(Project Number: 945301)

DELIVERABLE D6.7

Second Public Report

Lead Beneficiary: ENEN

Due date: 30/09/2023 Released on: 14/11/2023

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Start date of project:	**01/10/2020**	Duration: **36 Months**
Project Coordinator:	Assoc. Prof Mojmír Němec	
Project Coordinator Organisation:	CTU	VERSION: 1.3

Project co-funded by the European Commission under the Euratom Research and Training Programme on Nuclear Energy within the Horizon 2020 Programme

Dissemination Level		
PU	Public	**X**
RE	Restricted to a group specified by the Beneficiaries of the A-CINCH project	
CO	Confidential, only for Beneficiaries of the A-CINCH project	

Version control table

Version number	Date of issue	Author(s)	Brief description of changes made
1.0	02/11/2023	Roberta Cirillo	First Draft
1.1	14/11/2023	Roberta Cirillo	Corrected version
1.2	16/11/2023	Mojmír Němec	Coordinator's check
1.3	20/11/2023	Jana Peroutková	MST check

Project information

Project full title:	Augmented Cooperation in Education and Training in Nuclear and Radiochemistry
Acronym:	A-CINCH
Funding scheme:	Coordination and Support Action
ECGA number:	945301
Programme and call	H2020 EURATOM, NFRP-2019-2020
Coordinator:	Mojmír Němec
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Start date – End date:	01/10/2020 – 30/09/2023 i.e. 36 months
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"This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945301."

EXECUTIVE SUMMARY

This report presents the A-CINCH project and its outcomes achieved in the second half of the project implementation time frame.
To recall and provide some context: A-CINCH is the latest one in the CINCH project series. It is based on a collaboration among 16 partners from 12 countries, funded by the Euratom research and training program.
The project tackles the lack of interest of the young generations towards the fields of nuclear and radiochemistry. It attracts people to the field exploiting the 'learn through play' concept.

CONTENT

1 INTRODUCTION AND BACKGROUND

A-CINCH stands for "Augmented Cooperation in education and training In Nuclear and radiochemistry". It is the latest from a series of nuclear and radiochemistry dedicated actions collectively referred to as "CINCH series".
A-CINCH completes the CINCH learning materials and tools with the most modern methods, revises and complements the so far produced materials and ensures for easy access through the **newly developed CINCH HUB.**
The project **relied on the "learn through play" concept** with the aim of attracting high school students to the nuclear and radiochemistry field and provide nuclear and radiochemistry students and teachers with attractive and state-of-the-art teaching tools and sources.

Figure 1: A-CINCH approach to address the young generation's interest

1.1 Project Consortium

The A-CINCH consortium consists of 16 partners from 12 countries as summarized in Table 1 below.

Table 1: A-CINCH partners

N°	Participant organization name	Short name	Country
1	Czech Technical University in Prague - COORDINATOR	CTU	Czech Republic
2	Gottfried Wilhelm Leibniz University Hannover	LUH	Germany
3	Politecnico di Milano	POLIMI	Italy
4	Institut Jozef Stefan	JSI	Slovenia
5	Chalmers Tekniska Hoegskola Ab	CHALMERS	Sweden
6	Helsingin Yliopisto	UH	Finland

7	University Of Leeds	UNIVLEEDS	United Kingdom
8	Otto-von-Guericke University	OVGU	Germany
9	National Nuclear Laboratory Limited	NNL	United Kingdom
10	Institut Mines-Telecom	IMT	France
11	European Nuclear Education Network	ENEN	Belgium
12	University Of Cyprus	UCY	Cyprus
13	Universitetet I Oslo	UIO	Norway
14	The Secretary of State for Environment, Food and Rural Affairs	CEFAS	United Kingdom
15	Evalion s.r.o	EVALION	Czech Republic
16	Instituto Superior Tecnico	IST	Portugal

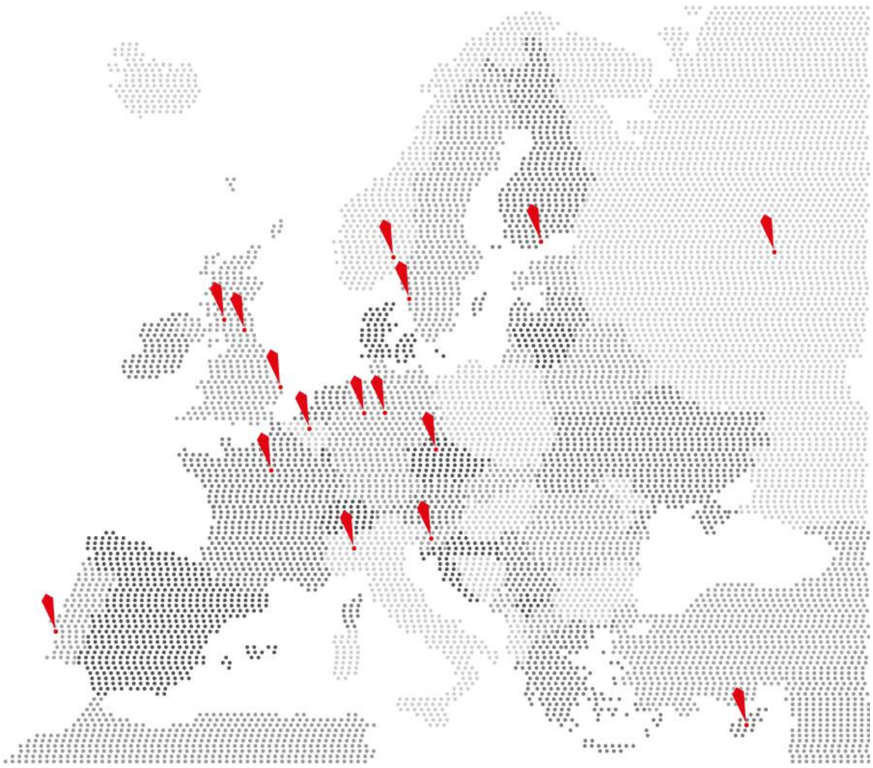

Figure 2: Location of the A-CINCH partners

2 A-CINCH SPECIFIC OBJECTIVES

As previously mentioned, A-CINCH is the latest of a series. Hence one important achievement for the project is to collect all the outputs in the same tool. For this reason, the first important outcome in A-CINCH is represented by the CINCH HUB.
It is a portal reachable at this address https://hub.cinch-project.eu/ that wraps up all previous CINCH results into a single user-friendly and easy-to-navigate interface.
It includes more recently developed courses and new materials, as well as a Virtual Lab. Figure 2 provides a graphic view of the structure of the CINCH HUB.

