

**GRE@T-
PIONEER**



Teaching advanced computational and experimental reactor physics in hybrid learning environments using active learning techniques – Experience from the GRE@T-PIONEER project

C. Demazière¹, J. Gomez² and C. Stöhr¹

¹Chalmers University of Technology, ²Università di Pisa
demaz@chalmers.se, j.gomezrodriguez@studenti.unipi.it and christian.stohr@chalmers.se



This project has received funding from the European Union's Euratom research and innovation programme 2014-2018 under the Grant Agreement n°890675. The content of this document reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

BACKGROUND

- **Advanced courses** = often offered as intensive onsite “workshops” or “summer courses”
 - Too condensed format to lead to “efficient” learning
 - Issuance of certificates of attendance (with no real measure of engagement, progress and understanding)
- **Online and hybrid learning environments** = more accessibility and flexibility
 - Often low engagement and high drop-out rates

BACKGROUND

- “Innovative” learning design proposed in the GRE@T-PIONEER project, having for objectives:
 - To offer **advanced** courses
 - In a **flexible** manner
 - Having a **high engagement** of the participants in the activities
 - And making sure that the **participants successfully learnt the concepts/principles/methods**

WHAT IS GRE@T-PIONEER?

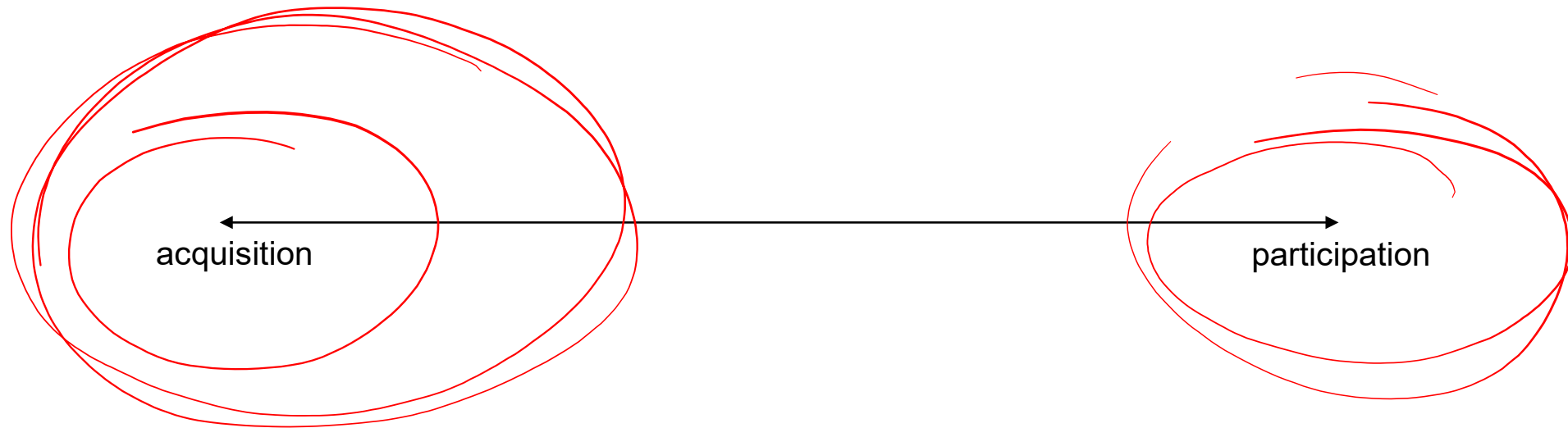
- **18** university teachers from **8** different universities in **6** different countries
- Main **goals** of the project:
 - Maintain or further develop **competences** in **computational and experimental nuclear reactor physics and safety**
 - Deliver **top-class courses** using **state-of-the-art pedagogical methods** (active learning through flipping)
 - Create a **community** of **reactor physicists**

COURSE OFFERING

- **9 course modules** offered:
 - 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
 - Hands-on exercises on the AKR-2 training reactor
 - Hands-on exercises on the CROCUS training reactor (onsite only)
 - Hands-on exercises on the BME training reactor
- **More info and registration at <https://great-pioneer.eu/register>**

PEDAGOGICAL METHOD

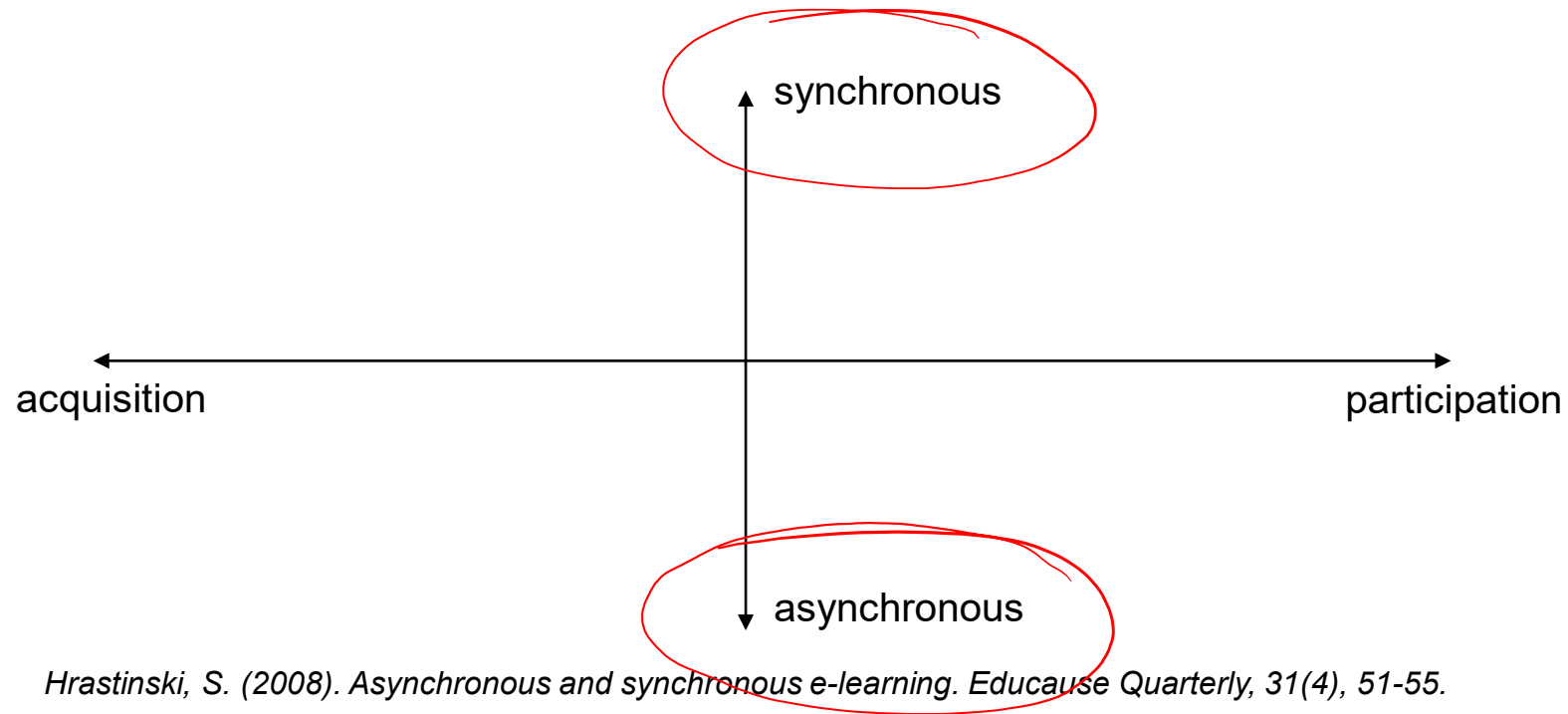
- Flipping:



Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. Educational researcher, 27(2), 4-13.

