GRE@T-PIONEΞR
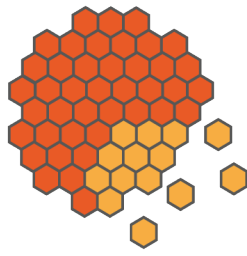
Teaching computational and experimental reactor physics using innovative pedagogical methods

NESTet2021

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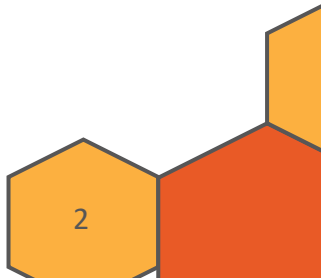
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INTRODUCTION

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- Industry relying more and more on **modelling** and **simulations**
- **Computational reactor physics** often taught via **advanced** courses
- Advanced courses **phased out** because of declining student enrolment in "nuclear engineering" at European universities
- ➢ **GRE@T-PIONEeR**:
  - CSA approved for funding by the EC within the 2019-2020 Euratom work program
  - 3-year project
  - Total budget: 2.6 MEUR, out of which 2.3 MEUR requested from the EC

INTRODUCTION

- GRE@T-PIONEeR **consortium**:
  - Chalmers University of Technology (Sweden – coordinator)
  - Ecole Polytechnique Fédérale de Lausanne (Switzerland)
  - Technical University of Munich and TU Dresden (Germany)
  - Budapest University of Technology and Economics (Hungary)
  - Politecnico di Torino (Italy)
  - Universidad Politénica de Madrid and Universitat Politècnica de València (Spain)
  - The European Nuclear Education Network (Belgium)
  - LGI Consulting (France)

INTRODUCTION

- GRE@T-PIONEeR **Advisory Board:**
  - Gesellschaft für Anlagen- und Reaktorsicherheit gGmbH – GRS (Germany)
  - The Swedish Radiation Safety Authority – SSM (Sweden)
  - Nuclear Energy Agency – OECD/NEA (France)
- GRE@T-PIONEeR **End-User Group**:
  - Vattenfall Nuclear Fuel (Sweden)
  - Studsvik Scandpower AB (Sweden)
  - Westinghouse Electric Sweden AB (Sweden)
  - Ringhals AB (Sweden)
  - Forsmark Kraftgrupp AB (Sweden)
  - Kärnkraftsäkerhet och Utbildning AB – KSU (Sweden)
  - MVM Paks Nuclear Power Plant Ltd. (Hungary)
  - Institut de Radioprotection et de Sûreté Nucléaire – IRSN (France)

INTRODUCTION

- GRE@T-PIONEeR **aims**:
  - Develop and provide **specialized** and **advanced** courses in **computational** and **experimental reactor physics**
  - Use **innovative pedagogical methods** promoting **student learning**
  - ➤**Target**: graduate level (MSc and PhD levels) and post-graduate level, as well as nuclear industry staff members
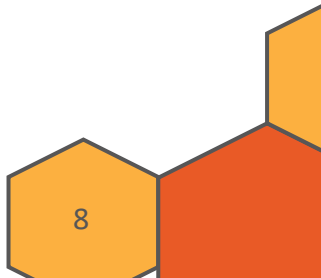
INTRODUCTION

- Plan of presentation:
  - Pedagogical set-up and principles
  - Overview of the courses and hands-on
  - Advancement of the project

PEDAGOGICAL SET-UP AND PRINCIPLES

PEDAGOGICAL SET-UP AND PRINCIPLES

- Core of the pedagogy = **active learning**

Traditional set-up:

Post-class activities

In-class activities

Bloom's Taxonomy

Create — Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate

Evaluate — Justify a stand or decision
Appraise, argue, defend, judge, select, support, value, critique, weigh

Analyze — Draw connections among ideas
Differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test

Apply — Use information in new situations
Execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch

Understand — Explain ideas or concepts
Classify, describe, discuss, explain, identify, locate, recognize, report, select, translate