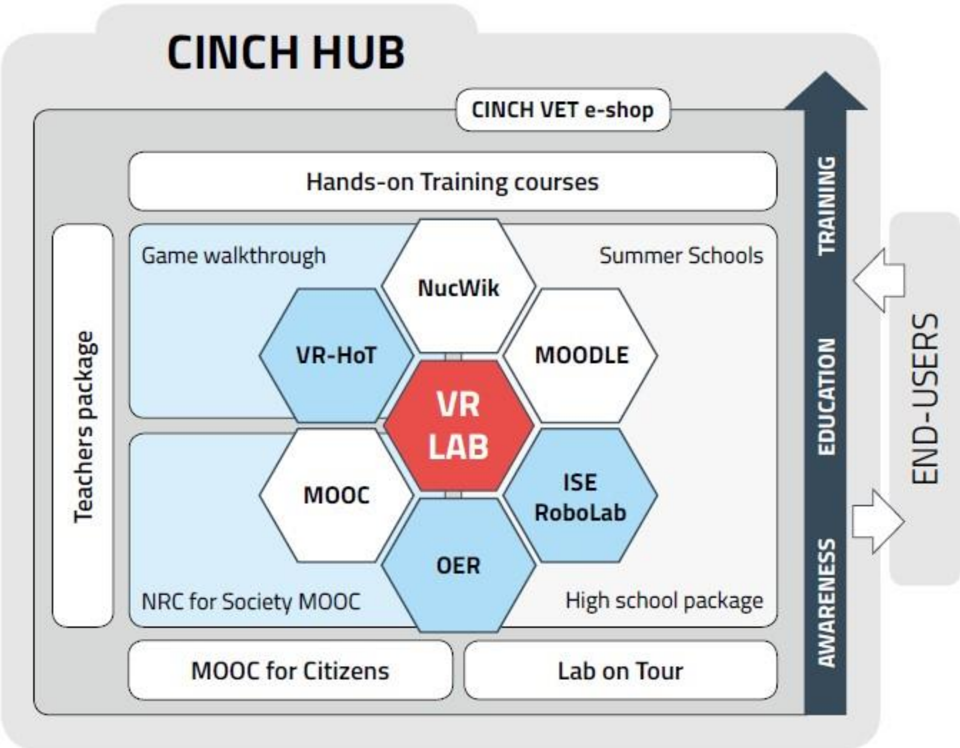

Figure 3: CINCH HUB structure - it is supposed to embed all the educational tools produced as project outputs both in A-CINCH and in the previous projects in the CINCH series.

As described in the previous report, the whole concept focuses on the VR-Lab which together with a special series of tools like:

- Massive Open Online Courses (MOOC);
- Nuclear and Radiochemistry Teaching Material Wiki (NucWik);
- Learning Management System platform (Moodle);
- Robotic Remote-Controlled Experiments (RoboLabs);

combined with a series of innovative methodologies:

- Virtual reality teaching;
- Online teaching;
- Virtual laboratories;
- Hands on Training;
- Flipped classroom;
- Gamification;

produce relevant content for teachers and students that can be used for:

- Summer schools;
- Class materials and teaching;
- Materials for introducing the nuclear radiochemistry to citizens;
- Materials for upgrading knowledge skills and competences of employees.

