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Developed course package on neutron transport at the fuel cell and assembly levels

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Summary

This document presents the main features of the course package on Neutron Transport at the Fuel Cell and Assembly Levels, which was developed and given during the academic year 2022/2023, as well as the feedback gathered after teaching the first edition of the course.

Approval

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History

Date	Version	Submitted by	Reviewed by	Comments
August 31st, 2023	1.0	C. Demazière (CHALMERS)		Creation of the structure of the report
October 20th, 2023	1.1	C. Demazière (CHALMERS)		Update of the document with course statistics
November 2nd, 2023	1.2	S. Dulla (POLITO)	C. Demazière (CHALMERS)	Finalization of the deliverable

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Abbreviations and Acronyms

Acronym	Description
ECTS	European Credit Transfer and Accumulation System
LMS	Learning Management System
SOUL	Smart Open Universe of Learning
WP	Work Package

Executive Summary

This document presents the main features of the course package on *Neutron Transport at the Fuel Cell and Assembly Levels*, which was developed and given during the academic year 2022/2023, as well as the feedback gathered after teaching the first edition of the course.

Keywords

Flipped classroom, active learning, hybrid teaching

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1. Introduction

The EU-funded GRE@T-PIONEeR project aims at developing a specialized education in reactor physics and nuclear reactor safety for PhD and postdoc students, for nuclear engineers, and taken as advanced courses for MSc students. The education encompasses both theory and hands-on training exercises, the latter heavily relying on the use of research/training reactors and of computer-based modelling environments. The aim is for the students to be able to perform nuclear reactor safety simulations understanding all the approximations on which such simulations rely. This is considered essential knowledge in the education of highly skilled nuclear safety analysts. The use of pre-recorded lectures and electronic teaching resources allows students to learn at their own pace and get prepared for the hands-on training sessions, following a flipped classroom approach. Those sessions are offered in a hybrid set-up (i.e., they could be attended both on-site and remotely). They use active learning methods under the close supervision and support of the teachers, thus promoting student learning.

This document presents the main features of the course package on *Neutron Transport at the Fuel Cell and Assembly Levels* that was developed and given during the academic year 2022/2023, as well as the feedback gathered after teaching the first edition of the course.

2. Reminder of the overall pedagogical concept

The course, following a flipped approach, consisted of two main sequences:

- An asynchronous online self-paced learning phase (preparatory phase), during which the students had to study the handbook developed for the course, watch short video lectures summarising the main key points presented in the handbooks, and answer quizzes. The amount of work corresponded to ca. 40 hours of self-studies.
- A synchronous learning phase (interactive phase), during which the students had to work, either individually or in groups, on different tasks. This phase was organized during five consecutive days and was offered in a hybrid set-up: the participants could either attend the sessions online or onsite at Chalmers University. The amount of work also corresponded to ca. 40 hours. Several teachers/guest lecturers participated to those sessions and supported the students during their work.

Whereas the preparatory phase focused on low-order thinking skills in Bloom's revised taxonomy for the cognitive domain, the synchronous learning phase targeted high-order thinking skills (Andersson et al., 2000). The activities proposed during the synchronous phase were thus more challenging, requiring constant teacher support and interactions with the teachers. The teachers were also available during the preparatory phase to answer questions from the students. The students had access to the LMS one month before the start of the interactive phase to complete the self-paced learning phase.

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3. Main features of the course package

All teaching resources during both the asynchronous and synchronous learning phases were made available to the students through the SOUL (Smart Open Universe of Learning) Learning Management System (LMS) from Tecnatom.

The asynchronous learning elements consisted of:

- A handbook of 128 pages, entitled “Neutron transport at the fuel cell and assembly levels” and made of 6 chapters.
- 6 short video lectures.
- 95 asynchronous quizzes (out of which 52 were identified as part of the compulsory asynchronous work to be performed to access the synchronous part of the course in the 2023/24 edition).

The synchronous learning elements consisted of:

- Short summarizing lectures.
- 5 synchronous quizzes.
- 17 sets of exercises.

In terms of course set-up, the following measures were implemented:

- To be accepted to the synchronous sessions, the participants should have watched at least 50% of the videos and taken at least 50% of the asynchronous quizzes. In the preparation of the second edition of the course for the year 2023/24, it was decided to define a subset of the asynchronous quizzes, amounting to 50% of the total, labelled as “COMPULSORY”, to ensure that students cover all the topics of the course with a minimum level of study.
- To obtain a certificate of successful course completion, the participants should have got at least 50 points (out of 100 possible points). Four extra weeks were also given to the participants to complete the synchronous activities.