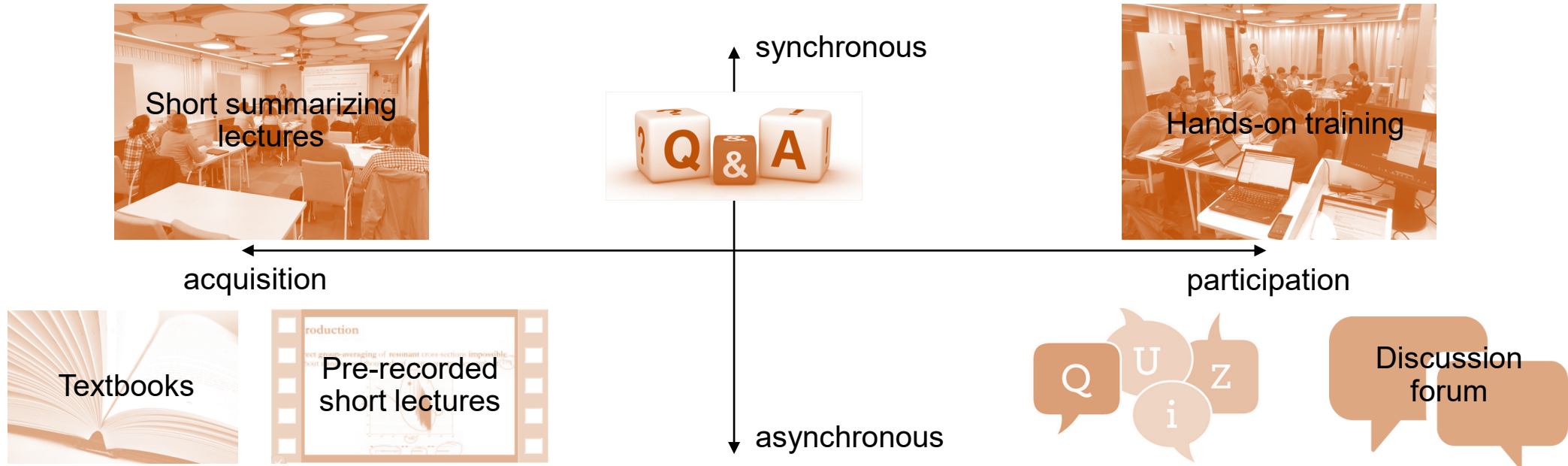
PEDAGOGICAL METHOD

- Flipping:



PEDAGOGICAL METHOD

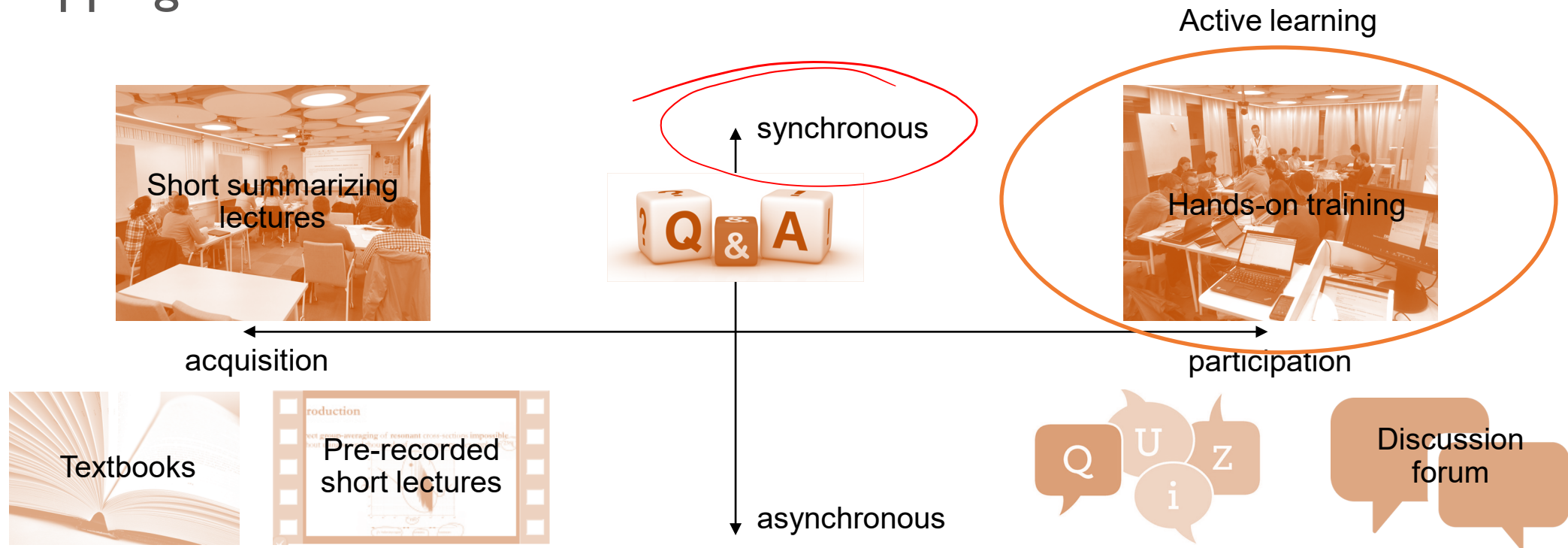
- Flipping:



Hrastinski, S. (2008). Asynchronous and synchronous e-learning. Educause Quarterly, 31(4), 51-55.

PEDAGOGICAL METHOD

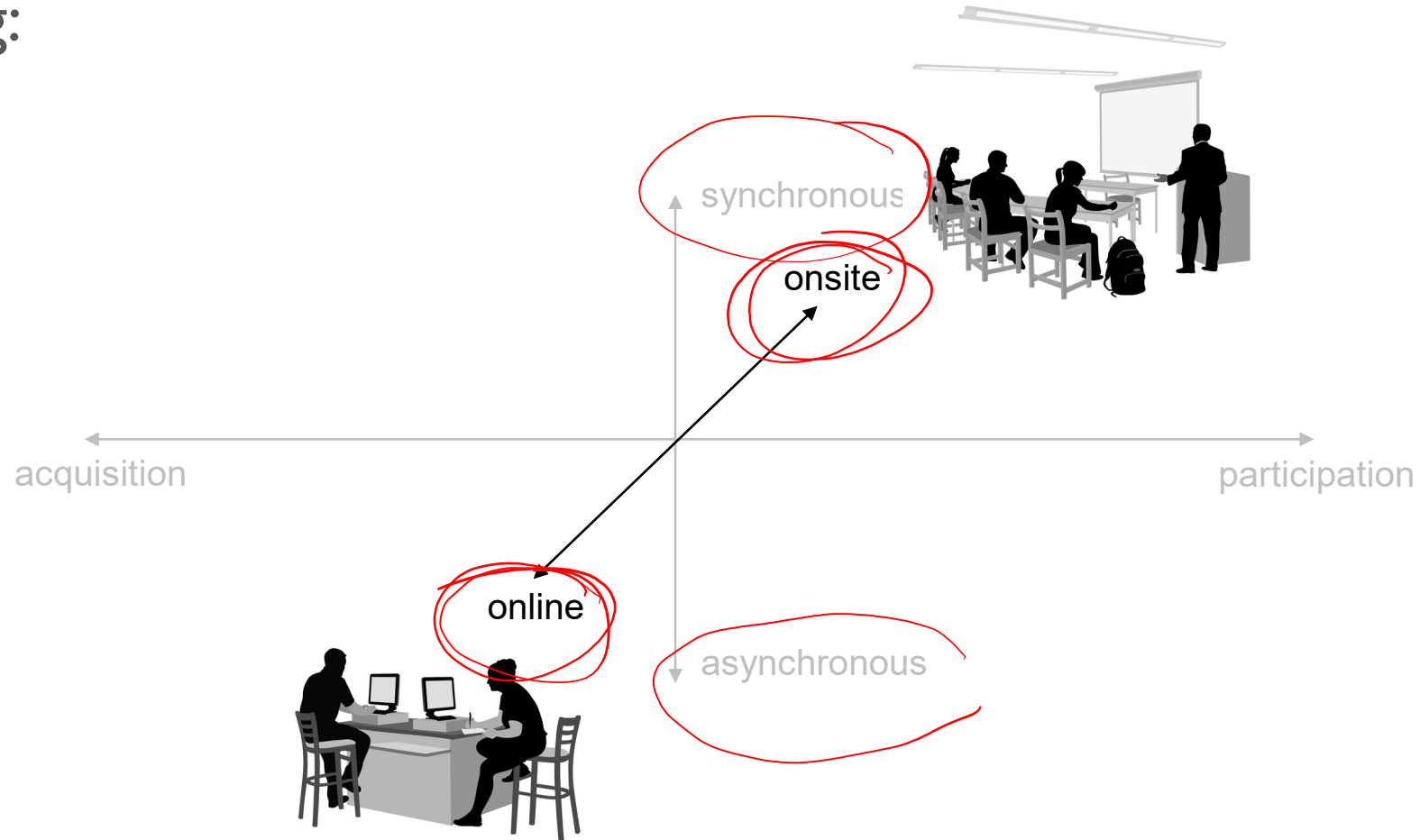
- Flipping:



Hrastinski, S. (2008). Asynchronous and synchronous e-learning. Educause Quarterly, 31(4), 51-55.

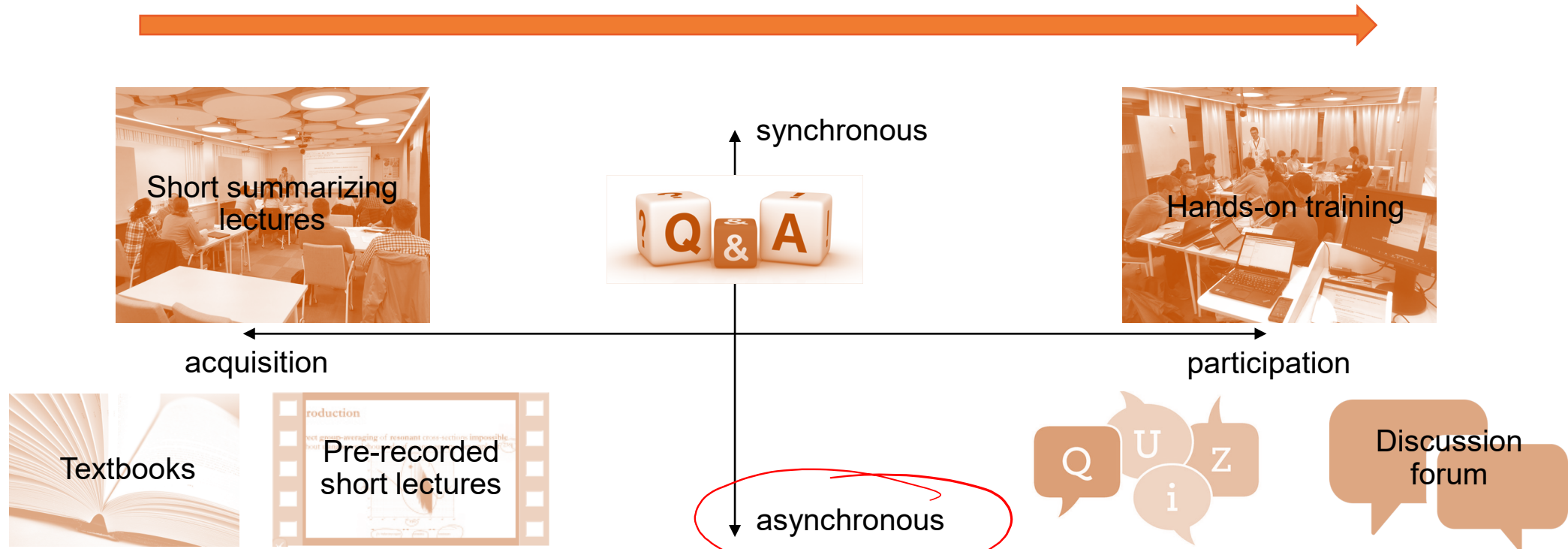
PEDAGOGICAL METHOD

- Flipping:



PEDAGOGICAL METHOD

Synchronous hybrid learning phase concentrated on 5 consecutive days



Hrastinski, S. (2008). Asynchronous and synchronous e-learning. Educause Quarterly, 31(4), 51-55.

Asynchronous online learning phase spread on 4 weeks (self-paced learning)

PEDAGOGICAL METHOD

- **Active learning** techniques used:
 - **Short summarizing lectures** followed by “**quizzes**”, with or without prior group discussions
 - Heavy use of **computer simulation tools** with different objectives:
 - **Implementing** nuclear reactor **modelling techniques** introduced in the other course elements
 - **Checking** the proper **understanding** of key concepts via small assignments
 - **Checking** the proper **use** of third-party nuclear simulation software against some reference solutions
- **Highly-structured sessions**

PEDAGOGICAL METHOD

- Boundary conditions/set-up:
 - To be **accepted** to the **synchronous sessions**, the participants should watch at least 50% of the pre-recorded videos and take at least 50% of the quizzes
 - To obtain a **course certificate**, the participants should get at least 50 points (out of 100)
- **All activities** are delivered, monitored and graded via the **SOUL** Learning Management System (LMS) from Tecnatom