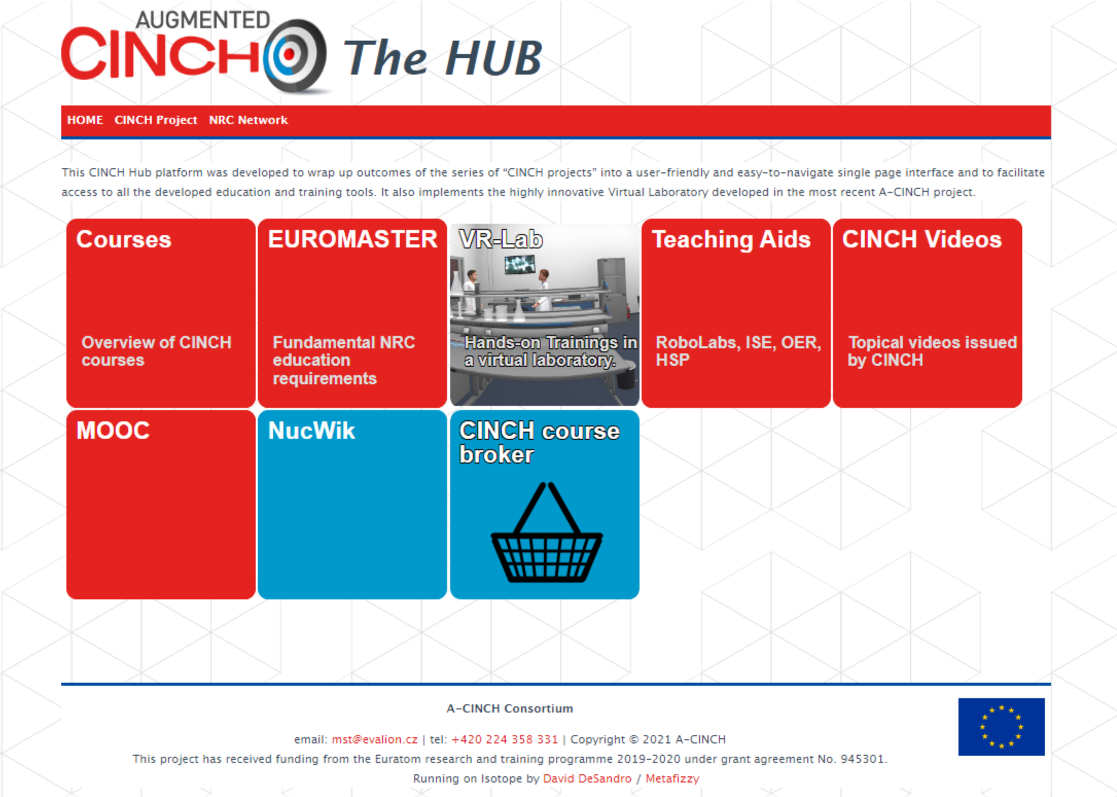

Figure 4: CINCH HUB home page

3 ORGANISATION OF THE WORK

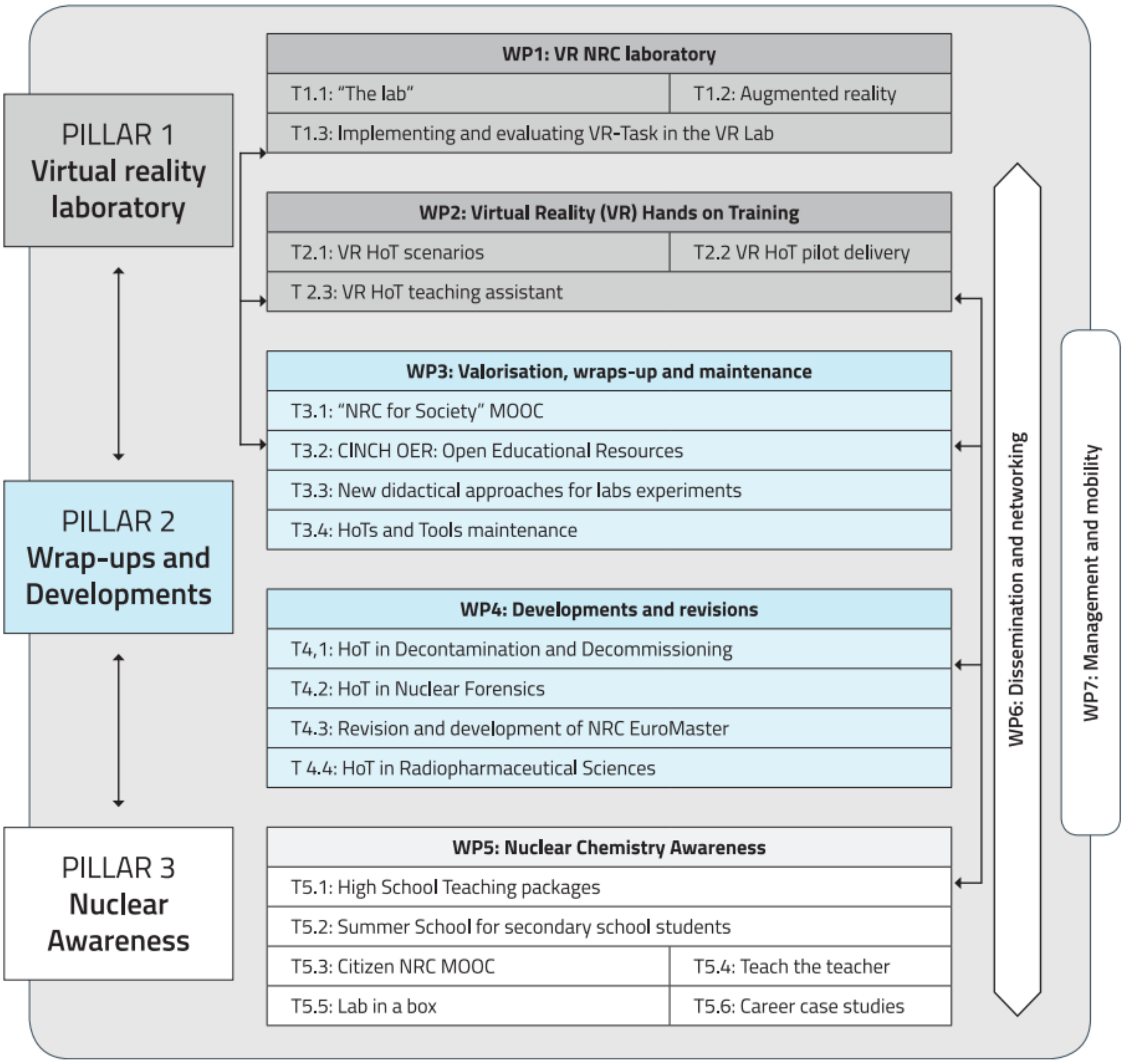

Figure 5: The A-CINCH project structure

ACINCH work was divided in 5 'technical' working packages (WP) tackling 3 pillars.

In the next session, detailed output produce by each WP will be presented.

4 OUTPUTS PRODUCED

This report is drafted at the end of the project implementation phase, it builds upon what has already been described in the 'first public report'.

The following paragraphs provide an overview of the most recently (M19-36) achieved project outputs.

4.1 Pillar 1: Virtual Reality Laboratory

As can be inferred from Figure 5, this pillar encompasses the work of

- WP1: Virtual reality NRC laboratory
  - Partners: LUH, UH, OVGU, UiO, MSU,
- WP2: Virtual Reality (VR) Hands on Training (HoT)
  - Partners: CTU, POLIMI, JSI, CHALMERS, UH, UiO, IST.

WP1 was dedicated to the development of a 3D environment for NRC laboratories. The outputs consist of a platform where the Virtual Reality (VR) Hands on Training (HoT) scenarios have been implemented. The main objective of WP2 is to develop scenarios and screenplays to be used in VR HoTs.
In the second half of the project, the final version of the VR-Lab was released. This version includes three vHoTs:

1. Determination of the half-life of K-40
2. Separation and sample preparation of Po-210 and Pb-210
3. Surface decontamination of metallic scraps and subsequent radioactive contamination conditioning.

In addition, the entering and leaving procedures of a control area can be practised and there is a "free exploration mode" in which users can freely explore the laboratory.
To evaluate the VR-Lab, two digital surveys were created to measure learning success, usability according to Brooke and cybersickness and to gain general feedback on the VR-Lab and the individual vHoTs. The new VR-Lab has been used at four different events and was also presented to the professional audience at the annual conference of the Radiation Protection Association of Germany and Austria.
The final version of the lab is available at this link: https://vrlab.cinch-project.eu/
The AR app was also implemented to the iOS app store so that it is also accessible to school classes, as these are usually equipped with iPads in Germany.