The course was worth 3 ECTS (European Credit Transfer and Accumulation System).

In addition to the above, the students could also participate to hands-on exercises offered either at the AKR-2 training reactor (TU Dresden, Dresden, Germany) or at the CROCUS training reactor (EFPL, Lausanne, Switzerland). A separate registration was necessary for participating to those hands-on exercises. Hands-on exercises at the BME Training Reactor (BME, Budapest, Hungary) were postponed due to too few applications received. In the following of this document, we will thus only report on the hands-on exercises at the AKR-2 and CROCUS training reactors.

The AKR-2 and CROCUS courses also followed a flipped approach consisting of:

- An asynchronous learning phase consisting of:
    - At AKR-2: 12 sets of instructions and 12 associated asynchronous quizzes.
    - At CROCUS: 6 sets of instructions and 6 associated asynchronous quizzes.
- A synchronous learning phase consisting of:
    - At AKR-2: 12 hands-on exercises and 12 associated synchronous quizzes.

- At CROCUS: 6 hands-on exercises.

The AKR-2 synchronous sessions were organized on two consecutive weeks (10 effective days) and offered in a hybrid set-up, whereas the CROCUS synchronous sessions were organized on 5 consecutive days and onsite exclusively. At AKR-2, one extra month was also given to the participants to complete the reports, whereas at CROCUS, one extra week was given. Successfully passing the courses resulted in the issuance of a certificate of successful completion (worth 4.5 ECTS at AKR-2 and 2 ECTS at CROCUS).

A more extensive description of the handbook and of the exercises/hands-on activities can be found in the Deliverable D3.1 titled "Overview of the course package on neutron transport at the fuel cell and assembly levels".

4. Feedback from the first edition of the course

The synchronous learning phase took place between December 16th and December 20th, 2022, at Chalmers University. Out of 41 applications received to attend the course, 3 were discarded. 6 participants had chosen an onsite participation to the synchronous sessions, the remaining 32 opted for the full online version of the course. Out of those 38 accepted applications, all participants were given access to the LMS.

An analysis of the student participation, performance and satisfaction is presented below in an aggregated manner. To better highlight differences, the analysis is made on different categories of students:

- A category called "Rejected" encompassing all students who did not reach the necessary level of completion rate on the asynchronous activities to qualify for the synchronous activities (10 students).
- A category called "Onsite – active" encompassing all students who qualified for the synchronous sessions, who chose the onsite attendance for the synchronous sessions and who completed at least one activity during those sessions (6 students).
- A category called "Online – active" encompassing all students who qualified for the synchronous sessions, who chose the online attendance for the synchronous sessions and who completed at least one activity during those sessions (17 students).
- A category called "Online – inactive" encompassing all students who qualified for the synchronous sessions, who chose the online attendance for the synchronous sessions but did not complete any activity during those sessions (5 students).

It should be noted that all onsite attendees completed at least one activity during the interactive sessions.

4.1. Analysis of student participation

Student participation was measured via the average value of the completion rate on the asynchronous elements (videos and asynchronous quizzes) and on the synchronous elements (synchronous quizzes and all other synchronous activities). This is presented in Figs. 1 and 2 for the asynchronous and synchronous activities, respectively.

As those figures demonstrate, a high completion rate on the asynchronous elements for the onsite and online students can be noticed. On the other hand, the rejected participants who did not qualify had a very low completion rate, explaining why they were not accepted to the synchronous activities. For the synchronous elements, the onsite students were significantly more engaged than the online active students. No data is presented on the synchronous elements for the rejected participants and the online inactive participants (the rejected participants were not accepted to the synchronous sessions and the online inactive participants did not complete any activity during those sessions).