ANALYSIS

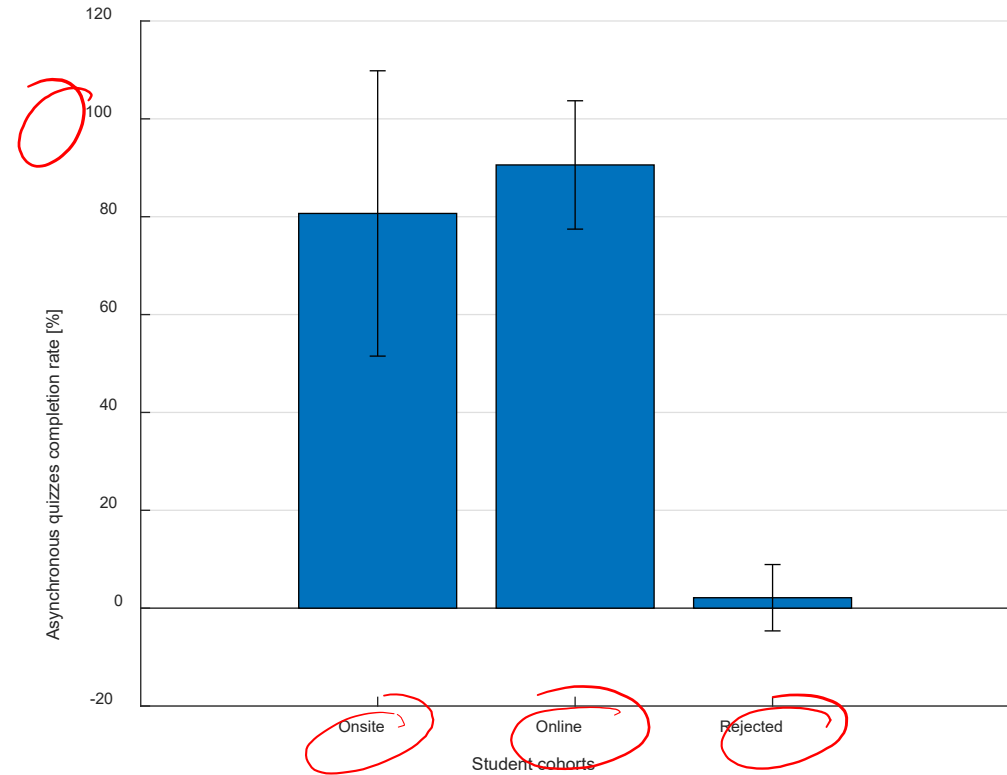
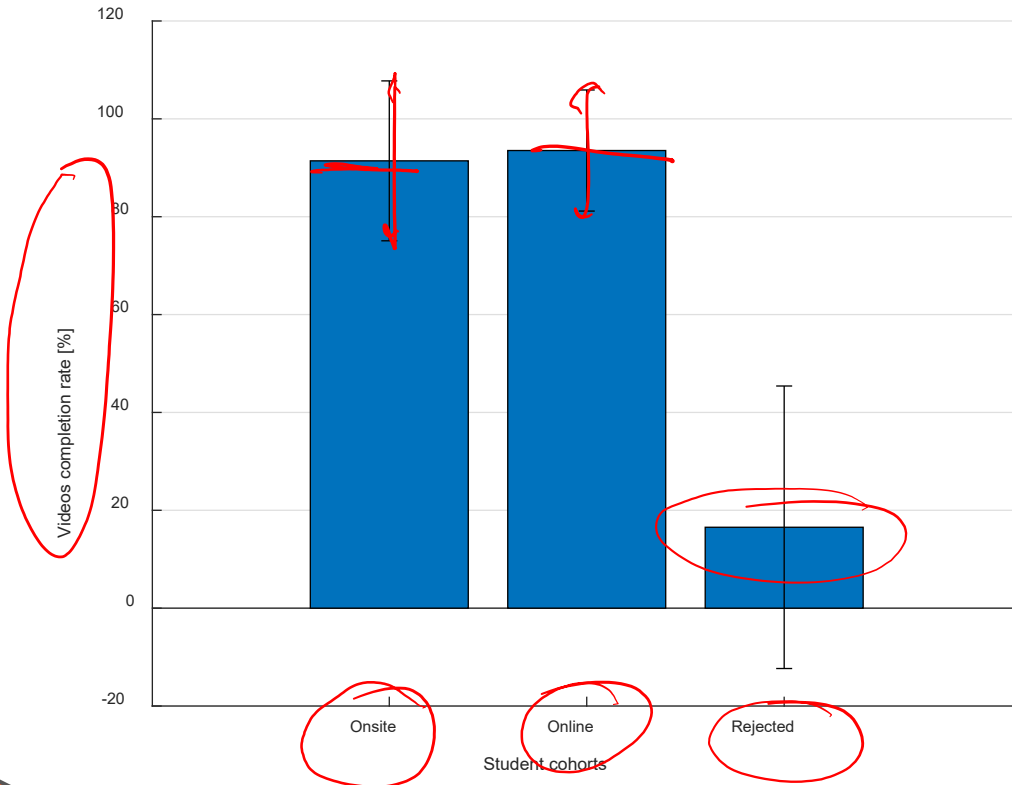
- Analysis of one of the courses: “Core modelling for core design”
- Timing:
 - **Asynchronous** learning phase: November 25, 2022 – January 8, 2023
 - **Synchronous** learning phase: January 9-13, 2023
 - **Extra time** to complete the synchronous activities: January 14-February 13, 2023

ANALYSIS

- Analysis of one of the courses “Core modelling for core design”
- Student statistics:
 - **58 applicants**
 - 6 rejected applications (upper limit for each course set to 50 participants)
 - **52 accepted applications** (12 onsite and 41 online) and granted access to the LMS
 - **31 participants qualified for the synchronous sessions** (with 12 onsite and 19 online)
 - **29 participants received a course certificate** (12 onsite and 17 online)
- Remark: all online participants took some of the first synchronous activities

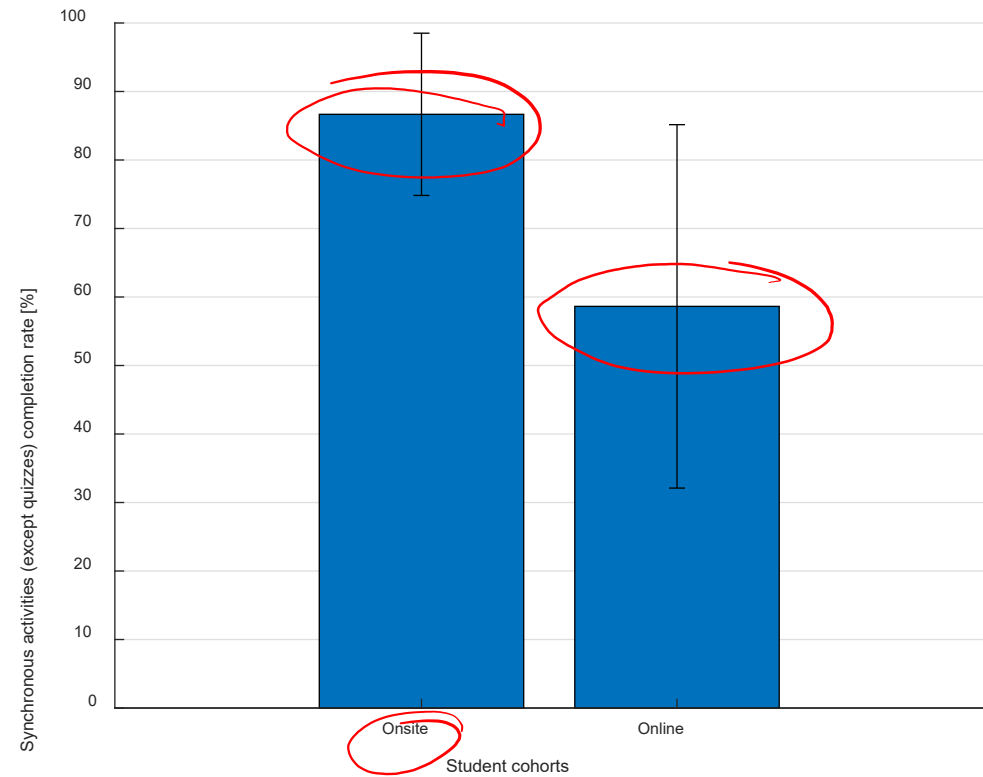
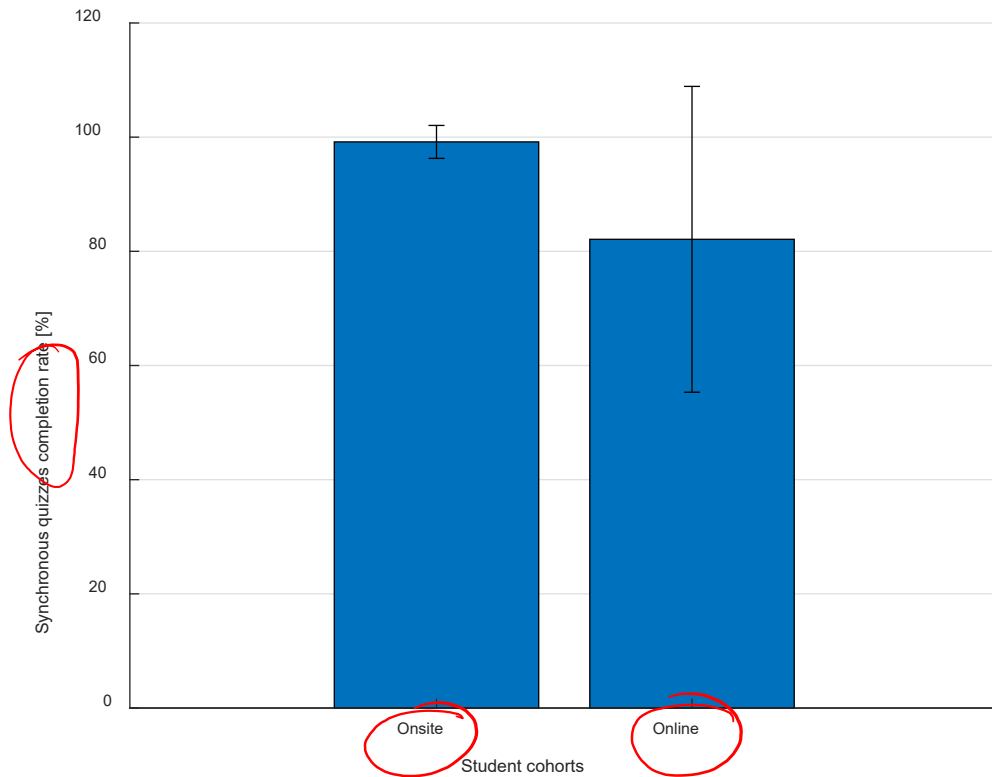
ANALYSIS