The aim of WP1 was to develop a virtual laboratory in cooperation with WP2 in which so-called virtual hands-on training can be carried out. This laboratory is intended to playfully engage young talents in the topic of radiochemistry and to give students the opportunity to expand their practical experience. The VR-Lab will give a new dimension to the toolbox of NRC teaching tools.

Determination of half-life
In the experiment to determine the half-life of K-40, participants weigh different amounts of KCl and determine the beta decay count rate. Because the beta particles absorb themselves as the thickness of the sample increases, the count rate does not increase linearly with the weight of the sample. Mathematical calculations can be used to determine the count rate of a sample without self-absorption from the measured values, from which the half-life of K-40 can be determined. To

assist the user, these calculations do not have to be performed by the user on their own, but are performed on a virtual computer.

Figure 6: Personal inventory overview

Investigation of water samples - chemical separation of Pb-210 and Po-210

The 2nd vHoT deals with the chemical separation of Pb-210 and Po-210 from a tap water sample and the subsequent sample preparation for the radiometric measurement of the analytes.

Improvements to increase realism of the virtual lab/experiment have been introduced, these additions also improve usability. An example is the automatic addition of foil and a clamp when a disk holder is added to a beaker, which will be placed on the heating and stirring block.

Figure 7: Beaker with disk holder, foil and clamp on the heating and stirring block.

It also possible to measure the required samples in an alpha spectrometer (see Figure 8) and a proportional counting (see Figure 9). The calculated spectrum can be downloaded as an csv-file to the user's PC for further use outside of the VR-Lab. Another major achievement in this HoT was to manage the different fluid combinations and their results.

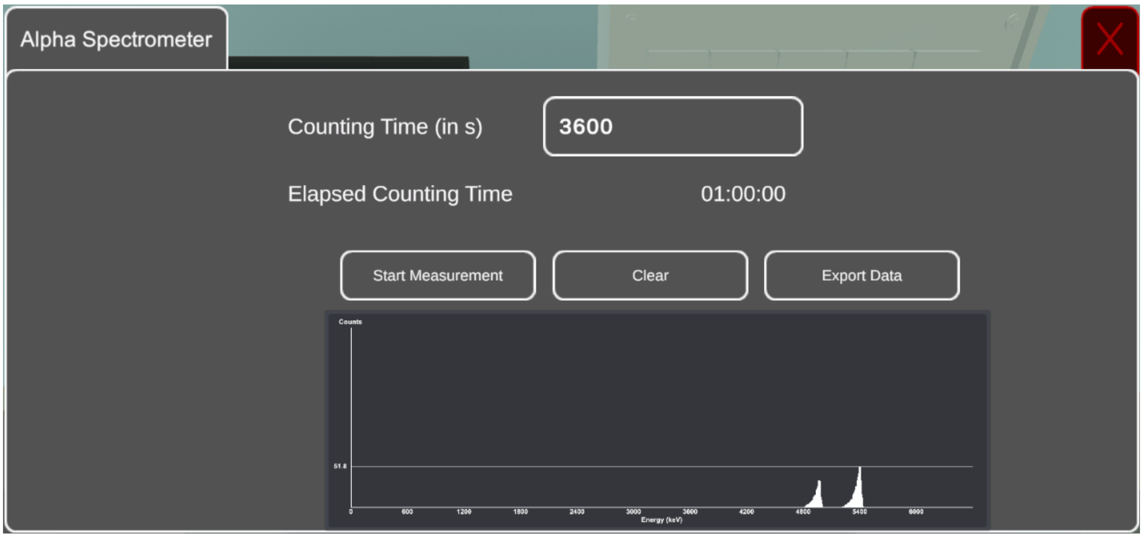

Figure 8: Output of alpha spectrometer used for sample used in JSI HoT.

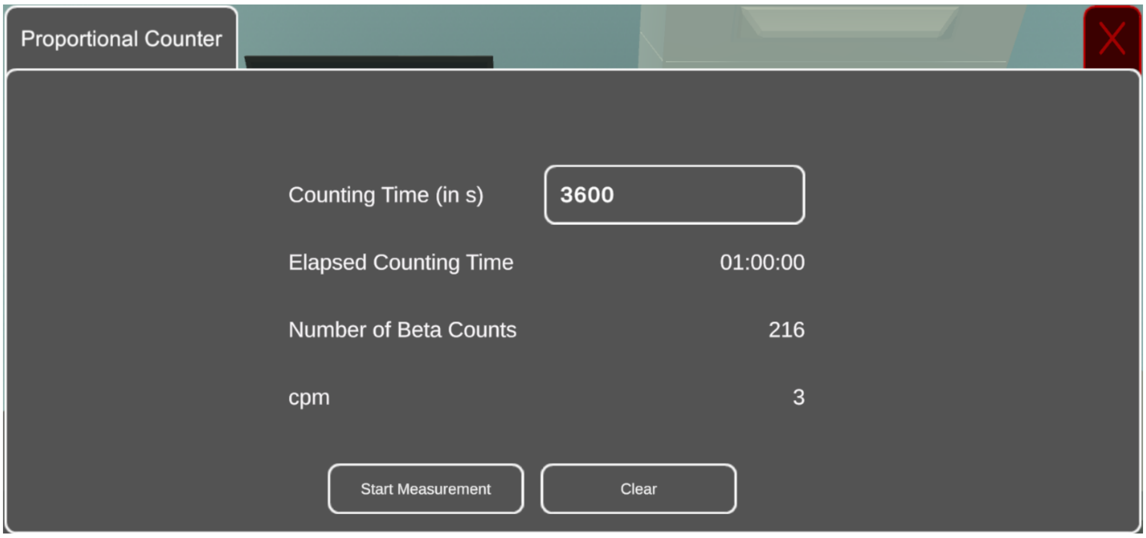

Figure 9: Output of proportional counter used for the sample used in JSI HoT.

