Guide to using Project-Based Learning in the classroom. *True Education Partnership*. [online]. [2020-12-05]. Available at: https://www.trueeducationpartnerships.com/schools/a-guide-to-using-project-based-learning-in-the-classroom/
[21] David A. Kolb, 1984

knowledge becomes an input for the next learning cycle evolving with an ever-increasing depth of understanding and skill.[22]

The **Experiential Learning Cycle** is indeed an educational approach which actively engages learners in four stages of learning[23]:

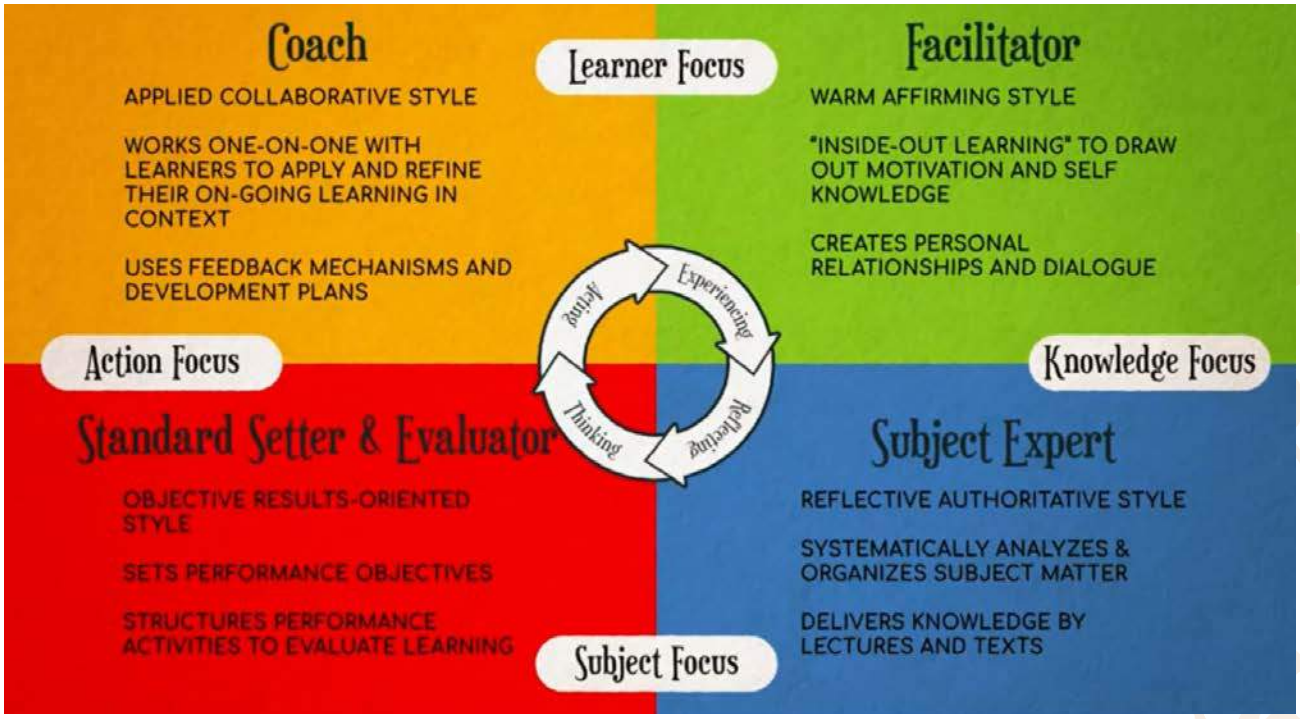
1. **Concrete learning** – the learner encounters a new experience or reinterprets an existing experience (*experience*).
2. **Reflective observation** – the learner reflects on the experience on a personal basis (*perception*).
3. **Abstract conceptualisation** – the learner forms new ideas or modifies existing abstract ideas, based on the reflections arising from the reflective observation stage (*cognition*).
4. **Experimentation and testing in new situations** – the learners apply the new ideas to his surroundings to see if there are any modifications in the next appearance of the experience (*behaviour*).