Remember — Recall facts and basic concepts
Define, duplicate, list, memorize, repeat, state

Illustration of Bloom's revised taxonomy for the cognitive domain, with higher-order thinking skills at the top of the diagram (figure derived from the Center for Teaching Vanderbilt University)

PEDAGOGICAL SET-UP AND PRINCIPLES

- Core of the pedagogy = **active learning**

Flipped set-up:

Post-class activities

In-class activities

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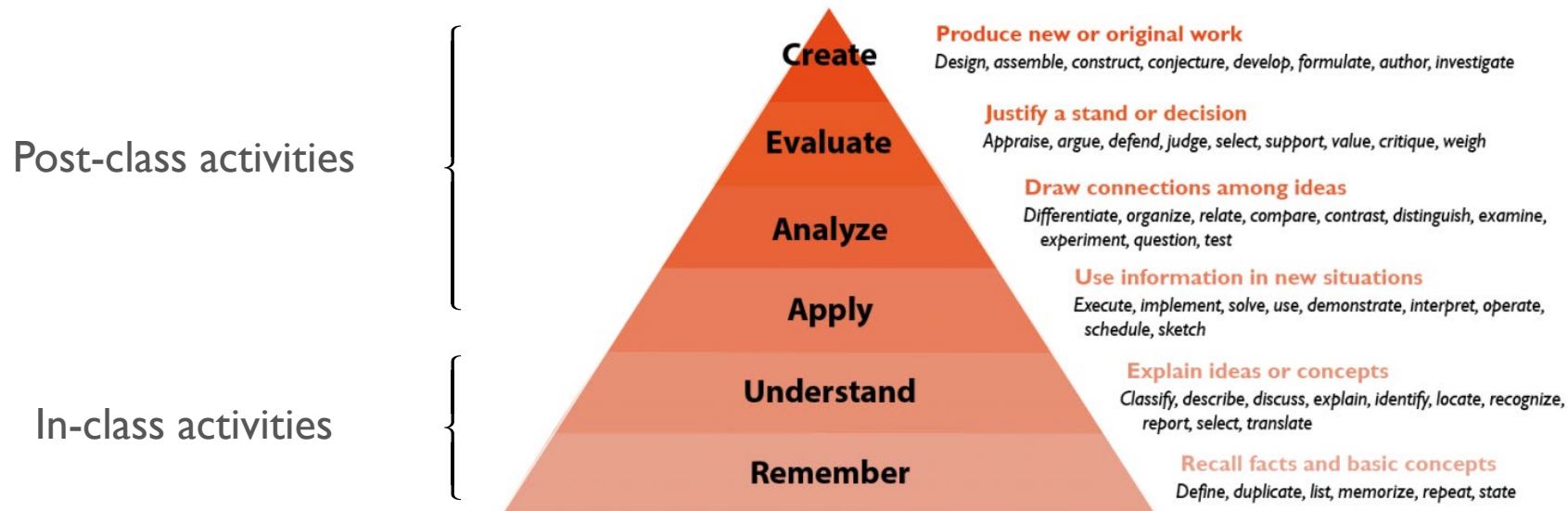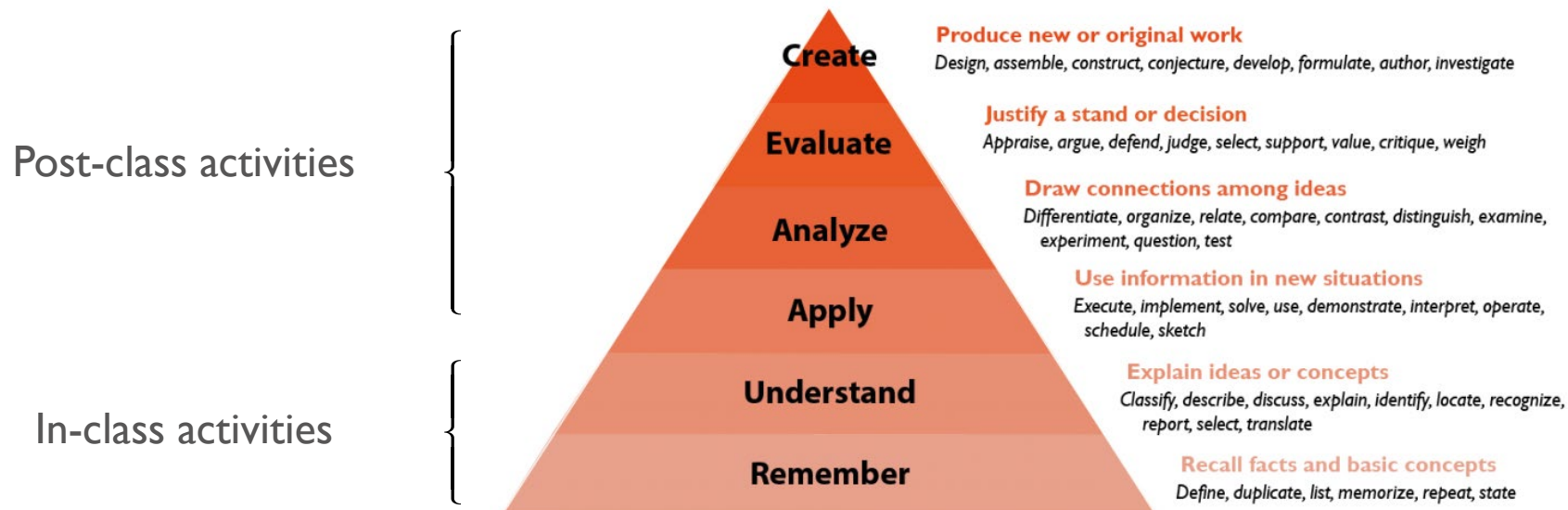Define, duplicate, list, memorize, repeat, state