Fluid Mixing Simulation

Initially, an approach was used to transfer liquids depending on the degree of rotation through direct control over a container. However, this approach turned out to be too imprecise, so that the approach was changed to a direct indication of the quantity to be transferred via the menu (see Figure 10). A crucial aspect that needs further investigation is the mixing behavior of different fluids. Only certain predefined fluid combinations are possible and lead to the desired result.

Figure 10: The left image shows the first approach of transfering fluid via direct user input that was withdrawn due to inaccurate handling. On the right the fluid transfer menu is shown that is used to indicate the amount of fluid that should be transfered from one container to another

Presets

Some objects like the heating block and thermostatic bath have several parameters that can be adjusted. Presets are predefined combinations of the values and the user can choose between them. If the used preset in the current situation is correct, the experiment proceeds further and desired result will be displayed. If the user chooses a preset that will not lead to the correct result, a message is shown that describes what would happen if these values would be used. The experiment only proceeds further when the user chooses the correct preset. Examples for presets are shown in Figure 11. In total, five preset menus for different devices are available in the VR-Lab.

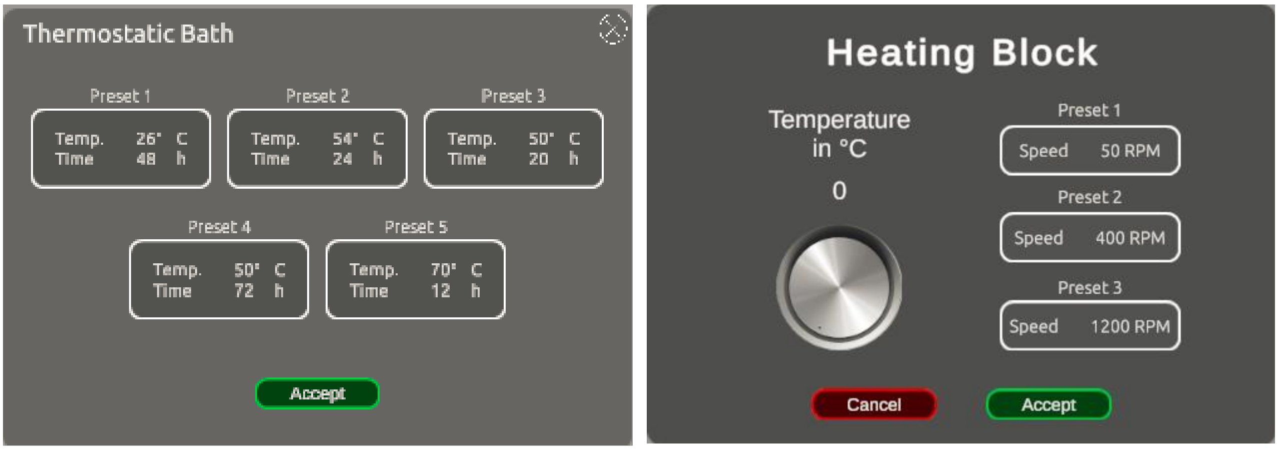

Figure 11: Example presets used for the thermostatic bath and the heating block.

Superficial decontamination with radioactive waste

The 3rd vHoT gives the user the possibility to attempt superficial decontamination of contaminated metallic waste and to condition the removed radioactive contamination in a stable waste form.
To complete the vHoT anyway, one major quest was designed as a video quiz. The concept for the video quiz was realized according to a flow chart provided by POLIMI (see Figure 12). Individual steps are shown in short videos. After each video, the user has to take a decision about how to proceed by selecting from a multiple-choice question. If the answer is wrong, they get an information text, why this was the wrong selection. If it is correct, the experiment continues and the next video is presented (see Figure 13).

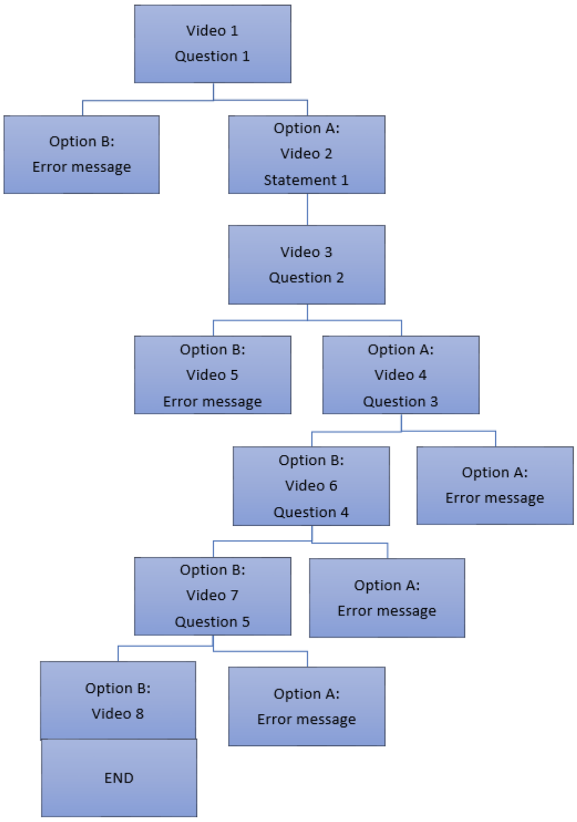

Figure 12: Flow chart of the video quiz concept at POLIMIs vHoTs.