The learning process **begins** with a person carrying out a particular action and then seeing the effect of the action in this situation. **The second step** is to understand these effects in the particular instance so that if the same action was taken in the same circumstances it would be possible to anticipate what would follow from the action. **The third step** would be understanding the general principle under which the particular instance falls. When the general principle is understood, **the last step** is its application through action in a new circumstance within the range of generalisation. The action is taking place in a different set of circumstances and the learner is now able to anticipate the possible effects of the action.[24]

The Experiential Learning Cycle approach is focused on here-and-now experience to test ideas and theories. In this context, students have a chance to acquire and apply knowledge and skills in an immediate and relevant setting, offering a direct encounter with the phenomena studied. In this perspective, **cognitive science and learning theory** confirm that learning occurs the most effective when the learner is most engaged to learn, such as seeking an answer to a question.[25]

The learning process is facilitated and make even more efficient if the educator adjusts its role in each phase of the Experiential Learning Cycle. Dynamic Matching Model proposes 4 common **educator roles** matching to the 4 phases of ELT.

[22] 8 Things To Know About the Experiential Learning Cycle. *EBLS: Experience-based learning system*. [online]. [2020-12-05]. Available: https://www.youtube.com/watch?v=v74nRbWSNqk
[23] Atherton, (2013) Learning and Teaching; Experiential Learning [On-line: UK] retrieved 6 September 2015 from http://www.learningandteaching.info/learning/experience.htm in Kolb's experiential learning. In: *Wikipedia: the free encyclopedia* [online]. San Francisco (CA): Wikimedia Foundation, 2020 [2020-12-05]. Available at: https://en.wikipedia.org/wiki/Kolb%27s_experiential_learning
[24] Smith, M. K. (2001, 2010). 'David A. Kolb on experiential learning', *The encyclopedia of pedagogy and informal education*. [online]. [2020-12-05]. Available at: https://infed.org/david-a-kolb-on-experiential-learning/
[25] Fong, B. C. (2014). Open for What? A Case Study of Transformation and Institutional Leadership. In T. Iiyoshi, & M. S. V. Kumar (Eds.*), Open Education: The Collective Advancement of Education through Technology, Content and Open Knowledge.* São Paulo: Abed.



Dynamic Matching Model of the Experiential Learning Cycle.[26]

Collaborative learning

Design & Development workshops as well as the OER's sessions will adopt and promote the **collaborative learning** approach.

Collaborative learning is an umbrella term for a variety of educational approaches involving a joint intellectual effort by students or students and teachers together. Usually, students are working in groups of two or more, mutually searching for understanding, solutions, or creating a product. Collaborative learning activities vary widely, but most focus on **students' exploration or application of the theoretical concepts**, not simply the teacher's presentation or explication of it.[27]

Collaborative learning is mostly based on students' **discussion** and **active work with the course material**. For collaborative learning, methodologies and environments, in which learners engage in a common task and where each individual depends on and is accountable to each other, are important. These include **face-to-face conversations** but also **digital interaction** (online forums, chat rooms, etc.).[28] Using the **social media**

[26] 8 Things To Know About the Experiential Learning Cycle. EBLS: Experience-based learning system. [online]. [2020-12-05]. Available: https://www.youtube.com/watch?v=v74nRbWSNqk

[27] Smith, L.; MacGregor, B. *What is Collaborative Learning?* [online]. [2020-12-05]. Available at: https://www.evergreen.edu/sites/default/files/facultydevelopment/docs/WhatisCollaborativeLearning.pdfin Collaborative Learning: A Sourcebook for Higher Education, by Anne Goodsell, Michelle Maher, Vincent Tinto, Barbara Leigh Smith and Jean MacGregor. It was published In 1992 by the *National Center on Postsecondary Teaching, Learning, and Assessment* at Pennsylvania State University