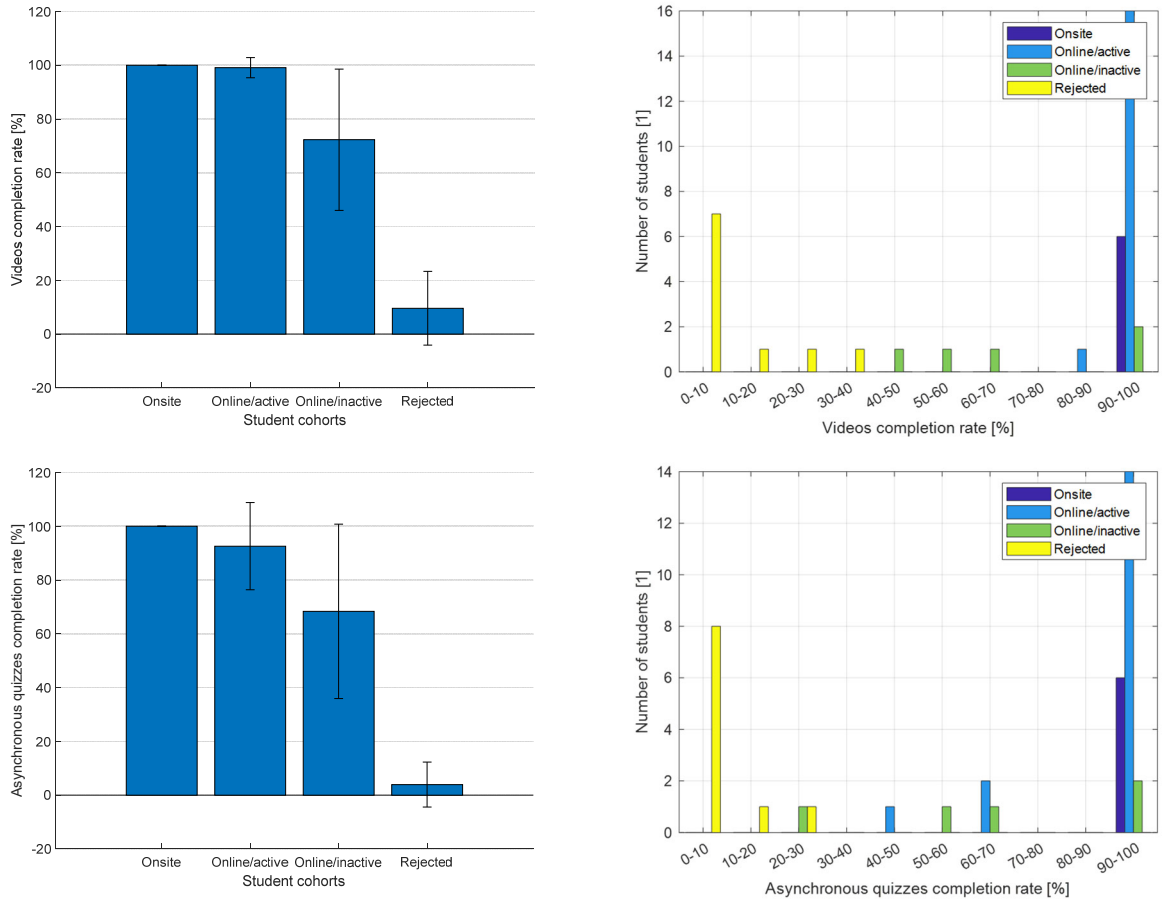

Figure 1. Completion rates averaged on each student group (left figures) and corresponding student distribution depending on the completion rates (right figures). The videos (top figures) and the asynchronous quizzes (bottom figures) are separately analysed. The completion rates on the left figures are also given with their respective standard deviations.