- **Use of the various teaching resources – asynchronous elements:**



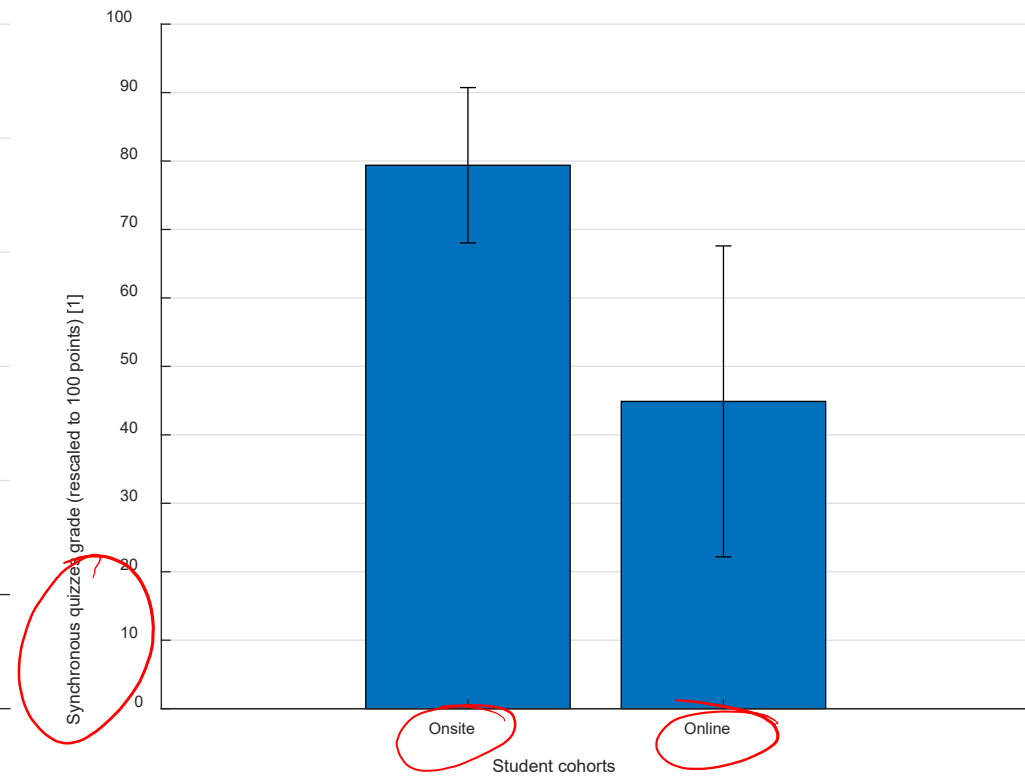
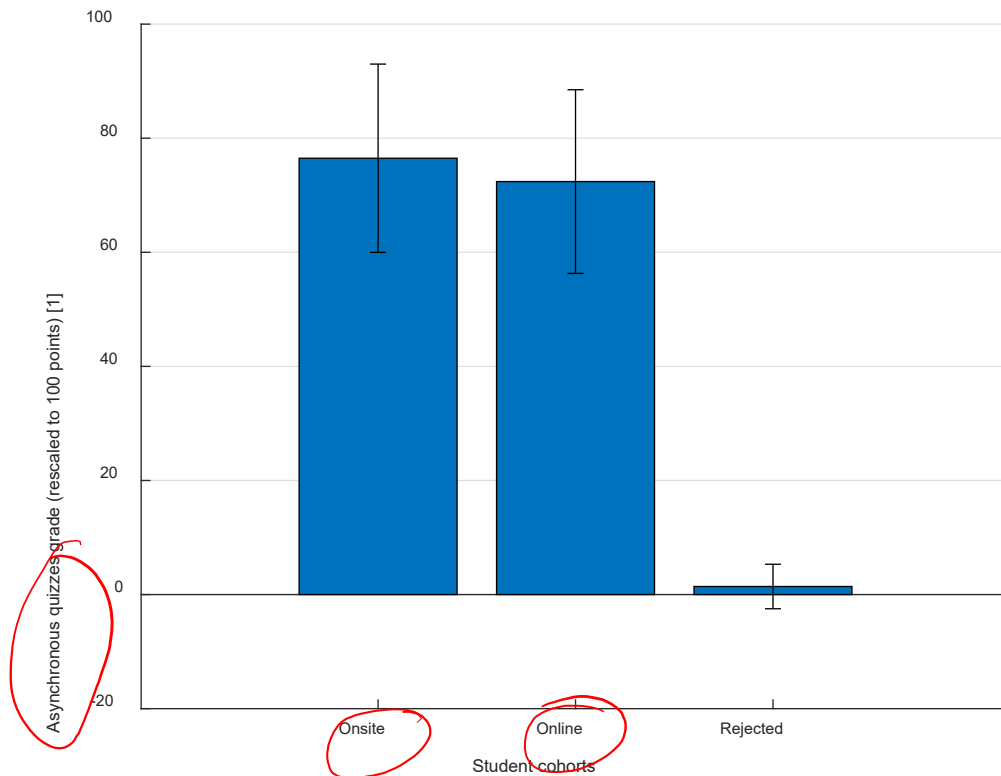
ANALYSIS

- Use of the various teaching resources – **synchronous** elements:



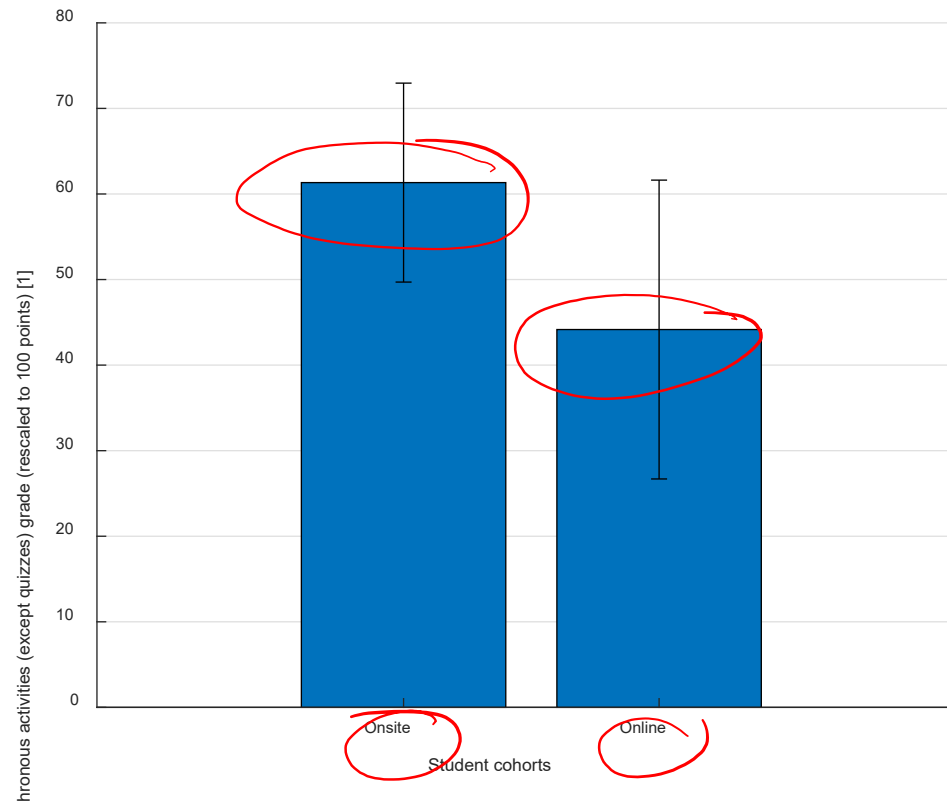
ANALYSIS

- **Learning of the theoretical concepts – asynchronous + synchronous quizzes**



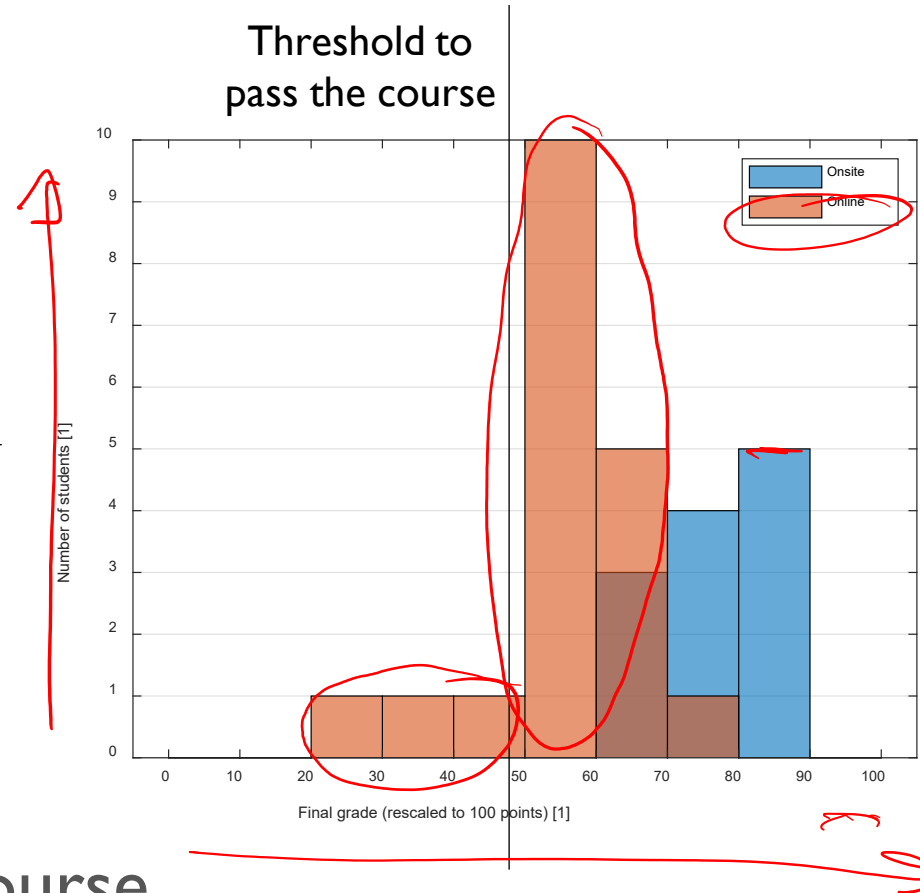
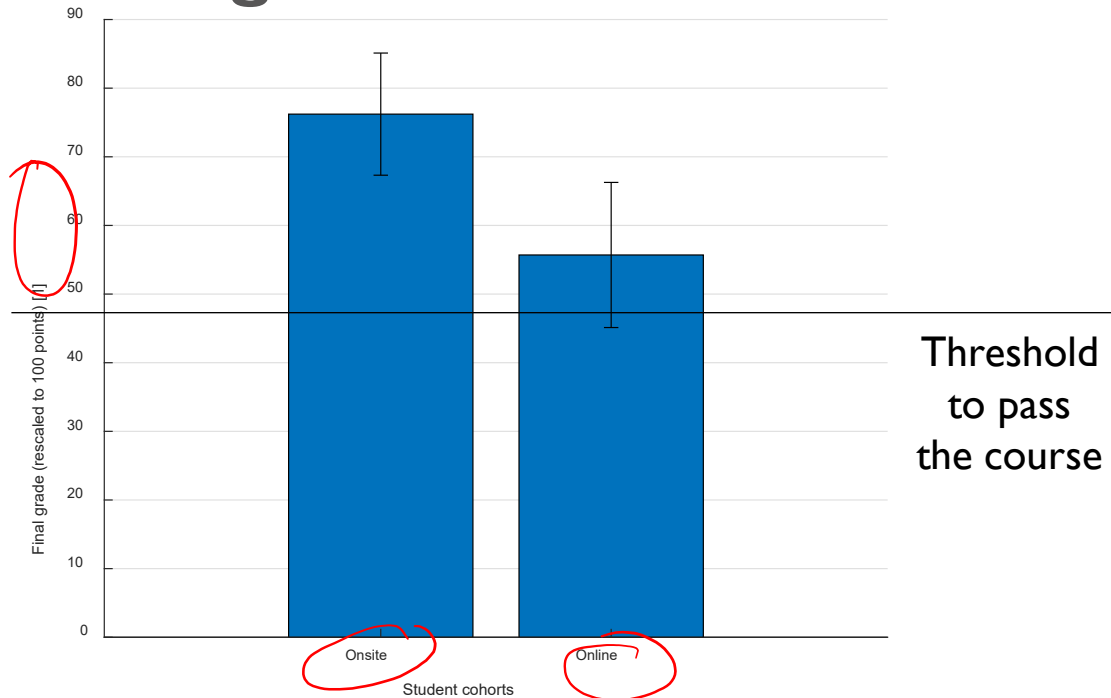
ANALYSIS

- **Ability to apply** the concepts in practical situations – **synchronous activities other than quizzes**