[28] Chiu, Ming. (2008). Effects of argumentation on group micro-creativity: Statistical discourse analyses of algebra students' collaborative problem solving. *Contemporary Educational Psychology.* 33. 382-402. 10.1016/j.cedpsych.2008.05.001. Available at:

such as Facebook, Twitter etc. and other digital means (e.g. e-mail) facilitates learning and knowledge sharing among students, teachers or trainers to the context in real-life situation and experiences, and thus supports collaborative learning.[29]

Collaborative learning approach brings multiple **benefits to students at a social, psychological, and academic level**.[30] Some of the benefits include[31] [32]:

- Promotion of diversity understanding among students and staff, and increase in understanding of diverse perspectives.
- Establishment of a positive atmosphere for modelling and practising cooperation.
- Involvement of students actively in the learning process
- Promotion of interaction and development of learning communities.
- Improvement of learning results.
- Development of higher-level thinking, critical thinking, oral communication, self-management and leadership skills.
- Increased in students' self-esteem, responsibility and motivation.
- Reduced students' anxiety.
- Preparation for real-life social and employment situations.

Co-production and co-creation

Co-production is defined as a service delivery philosophy that shifts the balance of power and control from the provider of a service to the user.[33] In the educational context, it can be seen as the power over the educational programme and content moving from institutions, teachers and other professionals to students and learners.

Co-creation in an educational context has been described as a pedagogical idea that emphasises **learner empowerment**[34]. This approach suggests a meaningful collaboration between students and staff (teachers,

https://www.researchgate.net/publication/222563653_Effects_of_argumentation_on_group_micro-creativity_Statistical_discourse_analyses_of_algebra_students'_collaborative_problem_solving

[29] Rahmi, W. M., Othman, M. S., & Musa, M.A. (2014). The Improvement of Students' Academic Performance by Using Social Media through Collaborative Learning in Malaysian Higher Education. *Asian Social Science*, 10. https://doi.org/10.5539/ass.v10n8p210

[30] Laal M., Ghodsi S.M., Benefits of collaborative learning, Procedia - *Social and Behavioral Sciences*, Volume 31, 2012, P. 486-490, ISSN 1877-0428, https://doi.org/10.1016/j.sbspro.2011.12.091. [2020-12-05]. Available at :http://www.sciencedirect.com/science/article/pii/S1877042811030205)https://www.sciencedirect.com/science/article/pii/S1877042811030205

[31] same as above

[32] Collaborative Learning. *Cornell University: Center for Teaching Innovation* [online]. [2020-12-05]. Available at: https://teaching.cornell.edu/teaching-resources/engaging-students/collaborative-learning

[33] Paget, A. *Pupil Power* [online]. DEMOS, 2016, 4(n.6), 49-55 [2020-12-05]. Available at: http://www.demos.co.uk/files/ECJ_p49-55_5%20Education-Pupil%20power.pdf

[34] Ryan, A., Tilbury, D. (2013). *Flexible pedagogies: new pedagogical ideas*. York: Higher Education Academy.

tutors and other professionals involved in their education), with students becoming more active participants in the learning process, constructing understanding and resources with academic staff.[35]

Co-creation relies upon and contributes towards, building positive relationships between staff and students, and between students and students. Students can be involved in education co-creation in different ways at different stages, for example, they might be: informed, consulted, involved, partners or leading work.[36] Generally, there are four roles (sometimes overlapping) that students adopt in co-creation work: **representative**, **consultant**, **co-researcher**, and pedagogical **co-designer**.[37]

In the development of CHOICE resources, students have a crucial role which corresponds to the typology of co-researcher and co-designer. They will actively collaborate and negotiate with the teachers, tutor and each other the content and elements of the proposed resources as well as the learning process. In fact, co-creation overlaps with the concept of **democratic education** and **active learning**, which aims to move students to adopt an active role involving interaction between teacher and students, and between students and students.