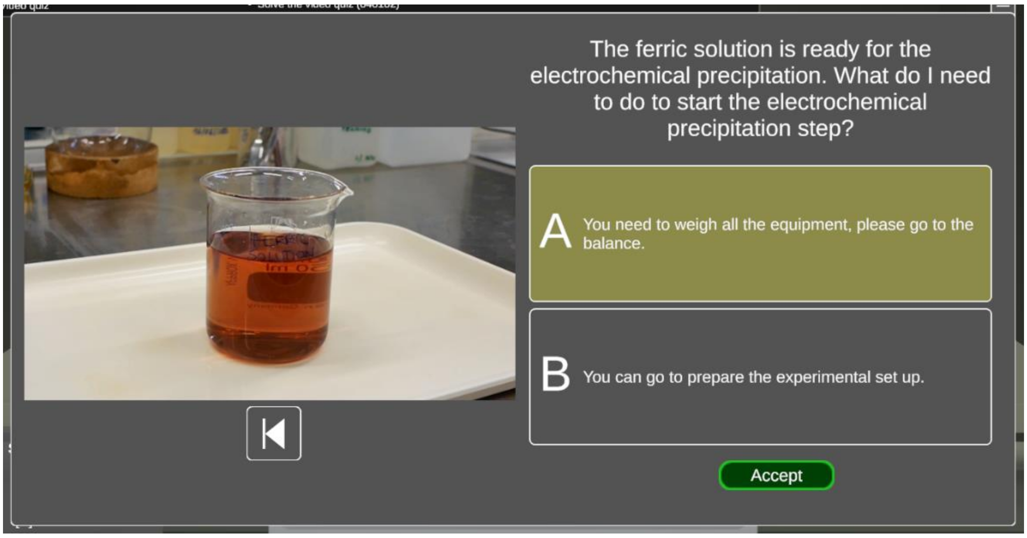

Figure 13: Screenshot from a multiple choise question after a video sequence.

The labelling function, described in the next section, was also introduced.

Labelling Function

The user has the possibility to add labels to virtual objects. As in a real lab, this helps the user to distinguish between e.g. certain beakers with fluids from each other. These labels can be added via the context menu and are displayed in the tool tip while hovering over an object (see Figure 14). These labels are also added to the personal journal when object information get stored.

Figure 14: Labelling input field and tool tip showing the labels name.

<u>Saving System</u>

The completion of individual vHoTs by students can take up to several hours, so multiple sessions are necessary. Also, if critical, non-reversible errors occur (e.g. disposing a unique chemical), possibilities to load & save the current state are necessary.

The saving and loading have to be realized locally on the current pc the student uses. It is possible to pre-define saving points at each major quest that can be delivered together with the website. This allows a teacher and a group of students to start at different stages within each vHoT, but still have an equal starting point across each student, which simplifies supervision.

For each loading point, predefined information is added to the personal journal and all material to pursue the vHoT is provided, allowing the student to continue an experiment the same way as they would do it manually.

In parallel to the VR Lab and annexed vHoTs an app for Augmented Reality (AR) has been developed and it is now available for download in the Apple App Store:

https://apps.apple.com/us/app/arradiation/id1619335572

4.2 Pillar 2: Wrap-ups and developments

As previously mentioned, this pillar is driving the work of:

- WP3: Valorisation, wrap-ups and maintenance
    - Partners: CTU, LUH, POLIMI, JSI, CHALMERS, UH, UCY, UiO, CEFAS, MSU, IST,
- WP4: Developments and revisions
    - CTU, LUH, POLIMI, JSI, IMT, UiO, CEFAS, MSU, IST.

WP3 focuses its effort in valorising the knowledge that has already been developed along the previous projects in the CINCH series.

The MOOC titled "Essential Radiochemistry for Society" has been delivered in three editions animated by webinars and forum discussions.

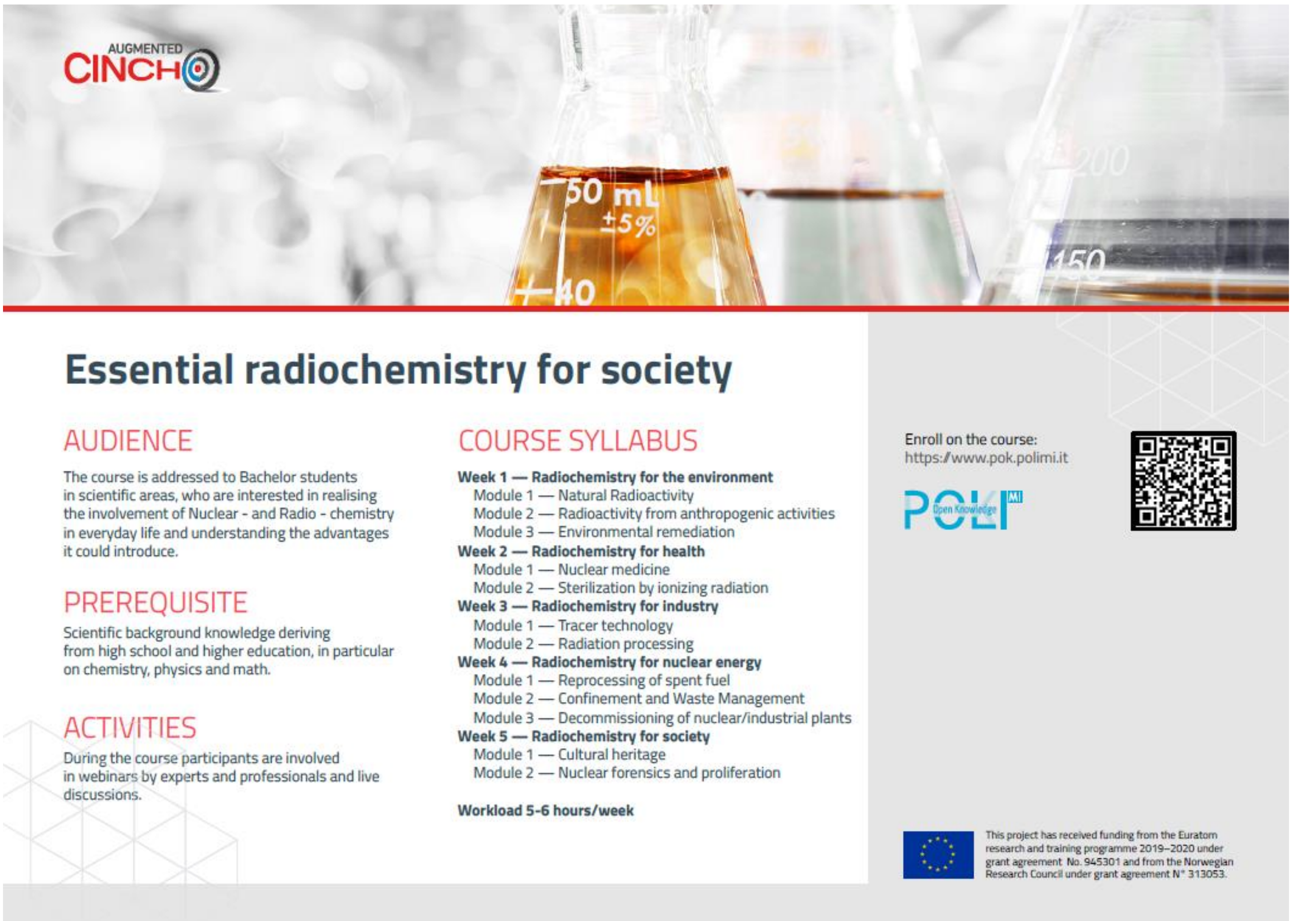

Figure 15: MOOC flyer

More CINCH Talks have been realised

- Radiation chemistry and technology as a basis for environmental protection technologies
- Gamma radiation for Cultural Heritage preservation at the Calliope Facility
- Nuclear Investigators: Tracing back the origin of radioactive findings
- Radiotracers - the singing detectives