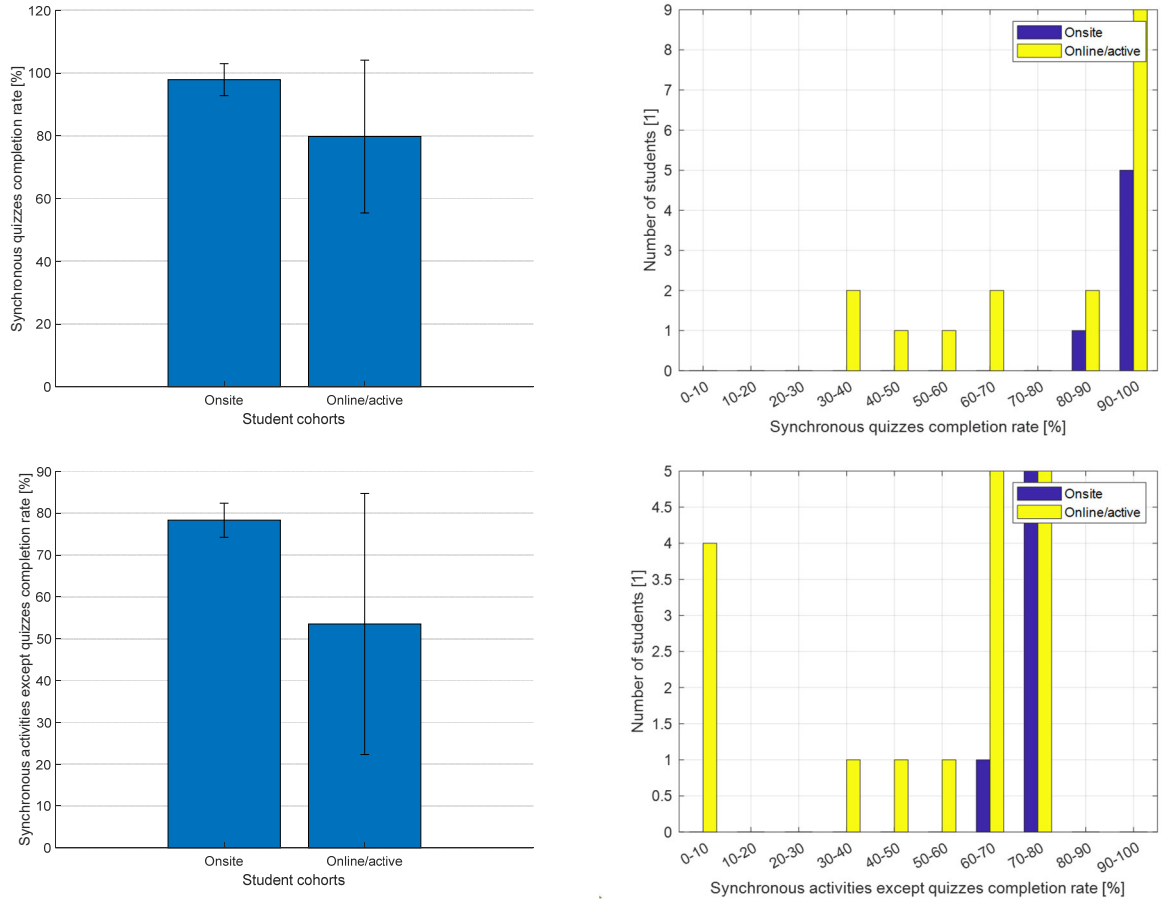

Figure 2. Completion rates averaged on each student group (left figures) and corresponding student distribution depending on the completion rates (right figures). The synchronous quizzes (top figures) and all other synchronous activities (bottom figures) are separately analysed. The completion rates on the left figures are also given with their respective standard deviations.

4.2. Analysis of student performance

Student performance was measured by the average value of the grades for each of the categories of graded activities (irrespective of whether those activities were taken or not – a non-taken activity was given a grade of zero). This is presented in Figs. 3 and 4 for the asynchronous and synchronous activities, respectively.

The final grade is also reported in Fig. 5. The final grade was estimated with a relative weight of 25% on the asynchronous quizzes and a relative weight of 75% on all synchronous activities.

As shown in those figures, whereas the success rate on the asynchronous elements does not differ between the onsite and the online active students, the onsite students perform much better on the synchronous activities than the online active ones (the online inactive students did not complete any

synchronous activity per definition). Also, some significant differences exist between the online active and inactive participants for the asynchronous quizzes. As activities As activities that were not taken were also counted in the grades, the lower grades on the synchronous elements for the online active participants is also the result of a significantly lower participation on the synchronous activities other than the quizzes – see Figs. 1 and 2.

Nevertheless, most of the online active participants got a grade larger than 50 points and thus passed the course, whereas all onsite participants passed the course.