However, the CHOICE project goes beyond co-creation and co-production adopting the approach of participatory design. **Participatory design** refers to a collaboration of a group of stakeholders including **external participants** besides teachers and students in the design and development process. Indeed, experts from the STEM-related academic and business field will be involved in the creation of CHOICE OERs and will participate at least in two D&D workshops, and at later stages will take part in field-visits with students, Open days, and Final conference.

Online collaborative techniques

Due to the current COVID-19 pandemics and related restrictions, some of the learning and co-creation activities may be transferred to the digital environment. With this in mind, here are suggested some ways of online collaboration that can be used by Creative Leadership Teams in the development of the OERs and in the preparation for face-to-face meetings.

[35] Bovill, C. (2017). A framework to explore roles within student-staff partnerships in higher education: which students are partners, when and in what ways? *International Journal for Students as Partners*, 1(1), 1–5.
[36] Same as above
[37] Bovill, C., Cook-Sather, A., Felten, P., Millard, L., & Moore-Cherry, N. (2016). Addressing potential challenges in co-creating learning and teaching: overcoming resistance, navigating institutional norms and ensuring inclusivity in student-staff partnerships. *Higher Education*, 71(2), 195–208.

Using digital technologies for communication and collaboration is advantageous in the promotion of open education as well. When using, producing, publishing, and sharing information in the context of openness, different users can interact online, engage to collaboratively achieve a goal of common interest, and in this way, knowledge can be built openly and meaningfully.[38]

Tools such as **Facebook** or **Whatsapp groups**, which are commonly used by students and young people, can be used for communication, sharing of information, materials as well as to assign and track activities carried out at a distance. More substantial materials can be shared via free cloud services, such as Google Drive or Dropbox.

There are various online collaborative learning strategies that allow shifting part of the learning process online while engaging students actively in the process. Below, two such techniques are described.

Jigsaw Technique[39]

The jigsaw technique is based on students teaching each other. Students are asked to learn just a piece of the material, or are made responsible for researching a part of whole research at home. For example, if studying different countries' approaches to healthcare policy, one student research societal views of healthcare, one the countries' overall health and demographics, one the healthcare systems, and one the economic impacts of those policies. Then the group meets (face-to-face or in an online video meeting), and works together to synthesise the information, share a greater understanding of the concept developed and create a presentation about what they've learned, or discovered in the research.

This technique supports strongly the development of interdependence, communication and cooperation skills.

Peer Review

Peer review can be used as a complementary technique to the Jigsaw and can be easily done from home using digital technologies and communication tools. To utilise the peer review technique, pair students from the study group (the pairs can be also anonymous) and ask them to review each other's work and provide their feedback including **positive points** as well as **opportunities for improvement**.[40]

Provide students with a simple **guideline** or a **template** for their feedback including the most important feedback characteristics:[41]

- Appropriateness;
- specificity;

[38] Moraes, M. C. (2008). *Ecology of Knowledge: Complexity, Transdisciplinary and Education*. São Paulo: Antakarana/WHH-Willis HarmanHouse
[39] https://app.eduflow.com/template/jigsaw-exercise
[40] Loes Vergroesen, L. 7 Online Collaborative Learning Strategies to Keep Students Engaged While At Home. *Eduflow* [online]. 2020 [2020-12-11]. Available at: https://www.eduflow.com/blog/online-collaborative-learning-strategies-to-keep-students-engaged-while-at-home
[41] Kofoed Wind, D. How effective is peer feedback for learning? *Eduflow* [online]. 2019 [2020-12-11]. Available at: https://www.peergrade.io/blog/effective-peer-feedback-for-learning/

- justification;
- suggestion;
- clear formulation.