ANALYSIS

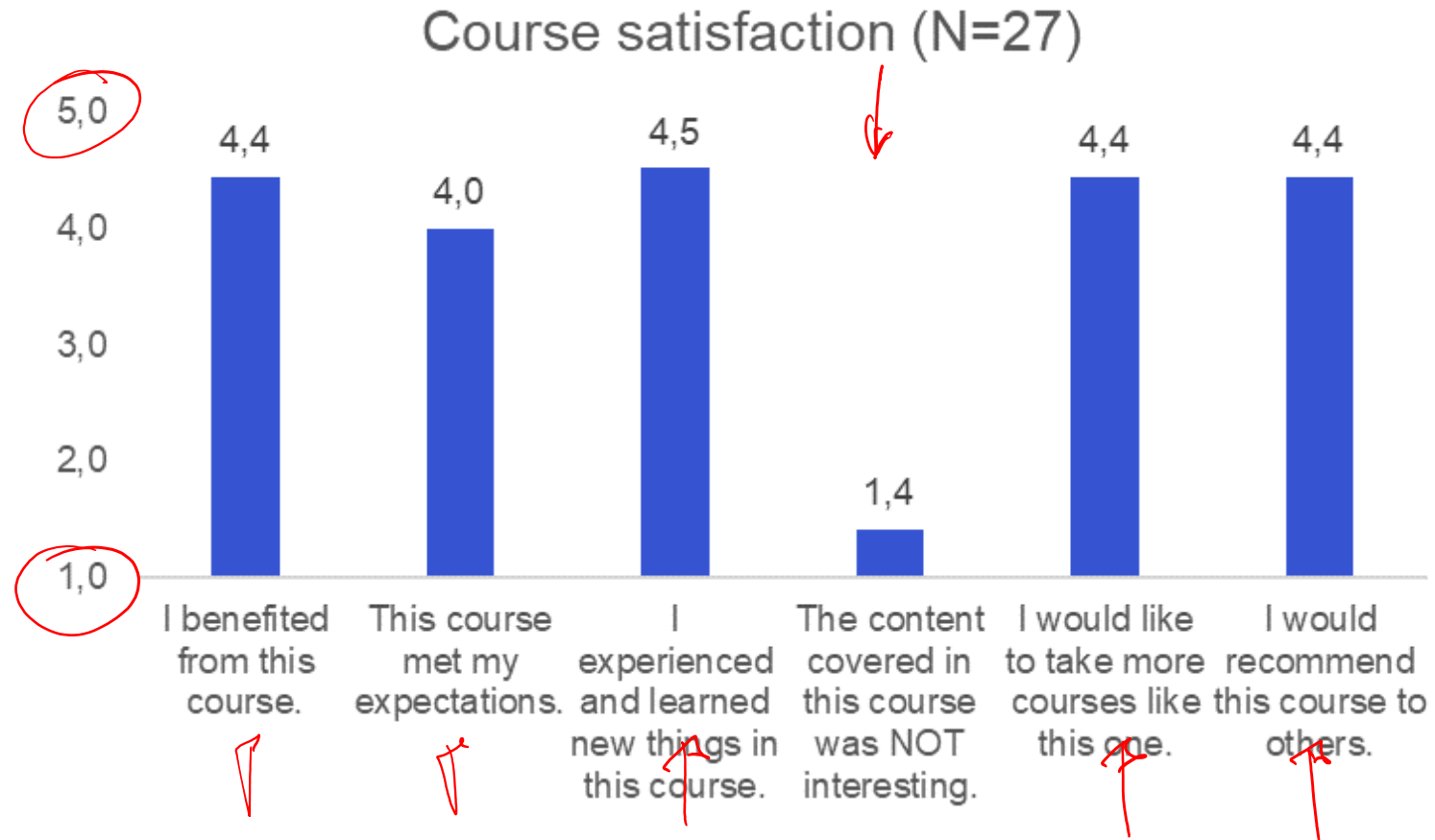
- **Final grades:**



- All 12 onsite students passed the course
- 17 of the 19 online students passed the course

STUDENT FEEDBACK

- Participants' own perception of the course



STUDENT FEEDBACK

- Thematic analysis of “things” participants liked (N=27):
 1. Practical Exercises / Tools / Codes / Software (16)
 2. Course Materials / Handbooks / Slides / Sources (11)
 3. Well-explained Topics / Quality of Teachers (9)
 4. Organization / Course Structure / Preparation (9)
 5. Networking / Interactions with Students and Professionals (6)
 6. Inclusive Atmosphere / Support from Teachers and Students (5)
 7. Flipped Classroom / Teaching Methods (3)
 8. Flexibility / Pace / Online Learning (2)
 9. Real-world Applications / Industry Relevance (2)
 10. Multidisciplinary / Diverse Backgrounds (2)

STUDENT FEEDBACK

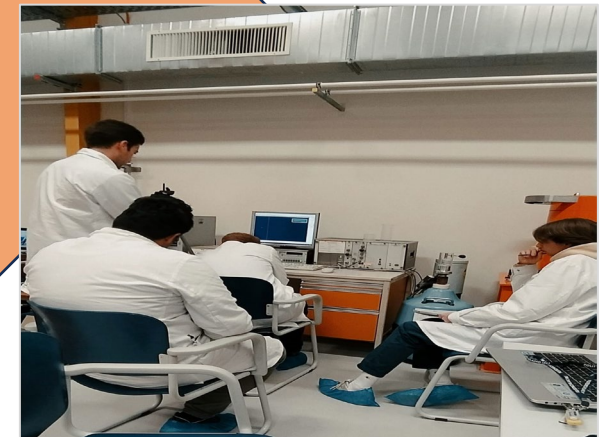
- Thematic analysis of “things” participants did not like (N=27):

- 1. Time Constraints and Pace (17 items)
2. Content and Instruction (13 items)
3. Technical Issues and Software (11 items)
4. Course Structure and Topics (6 items)
- 5. Workload and Assignments (5 items)
6. Course Format and Recommendations (4 items)
7. Instructor-related Issues (3 items)

STUDENT FEEDBACK

STUDENT FEEDBACK

My personal views on the project:
A timeline on how it feels to be part of courses onsite,
online, theoretical and hands-on training.



**GRE@T-
PIONEER**

REGISTER



STUDENT FEEDBACK







- **Registration** procedure is extremely easy and web platform is very friendly.
- Once accepted, availability from professors is excellent. Indeed, the platform is simple and complete with announcements, chat and forum.
- Potential funding from ENEN mobility support.

FORUM

In case of questions, use primarily the forum.

When starting a new discussion thread, please put in the title of the discussion thread the chapter number (and possibly section number) the discussion refers to.

[Add a new discussion topic](#)

Discussion	Started by	Last post ↑	Replies
☆ Chapter 3. Page 31 and Step-by-Step procedure to solve eq 3.7 and 3.8	 JUAN GOMEZ 2 Dec 2022	 JUAN GOMEZ 2 Dec 2022	2
☆ Chapter 5.1.a Equivalence Method: IR Intermediate Resonance	 JUAN GOMEZ 3 Dec 2022	 Christophe Dema... 4 Dec 2022	1
☆ To access the course on your mobile devices	 Hamed KHODADA... 7 Dec 2022	 Christophe Dema... 7 Dec 2022	1

STUDENT FEEDBACK

The **asynchronous** part is well-structured and didactic. Recordings with clear audio, video and quizzes of the content of the self-paced learning is done.

Some contents are challenging and bring to our minds new concepts or expand in those that are learnt previously.

Deterministic modelling

Resulting balance equations:

$$\frac{1}{v_g} \frac{\partial \phi_{g,n}}{\partial t}(t) = - \sum_{N=x,y,z} \frac{J_{g,n}^N(t) - J_{g,n-1}^N(t)}{\Delta N} - \Sigma_{t,g,n}(t) \phi_{g,n}(t) + \sum_{g'=1}^G \Sigma_{s0,g' \rightarrow g,n}(t) \phi_{g',n}(t)$$
$$+ \chi_{g,n}^p (1 - \tilde{\beta}_n) \sum_{g'=1}^G \nu_{g',n} \Sigma_{f,g',n}(t) \phi_{g',n}(t) + \sum_{i=1}^{N_d} \chi_{i,g,n}^d \lambda_{i,n} C_{i,n}(t)$$

and

$$\frac{\partial C_{i,n}}{\partial t}(t) = \tilde{\beta}_{i,n} \sum_{g'=1}^G \nu_{g',n} \Sigma_{f,g',n}(t) \phi_{g',n}(t) - \lambda_{i,n} C_{i,n}(t), i = 1, \dots, N_d$$

The homogeneous B1 method relies on the truncation of the Legendre expansion of:

- a. Both the scattering kernel and the angular neutron flux.
- b. Only the angular neutron flux.
- c. Only the scattering kernel. ✓

Although only the two first moments of the Legendre expansion of the angular neutron flux are required, there is no necessity to truncate this development.