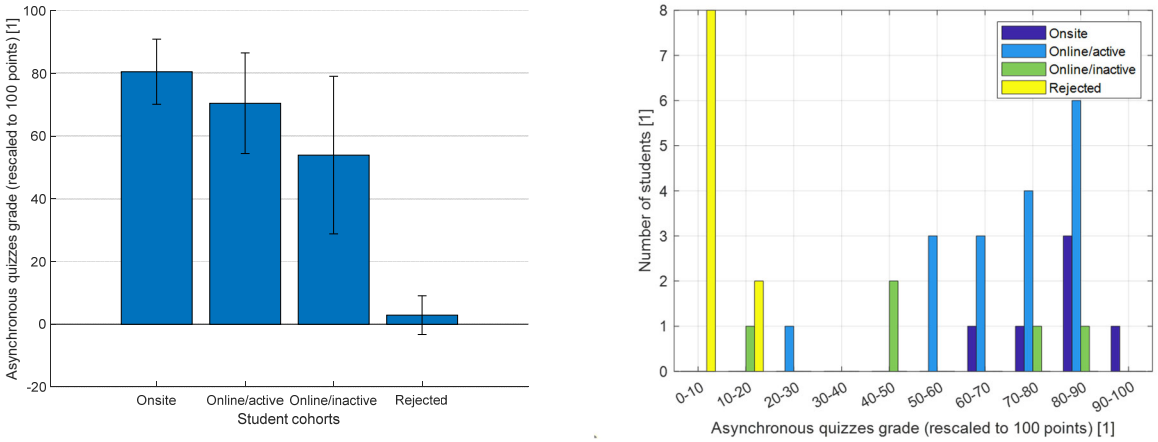

Figure 3. Grades on the asynchronous quizzes averaged on each student group (left figure) and corresponding student distribution depending on the grades (right figure). The grades on the left figure are also given with their respective standard deviations.

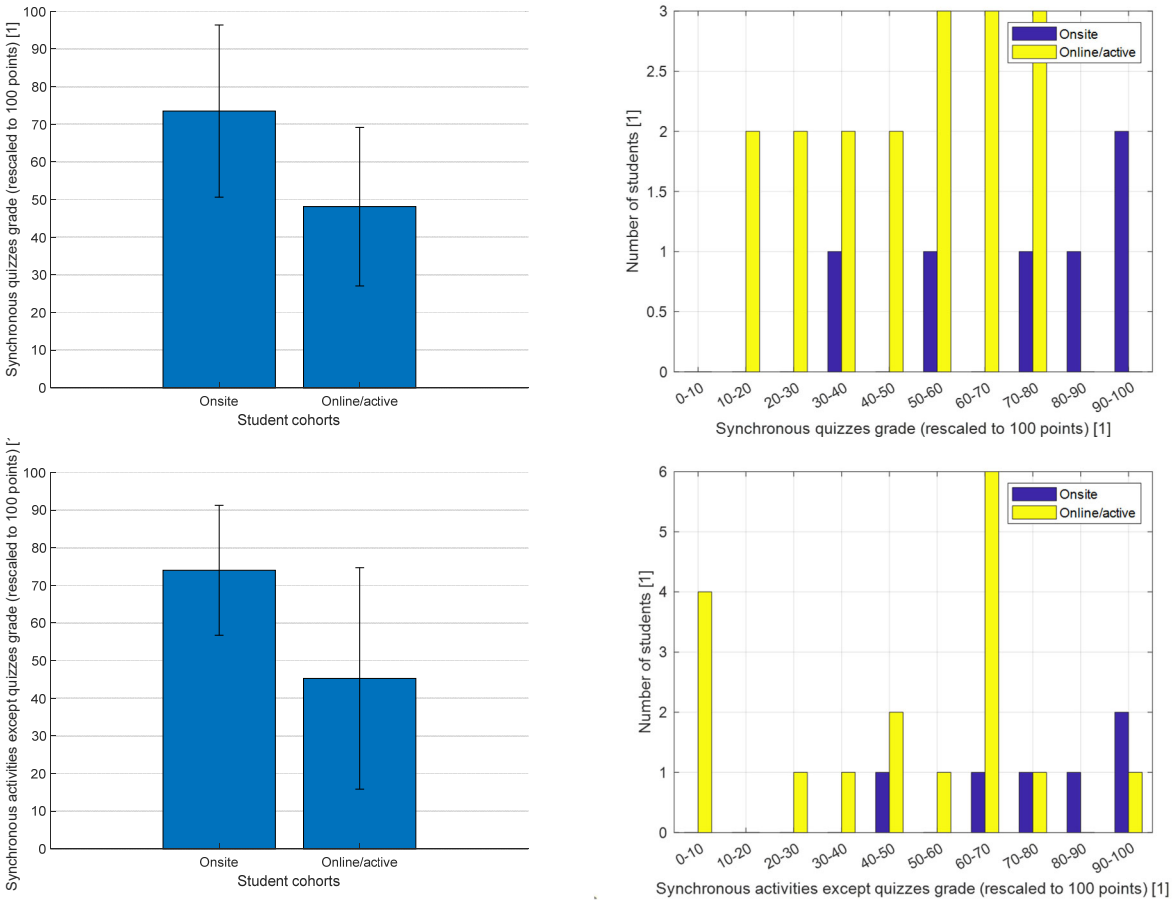

Figure 4. Grades averaged on each student group (left figures) and corresponding student distribution depending on the grades (right figures). The synchronous quizzes (top figures) and all other synchronous activities (bottom figures) are separately analysed. The grades on the left figures are also given with their respective standard deviations.