The main goal of WP4 is the development of new HoT courses.
In the previous CINCH projects, several courses were fully developed and tested. The new HoT courses covered the areas that are now receiving high attention in the European scientific community. They are:

HoT on Decontamination and Decommissioning (D&D)
Hands-on Training in Decontamination and Decommissioning course was created. Within this course, four laboratory, practical exercises were developed and all the related materials uploaded to CINCH Moodle platform, inside prepared structure, ready to use (https://moodle.cinch-project.eu/course/view.php?id=112).

- “Separation of activation radionuclides in decontamination loop”
- “Determination of Sr-90 for radioactive waste characterization”
- “Superficial decontamination of radioactive metallic waste”
- “Decontamination of Metallic Wastes”

HoT in Nuclear Forensics

Hands-on Training in Nuclear Forensic course was created. Within this course, four laboratory, practical exercises were developed and all the related materials uploaded to CINCH Moodle platform, inside prepared structure, ready to use (https://moodle.cinch-project.eu/course/view.php?id=113).

- "Analysis of HoT Particles and rapid detection of radiosilver"
- "MC-ICP-MS determination of U isotope ratios"
- "Alpha spectrometry of uranium isotopes"
- "AMS determination of U-236 isotopic ratio"

HoT in Radiopharmaceutical Sciences (RS)

Hands-on Training in Radiopharmaceutical Sciences course was created. Within this course, four laboratory, practical exercises were developed and all the related materials uploaded to CINCH Moodle platform, inside prepared structure, ready to use (https://moodle.cinch-project.eu/course/view.php?id=114). It consists of the following practical exercises:

- Measurement of the Activity of a Medical Radionuclide
- Analytical Techniques for Radiochemical Purity Determination
- Synthesis and Characterization of Cold Precursors and Surrogates
- Synthesis and Purification of a Radiopharmaceutical
- In Vitro Evaluation of a Radiopharmaceutical
- Cell lines and cell culture
- Cellular Studies of a Target-Specific Radiopharmaceutical
- Biodistribution and Metabolism Studies of a Target-Specific Radiopharmaceutical

4.3 Pillar 3: Nuclear Awareness

As previously mentioned, this pillar is driving the work of:

- WP5: Nuclear Chemistry Awareness
    - Partners: LUH, POLIMI, CHALMERS, UNIVLEEDS, NNL, UCY, CEFAS, MSU, IST.

The WP5 overall objective is to make the field attractive to the younger generation and motivate students to pursue a career in nuclear chemistry either in the industry or academia. WP5 targets the pupils, general public as well as high school teachers to make them aware of the importance of NRC for the society. This action also aims to equip parents and teachers with insights to inform their children or students about careers in this field. Although each task is a standalone resource (or tool). The products have been designed so that they can be utilised together to enhance their effectiveness.

Two different lesson packages have been developed, tested and finalised. The lessons have been linked to the high school curriculum and focus on topics covered within the curriculum.
The first lesson explores nuclear medicine and chromatography using a virtual Interactive Screen Experiment (ISE).
The second lesson explains how electrochemical cells are used in pyro-processing to create a closed nuclear fuel cycle.
Each lesson package contains an introductory video, a PowerPoint presentation, a teacher guide, and a student workbook with experiment instructions and extension activities.
The lesson packages have been designed so that workshops can be delivered independently by teachers and STEM ambassadors without involvement from the A-CINCH team. The resources have been uploaded to NNL's Outreach database and will be uploaded to the CINCH Hub for use in future

outreach events. To enable public use of the lesson packages, they have been uploaded to the STEM Community website https://community.stem.org.uk/home, this is a forum for STEM educators where resources and discussions on chemistry education are shared.

Furthermore, the MOOC "NRC for citizens" has been released. It presents the design and development of an engaging and informative Massive Open Online Course (MOOC) for the general public, designed to empower learners with a comprehensive understanding of nuclear science, radioactivity, and their multifaceted applications. The innovative MOOC course "Discovering Nuclear Science: Energy and Beyond" is structured into three sections ("weeks"), with a total of ten modules, each meticulously crafted to deliver an immersive learning experience.

- Week 1, "*The Nature of Radioactivity*", kicks off the journey by delving into the world of radioactive elements present in nature and those ones artificially produced by humankind for several purposes. Learners gain insights into the origins of radioactivity, setting the stage for deeper exploration.
- Week 2, "*Ionizing Radiation in Action*", offers a closer look at the practical applications of ionising radiation. Modules cover a wide spectrum of topics, from the use of radiation for sterilisation and industrial processes to its pivotal role in healthcare and technological progress.
- In Week 3, "*Navigating Nuclear Hazard*", learners confront the multifaceted aspects of the most famous and discussed nuclear themes, including nuclear energy, the environmental impact of radionuclides, nuclear threats, and nuclear waste. This section provides a perspective on the challenges and opportunities associated with nuclear science for energy.

The pedagogical framework underlying the course employs a scenario-based learning approach, fostering engagement and critical thinking through four key steps: "Bring into Play" "From Detail to Understanding" "Food for Thought" and "Self-assessment". This pedagogical structure enhances the learning experience and encourages active participation, ensuring that learners receive a well-structured and informative educational resource.