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Flipped set-up:

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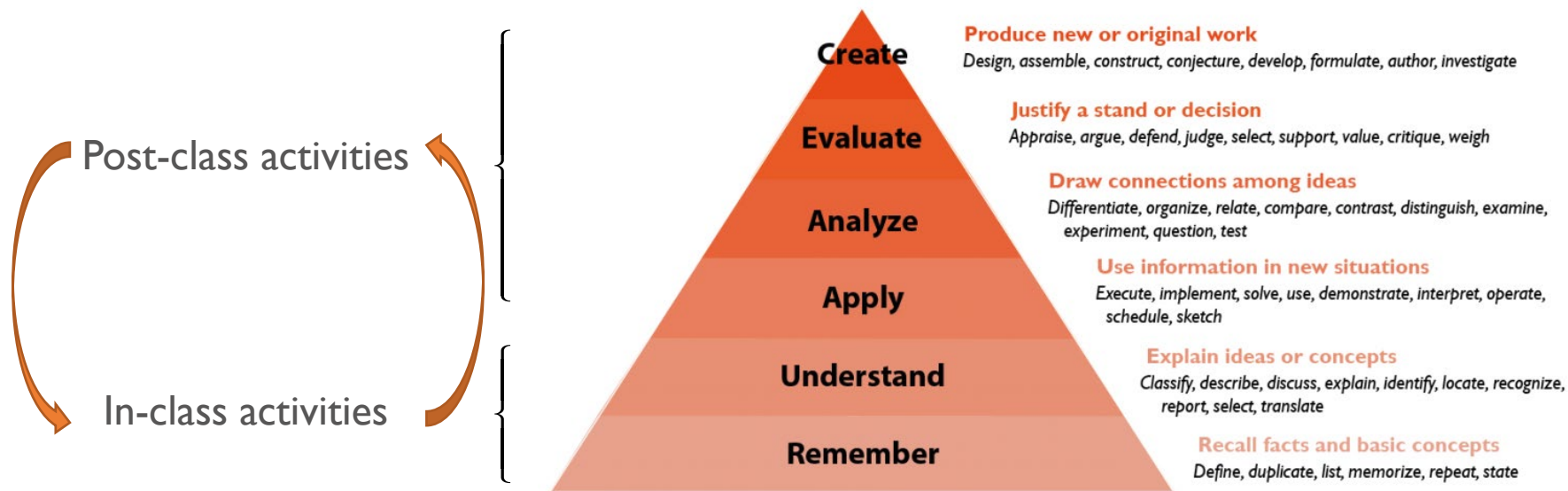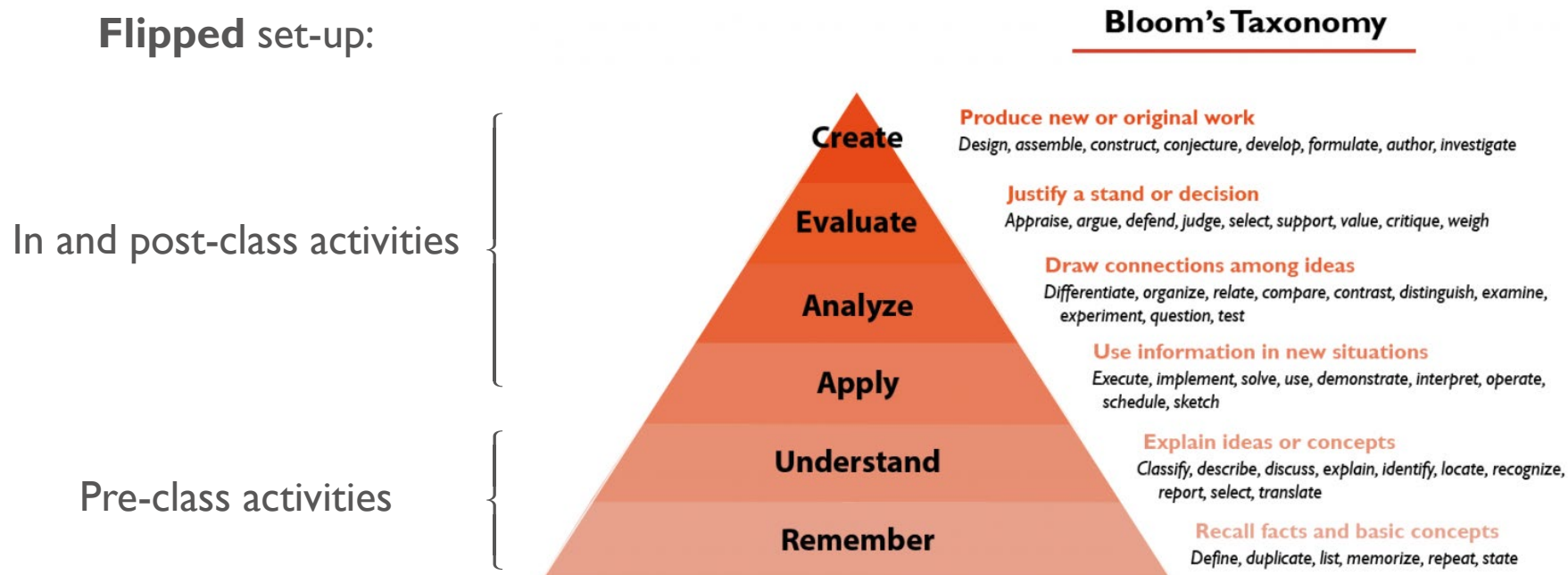*Define, duplicate, list, memorize, repeat, state*

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PEDAGOGICAL SET-UP AND PRINCIPLES

- Core of the pedagogy = **active learning**

Flipped set-up:

In and post-class activities

Pre-class activities

Bloom's Taxonomy

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PEDAGOGICAL SET-UP AND PRINCIPLES

- **In-class** sessions offered in a **hybrid** learning environment:

On-site
attendance

+

Off-site
attendance

PEDAGOGICAL SET-UP AND PRINCIPLES

- **In-class** sessions offered in a **hybrid** learning environment:

Interactive teaching room
Chalmers University of Technology, Gothenburg, Sweden
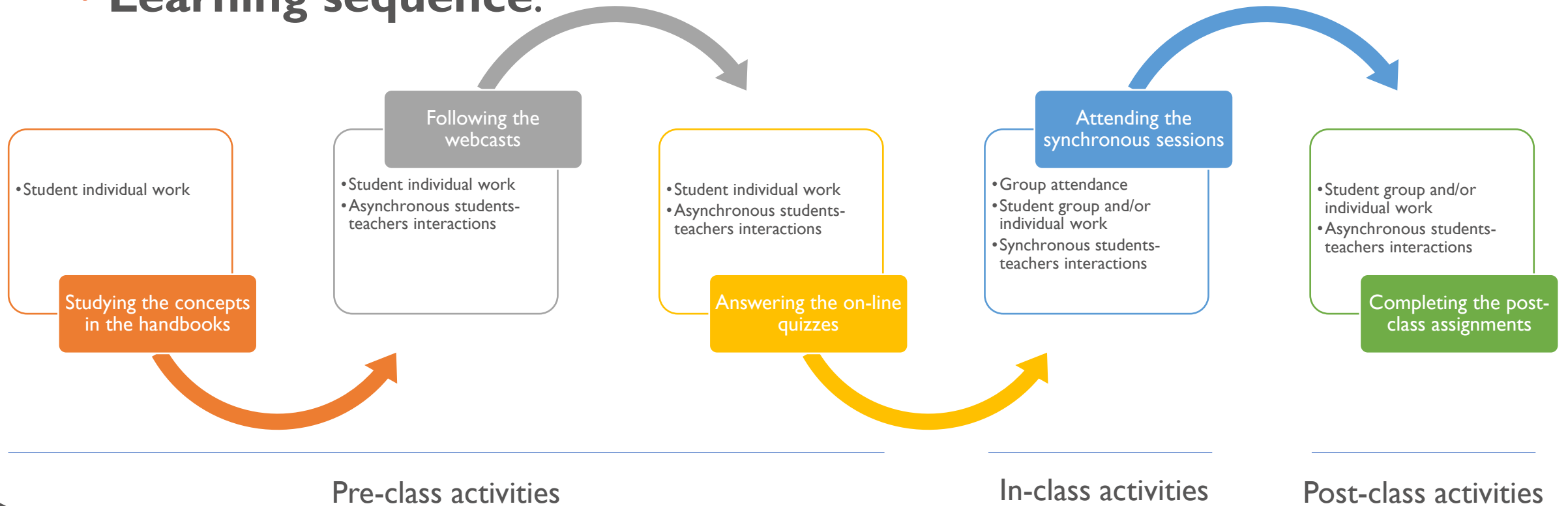
COURSE OFFERING

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- Course **elements**:
  - Handbooks
  - Pre-recorded lectures (webcasts)
  - On-line quizzes
  - Asynchronous interaction tools
  - Active learning synchronous sessions

Online

Hybrid

COURSE OFFERING

- **Learning sequence**:

Studying the concepts in the handbooks
- Student individual work

Following the webcasts
- Student individual work
- Asynchronous students-teachers interactions

Answering the on-line quizzes
- Student individual work
- Asynchronous students-teachers interactions

Attending the synchronous sessions
- Group attendance
- Student group and/or individual work
- Synchronous students-teachers interactions

Completing the post-class assignments
- Student group and/or individual work
- Asynchronous students-teachers interactions

Pre-class activities   In-class activities   Post-class activities

COURSE OFFERING

- Course **topics**:
  - Nuclear cross-sections for neutron transport
  - Neutron transport at the fuel cell and assembly levels
  - Core modelling for core design
  - Core modelling for transients
  - Reactor transients, nuclear safety and uncertainty and sensitivity analysis
  - Radiation protection in nuclear environment

COURSE OFFERING

- **Hands-on** exercises:
  - Relying on the use of 3 **training reactors**:

AKR-2
TUD, Dresden, Germany

CROCUS
EPFL, Lausanne, Switzerland
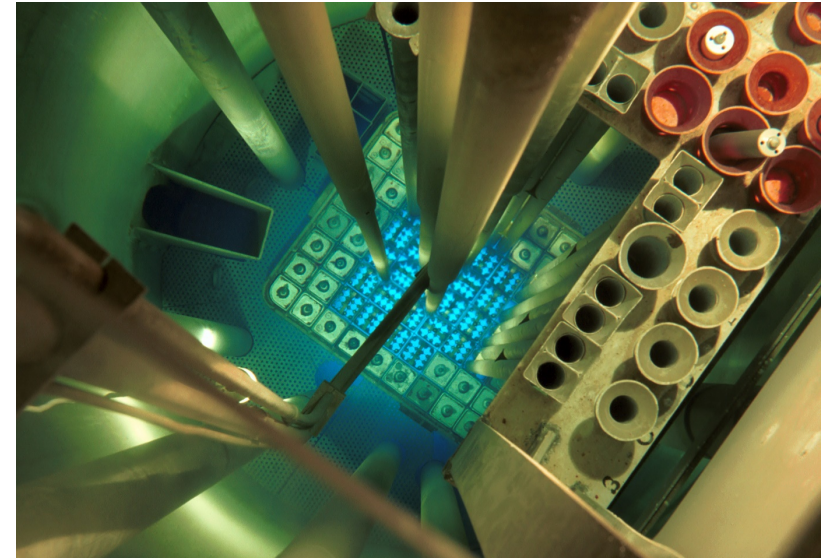
BME Training Reactor
BME, Budapest, Hungary

COURSE OFFERING

- **Hands-on** exercises:
  - Relying on **computer-based modelling** and **simulations**:
    - Either **using existing tools** (commercial and open-source)
    - Or **implementing algorithms** in computing environments

Previous example of a short course on "Deterministic modelling of nuclear systems", September 9-13, 2019, Chalmers University of Technology
(ESFR-SMART Horizon 2020 project)

ADVANCEMENT OF THE PROJECT

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- Project running for **11 months** and **on schedule**

- **Development** of **course materials**:
  - Table of contents of all handbooks developed
  - All handbook being written (some already finalized)
  - All hands-on defined

ADVANCEMENT OF THE PROJECT

- **Project implementation**:
  - Inventory of e-resources available to the partners carried out
  - Purchase of a Learning Management System (LMS): Soul (Tecnatom)
  - Two recording studios available
  - Own screencasting/recording software to be used by each partner
  - Two Active Learning Classrooms (ALCs) available
  - Heavy use of learning analytics (embedded in the LMS directly)
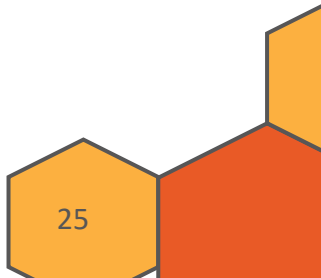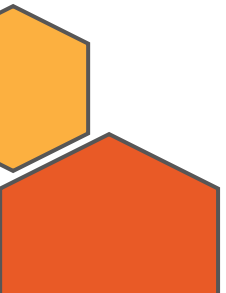
ADVANCEMENT OF THE PROJECT

- **Mapping** of the **stakeholder needs** versus **course offering** and **teaching methods** carried out

➤**Workshop** organized on November 18, 2021, in Brussels:
  - Presentation of the results
  - Co-construction of educational programs and courses in nuclear engineering

CONCLUSIONS AND OUTLOOK

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- Project aimed at **securing competences** on the **long term**

- **Innovative pedagogical methods** at the core of the project

- **Active learning** heavily relying on **programming**-based, **computer**-based and **research reactor**-based **hands-on** training exercises

- Teachers working **together** to develop a set of **coherent** and **complementary** courses

- **Condensed** course modules organized along a "**story to tell**"

➢ GRE@T-PIONEeR: **pioneering** education in computational and experimental reactor physics

- **Delivery** of the courses planned in **late 2022/early 2023**

Thank you!

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