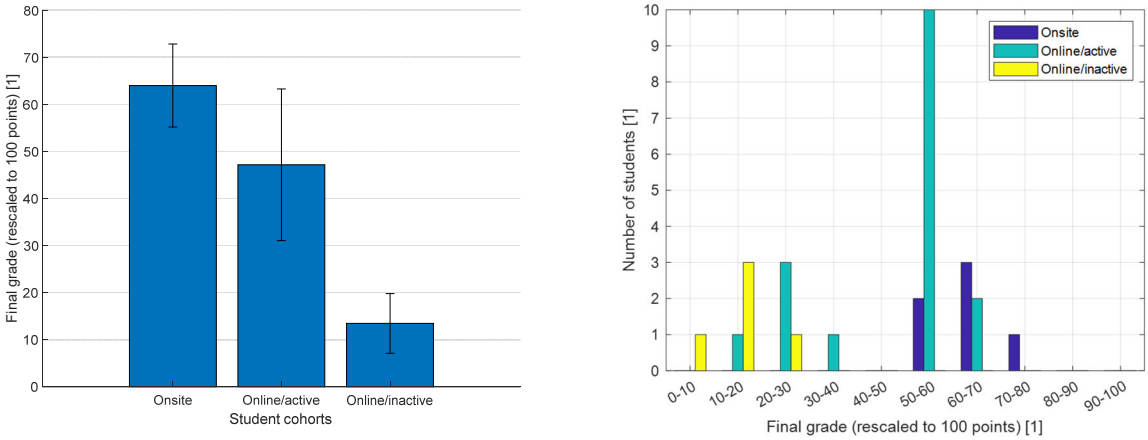

Figure 5. Final grades averaged on each student group (left figure) and corresponding student distribution depending on the grades (right figure). The grades on the left figure are also given with their respective standard deviations.

4.3. Analysis of student satisfaction

A course evaluation questionnaire was given on the last day of the synchronous sessions. Time was allocated to let the student answer the questionnaire on a voluntary basis. The questionnaires were not anonymous. Although the questionnaire contained many parts, only the following six statements that the students had to agree/disagree with on a 5-point Likert scale are analyzed hereafter. Those statements, which give an overview of student satisfaction, were:

- Q1: I benefited from this course.
- Q2: This course met my expectations.
- Q3: I experienced and learned new things in this course.
- Q4: The content covered in this course was NOT interesting.
- Q5: I would like to take more courses like this one.
- Q6: I would recommend this course to others.

The results are presented in Fig. 6. A high average agreement with the statements above can be noticed, supplemented by the negative statements that had a high average disagreement.

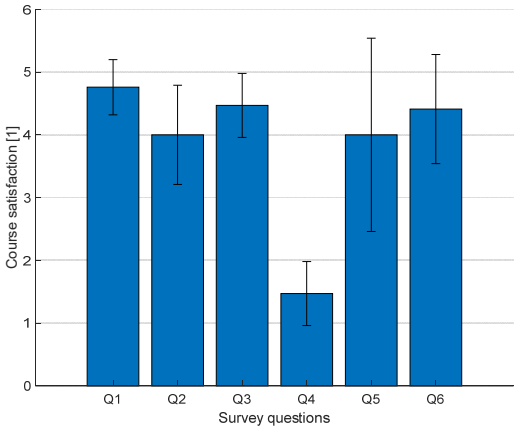

Figure 6. Mean values and associated standard deviations of agreement with the statements regarding course satisfaction (1=strongly disagree – 5=strongly agree). 17 students answered the questionnaire.

5. Feedback from the first edition of the hands-on sessions at AKR-2

The synchronous learning phase took place between April 17 and 28, 2023, at TU Dresden, Dresden, Germany. Out of 24 applications received to attend the course, two were discarded. 11 participants had chosen an onsite participation to the synchronous sessions, the remaining 11 opted for the full online version of the course. Out of those 22 accepted applications, 21 participants were given access to the LMS (due to late cancellation).

An analysis of the student participation, performance and satisfaction is presented below in an aggregated manner. In order to better highlight differences, the analysis is made on different categories of students:

- A category called “Rejected” encompassing all students who did not reach the necessary level of completion rate on the asynchronous activities to qualify for the synchronous activities (11 students).
- A category called “Onsite – active” encompassing all students who qualified for the synchronous sessions, who chose the onsite attendance for the synchronous sessions and who completed at least one activity during those sessions (five students).
- A category called “Online – active” encompassing all students who qualified for the synchronous sessions, who chose the online attendance for the synchronous sessions and who completed at least one activity during those sessions (four students).
- A category called “Online – inactive” encompassing all students who qualified for the synchronous sessions, who chose the online attendance for the synchronous sessions but did not complete any activity during those sessions (one student).