Your answer is correct.

STUDENT FEEDBACK

During the **asynchronous** part, course designed handbook is written and is read.

The **handbooks** are **understandable and concise**, however, to complete all the asynchronous reading, watching all video lectures and the quizzes is needed a great deal of **time**.

Be prepared for the **synchronous** part is demanding, necessary and rewarding.

Course Handbook

Core design and operation

5. PWR in-core fuel management.....	5-1
5.1. In-core fuel management: objectives	5-1
5.1.a. Long-term in-core fuel management	5-2
5.1.b. Medium-term in-core fuel management	5-2
5.1.c. Short-term fuel management	5-2
5.1.d. Final design of the reactor core	5-3
5.2. Fuel loading patterns	5-3
5.2.a. Types of loading patterns	5-3
5.2.b. Loading pattern optimization	5-5
5.2.c. Stretch out and shortening of cycles	5-6
5.2.d. Trends in operating strategies and loading patterns	5-6

STUDENT FEEDBACK



At the neutron transport at fuel cell and assembly level course in Gothenburg, Sweden

During the **synchronous** sessions:

- ✓ Bidirectional **discussions** in already grounded topics during the asynchronous time.
- ✓ Exchange with colleagues of diverse countries, and levels: master students, PhD candidates, experienced nuclear engineers and operators.
- ✓ The courses **strengthen** and introduce fundamental topics, e.g., discrete ordinate method for neutron transport.
- ✓ Good opportunity for networking.

STUDENT FEEDBACK

- ✓ Courses include **extra features** such as programming tasks and use of codes: Jupyter notebooks, Serpent 2.2, CASMO4, OpenMC, SIMULATE3.
- ✓ Give the opportunity to manipulate equipment, devices, samples, sources.
- ✓ Perform experiments such as CR calibration, transfer function measurement, pile oscillator, etc.
- ✓ Courses provide **ECTS credits**.



At the two weeks hands-on training at the AKR-2 Reactor at Technical University of Dresden, Germany

STUDENT FEEDBACK

And undoubtedly, it is also a great opportunity to meet new people, new places, eat unknown food, practice other languages and create good memories in one's mind.



During a Saturday of hiking at Saxon Switzerland National Park, Germany.

CONCLUSIONS

- **Very good outcomes** in terms of **participation, engagement and completion**
- **Very good feedback** from **students**
- **Significant differences** between **onsite** and **online** participants
 - **“Strategic” learning** for the **online** participants?
 - **High workload** to be combined with **other duties**?
- **Very rewarding** to reach such a high level of teachers-students interactions during the synchronous sessions, thanks to flipping
- Courses being **re-offered** during this academic year

Thank you!

Contact details:



Name: *Prof. Christophe Demazière*



Email: *demaz@chalmers.se*



www.great-pioneer.eu



[@GREATPIONEER_EU](https://twitter.com/GREATPIONEER_EU)



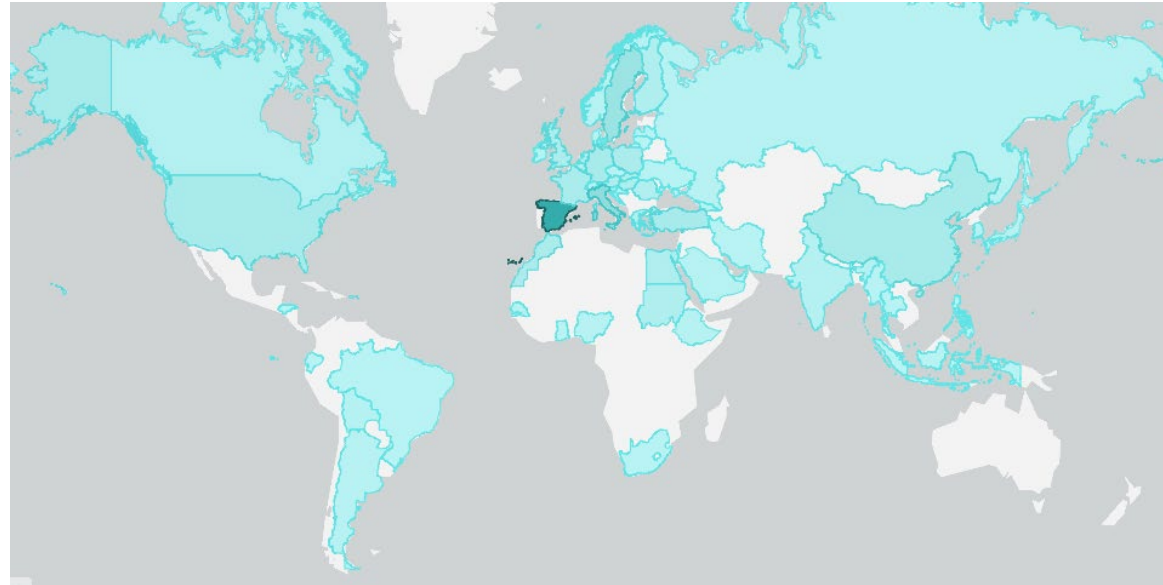
[@GREAT-PIONEER](https://www.linkedin.com/company/GREAT-PIONEER)



EXTRA SLIDES ON OVERALL ANALYSIS OF ALL COMPLETED COURSES

EXTRA SLIDES ON OVERALL ANALYSIS OF ALL COMPLETED COURSES

- For the first 4 delivered courses:
 - **Origin** of the access to the LMS:



➤ Almost worldwide coverage

EXTRA SLIDES ON OVERALL ANALYSIS OF ALL COMPLETED COURSES

- For the first 4 delivered courses:
 - **246 applicants**
 - 51 rejected applications (upper limit for each course set to 50 participants)
 - **195 accepted applications** (49 onsite and 146 online)

- 199 participants actually granted access to the LMS
- **142 participants qualified for the synchronous sessions** (with 47 onsite and 75 online participants taking the first synchronous activity)
- **113 participants received a course certificate** (47 onsite and 66 online)
- **113 course certificates of successful completion already granted!**

EXTRA SLIDES ON OVERALL ANALYSIS OF ALL COMPLETED COURSES

- For the first 4 delivered courses:
 - Completion rate of the participants granted access to the LMS: 57%
 - Completion rate of the participants qualified for the synchronous sessions: 80%
 - **Completion rate of the participants taking the first activity of the synchronous sessions: 93%** (100% for the onsite participants and 88% for the online participants)
 - Fantastic engagement of the participants who take the first synchronous activity

EXTRA SLIDES ON OVERALL ANALYSIS OF ALL COMPLETED COURSES

- For the first 4 delivered courses:
 - **Participant course questionnaires:**
 - I benefited from this course (1-5): 4.7
 - This course met my expectations (1-5): 4.2
 - I experienced and learned new things in this course (1-5): 4.6
 - The content covered in this course was NOT interesting (1-5): 1.5
 - I would like to take more courses like this one (1-5): 4.5
 - I would recommend this course to others (1-5): 4.5
 - **Fantastic responses and feedback from all participants**, irrespective of whether they were onsite or online