"Discovering Nuclear Science: Energy and Beyond" serves as a valuable educational resource for individuals seeking to expand their knowledge of nuclear science, radioactivity, and their diverse applications. By fostering inclusivity, engagement, and critical thinking, this course empowers learners to explore the fascinating world of nuclear science and its implications for our modern society.

Moreover, several 'off the shelf' outreach activities have been realised to be used by institutions to promote nuclear and radiochemistry at schools, colleges or science fairs.

The nine activities are collectively referred to as 'Lab in a Box':

1. Bright Salt: Structural energy;
2. Order of Radioactivity: Radiation around us;
3. For Your Glove: Nuclear contamination demonstration;
4. Nuclear Energy: I'm in the middle of a (nuclear) chain reaction;
5. Radioactive Nuclei: Decay and half-life demonstration;
6. Imposter: Keeping nuclear materials safe;
7. Nuclear Medicine: Separating radionuclides;
8. RADiation Robots: Handling nuclear waste
9. Think Inside The Box: Glove box handling techniques.

Last but not least, two summer schools have been organized one in the UK and one in Cyprus, both attracted young students who benefitted from a week of classes and activities related to nuclear and radiochemistry.

4.4 Cross Cutting Activities

4.4.1 WP6: Dissemination and Networking

WP6 main objective is to provide support in the dissemination and implementation of project results to ensure that the information about the project and its outputs will be delivered among the nuclear community, all relevant target groups and end-users.
At the same time, WP6 should assure the long-term sustainability and exploitation of the CINCH series results.
Promotion of opportunities or participation in networking events at national and international levels complete the list of tasks.
In the latest 18 months of A-CINCH implementation, the A-CINCH project has been promoted at the following events:

- {May 2022} The A-CINCH project has been presented at the NUCLEAR 2022 , Mioveni (Romania) on 18 - 20 May. A-CINCH poster was also exposed.
- {May 2022} The A-CINCH poster was exposed at FISA EURADWASTE 2022 , Lyon(France) on 30 May – 3 June. A-CINCH was also addressed in an oral contribution and described in a paper titled SUPPORTING ACCESS TO KEY PAN-EUROPEAN RESEARCH INFRASTRUCTURES AND INTERNATIONAL COOPERATION published in the EPJ-N journal (https://doi.org/10.1051/epjn/2022032)
- {May 2022} A-CINCH activities have been promoted at RadChem 2022 Conference in Mariánské Lázně (Czech Rep) 15 - 20 May 2022.
- {August 2022} A-CINCH was mentioned in the ICONE29 conference (Shenzen, China) via a recorded video contribution sent to take part in the »Women in Nuclear« panel.
- {August 2022} A presentation about the MOOC in Radiochemistry was given at ICARST 2022, (Second International Conference on Applications of Radiation Science and Technology) – 22-26 August 2022 Vienna, Austria.
- {September 2022} The A-CINCH poster was presented at the 14th International Symposium on Nuclear and Environmental Radiochemical Analysis, York (UK) 13-15 September 2022.
- {September 2022} A-CINCH was presented in connection with other projects at 31NENEConference, Portoroz (Slovenia) on 12-15 September.
- {November 2022} A-CINCH was presented at the ICOND Conference (Aachen, Germany) on 17 November.
- {February 2023} opportunities provided for youngsters by the A-CINCH project were presente in an online WEBINAR on 10 February.
- {March 2023} A-CINCH was presented at the Euratom Coordinators Hub day organized by SNETP in Brussels, Belgium, on 14 March.
- {May 2023} A-CINCH was presented at 3rd International conference on Radioanalytical and Nuclear Chemistry - RANC, Budapest, Hungary, 7-12 May.
- {May 2023} A-CINCH poster was exposed at ENYGF in Krakow, Poland, on 11 May.

- {June 2023} A-CINCH was presented (in particular the travel fund and opportunities for youngsters) at ANIMMA Conference, in Lucca (Italy) on 16 June.
- {September 2023} A-CINCH poster and interactive material was exposed at ENEN 20th brithday celebration.

The work of this WP runs horizontally throughout the project duration in order to drive the results towards their exploitation and the long-term sustainability.

4.4.2 WP7: Management and mobility

WP7 is the second transversal activity of the project. Its objective is to provide an efficient management of the A-CINCH activities including overall project steering.
Furthermore, the A-CINCH Travel Fund is managed and administered in WP7. This to assure the international exchange of knowledge and practical experience among students, teachers for secondary, higher and vocational education, end-users, and lecturers through the mobility scheme.

Between April 2022 and September 2023, the following activities have been supported by the ACINCH travel fund, providing lump sums to selected participants.

- HoT on Radiochemical spectroscopic analysis - Organised by JSI and UCY in June 2022
- HoT on Working with Plutonium and Actinides – Organised by CHALMERS in May 2023
- Summer school in Nuclear and Radiochemistry – Organised by UCY, NNL and UnivLeeds in June 2023
- HoT in Synthesis and Analytical Control of Radiopharmaceuticals – Organised by IST in July 2023
- HoT on Nuclear Forensics – Organised by LUH in August 2022
- ENEN Nuclear Art Competition – Organised by ENEN during summer 2023

Overall, with the above activities, 36 people (between M19-M36 of the project) have received a lump sum to support their travel and accommodation expenses. The teaching was delivered free of charge by project partners in different locations across Europe. The registration to the course has been managed via the main project website (exploiting the CINCH VET e-shop): https://eshop.cinch-project.eu/products?page=1&date=upcoming whilst applications for grants have been managed by ENEN via its dedicated platform http://apply.enen.eu/ .

GENERAL CONCLUSIONS

The A-CINCH project is the latest in the series of CINCH projects, all of them revolving around education and training in nuclear and radiochemistry.

A-CINCH started in October 2020 and concluded on September 2023.

The general concept permeating all A-CINCH output is 'learn through playing' in order to light up the interest of the younger generation for nuclear radiochemistry and make the NRC studies more attractive for current and future students.

Since many educational tools have been produced already in the previous CINCH projects, and more new ones have been developed under A-CINCH, a portal called CINCH HUB has been delivered during this project. It is reachable at this address https://hub.cinch-project.eu/ and it provides easy-to-navigate interface to all CINCH materials and tools for all target groups.