The peer-review process has numerous benefits for both the reviewer and the reviewee, such as helping students deepen their knowledge of the subject matter and improve their writing skills.[42]

> *The more students are encouraged to review each other's work and share feedback and ideas, the better they get at receiving feedback as well. And even better, understand the intention behind the work they do. Empowering students by engaging them in the feedback process, allows them to become more independent and involved in their own learning process.*[43]

Conclusion

CHOICE working guidelines *Non-formal education for promoting co-production of educational resources* presented the project's core approaches and concepts: STEM and STE(A)M education, Open Education, and Open Educational Resources (OER). The programme and process of implementation of Design & Development workshops were described, including some practical suggestions for teachers and tutors. The Guide also specified the description of Creative Leadership Team members' roles and offered various methodologies to be utilised in co-production of open educational resources, i.e. project-based learning, inquiry-based learning, experiential learning cycle, collaborative learning, co-production and co-creation. Considering the context of COVID-19 pandemics, in which the Guide is being created, a brief final section was dedicated to online collaborative techniques with a view to facilitating remote co-creative and learning process.

[42] As above
[43] Peer Review. *Eduflow* [online]. [2020-12-11]. Available at: https://app.eduflow.com/template/peer-review

Annex I: CHOICE Open Educational Resource (OER) Template

Partner organisation: *Name of CHOICE partner*
Creative Leadership Team members (authors): *Names, roles and home instruction of the authors*

Title: *The title of the OER*

Subjects covered: *STEM and non-STEM subjects covered by the resource*

Format: *(e.g. interactive slideshow, video, text etc.)*

Teacher preparation time: *approximate time in minutes*

Lesson time required: *approximate time in minutes*

Age range: *within the range 13-18 years*

Key words: *key words best describing the resource*

Summary: *a short summary outlining the resource, its objective and content*

Introduction: *a brief introduction to the topics addressed*

Background knowledge: *what knowledge should students already have*

Learning outcomes: *at least 3 learning outcomes to be defined based on Bloom's taxonomy*

Theoretical and factual background: *may include a glossary, explanation of theoretical concepts, mathematical formulas, physical law etc.*

Resources and equipment needed: *all the equipment and materials needed to deliver a teaching lesson based on the resource*

Scenario and activities: the core of the resource. *May include exercises, description of experiments and activities to be carried out by students including detailed instruction for both students and teachers. This part should include text and additional media (pictures, figures, videos etc.) in order to provide clear and detailed material to use with students and guidance to follow.*

The content will be two-fold:

1. Educational materials and tasks for students
2. Guide/instruction for teachers

Solutions and conclusions

Resources and links

Annex II: Formulation of learning objectives based on Bloom' taxonomy

Bloom's Level	Key Verbs (keywords)	Example Learning Objective
Create	design, formulate, build, invent, create, compose, generate, derive, modify, develop.	*By the end of this lesson, the student will be able to design an original homework problem dealing with the principle of conservation of energy.*
Evaluate	choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, support, convince, select, evaluate.	By the end of this lesson, the student will be able to determine whether using conservation of energy or conservation of momentum would be more appropriate for solving a dynamics problem.
Analyse	classify, break down, categorize, analyse, diagram, illustrate, criticize, simplify, associate.	*By the end of this lesson, the student will be able to* differentiate between potential and kinetic energy.
Apply	calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, perform, present.	*By the end of this lesson, the student will be able to* calculate the kinetic energy of a projectile.
Understand	describe, explain, paraphrase, restate, give original examples of, summarize, contrast, interpret, discuss.	*By the end of this lesson, the student will be able to* describe Newton's three laws of motion to in her/his own words
Remember	list, recite, outline, define, name, match, quote, recall, identify, label, recognize.	*By the end of this lesson, the student will be able to* recite Newton's three laws of motion.

Learning objective examples adapted from, Nelson Baker at Georgia Tech: nelson.baker@pe.gatech.edu in SHABATURA, Jessica. Bloom's Taxonomy to Write Effective Learning Objectives. University of Arkansas [online]. 2013 [2020-12-05]. Available at: https://tips.uark.edu/using-blooms-taxonomy/

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