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It should be noted that all onsite attendees completed at least one activity during the interactive sessions.

5.1. Analysis of student participation

Student participation was measured via the average value of the completion rate on the asynchronous elements (asynchronous quizzes) and on the synchronous elements (reports and synchronous quizzes). This is presented in Figs. 7 and 8 for the asynchronous and synchronous activities, respectively.

As those figures demonstrate, a high completion rate on the asynchronous elements for the onsite and online students can be noticed. For the synchronous elements and especially the lab reports, the onsite students were significantly more engaged than the online active students.

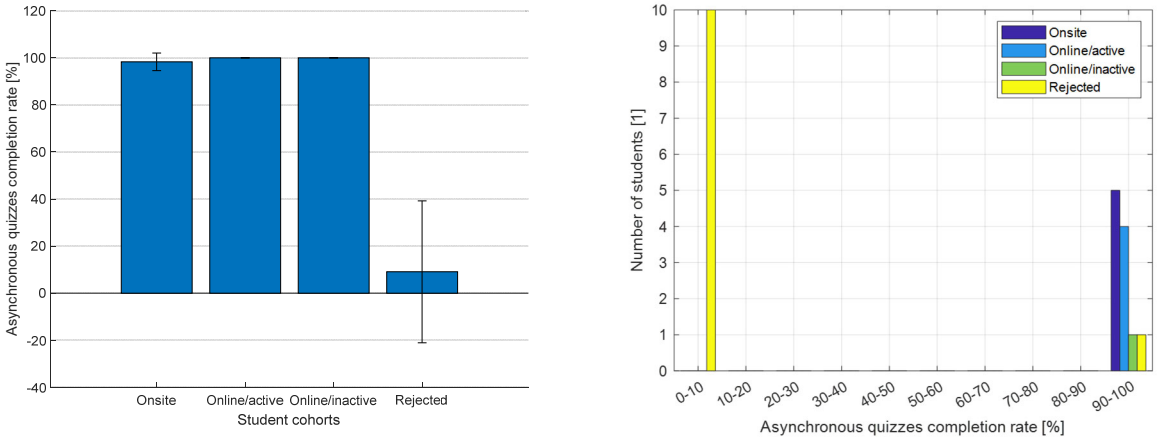

Figure 7. Asynchronous quizzes completion rates averaged on each student group (left figure) and corresponding student distribution depending on the completion rates (right figure). The completion rates on the left figure are also given with their respective standard deviations.

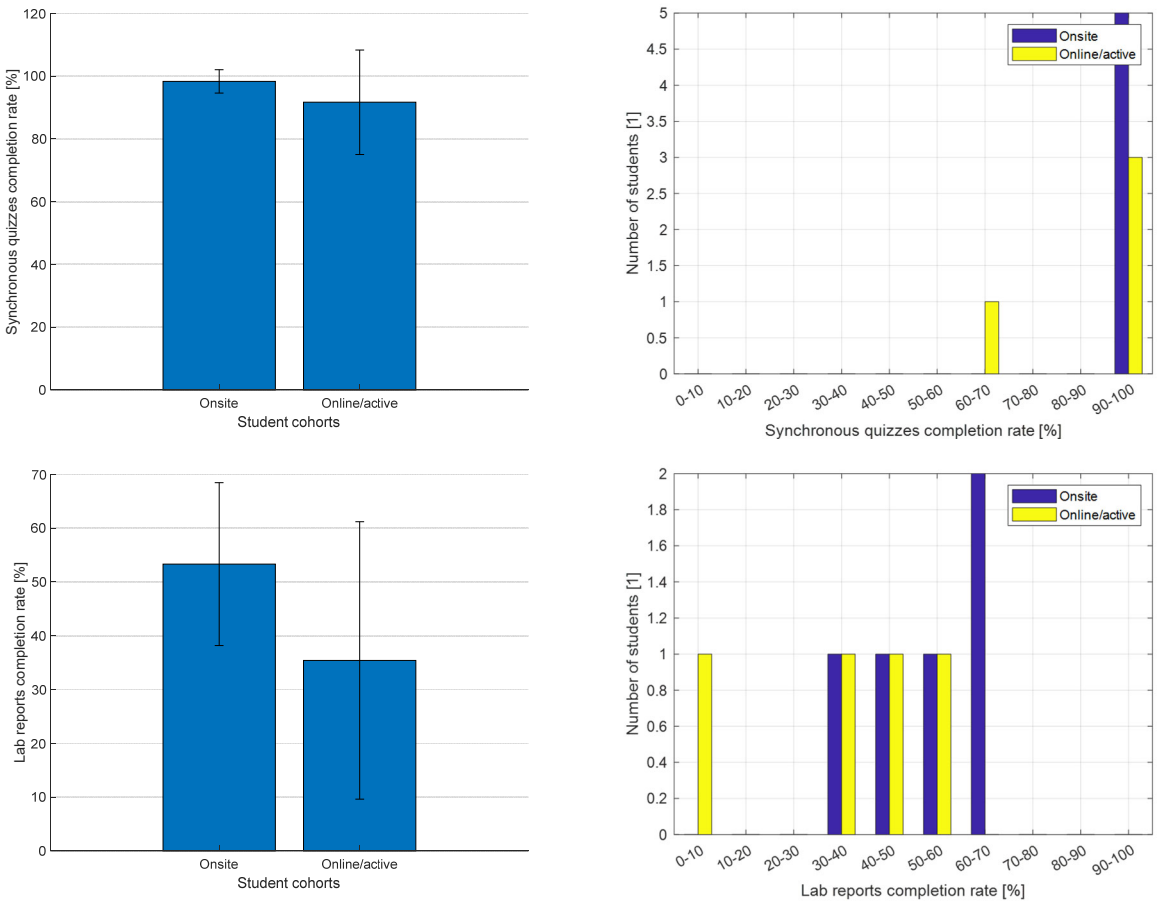

Figure 8. Completion rates averaged on each student group (left figures) and corresponding student distribution depending on the completion rates (right figures). The synchronous quizzes (top figures) and the lab reports (bottom figures) are separately analysed. The completion rates on the left figures are also given with their respective standard deviations.

5.2. Analysis of student performance

Student performance was measured by the average value of the grades for each of the categories of graded activities (irrespective of whether those activities were taken or not – a non-taken activity was given a grade of zero). This is presented in Figs. 9 and 10 for the asynchronous and synchronous activities, respectively. The final grade is also reported in Fig. 11. The final grade was estimated with a relative weight of 25% on the asynchronous quizzes and a relative weight of 75% on all synchronous activities.

As shown in those figures, whereas the success rate on the asynchronous elements does not differ between the onsite and the online active/inactive students, the onsite students perform much better on the synchronous activities than the online active ones. Nevertheless, most of the online active participants got a grade larger than 50 points and thus passed the course, whereas all onsite participants passed the course.

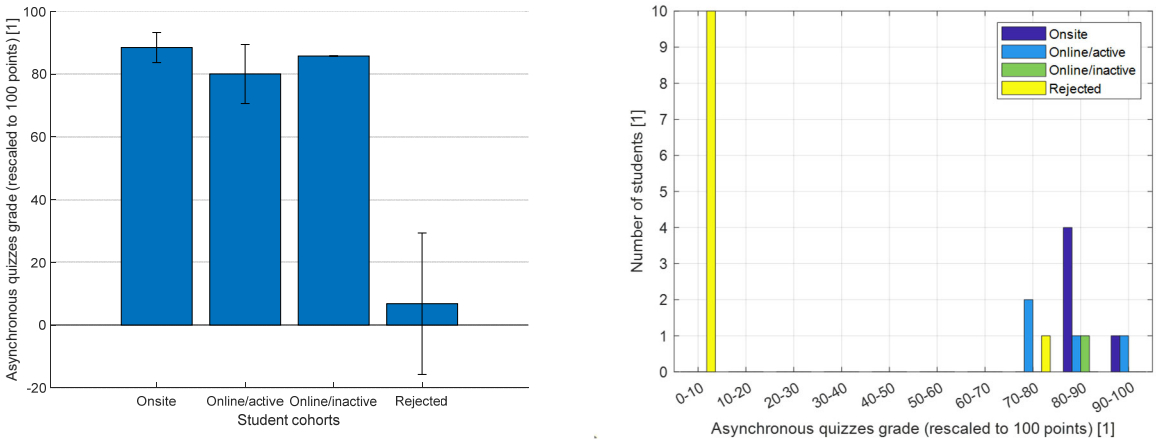

Figure 9. Grades on the asynchronous quizzes averaged on each student group (left figure) and corresponding student distribution depending on the grades (right figure). The grades on the left figure are also given with their respective standard deviations.

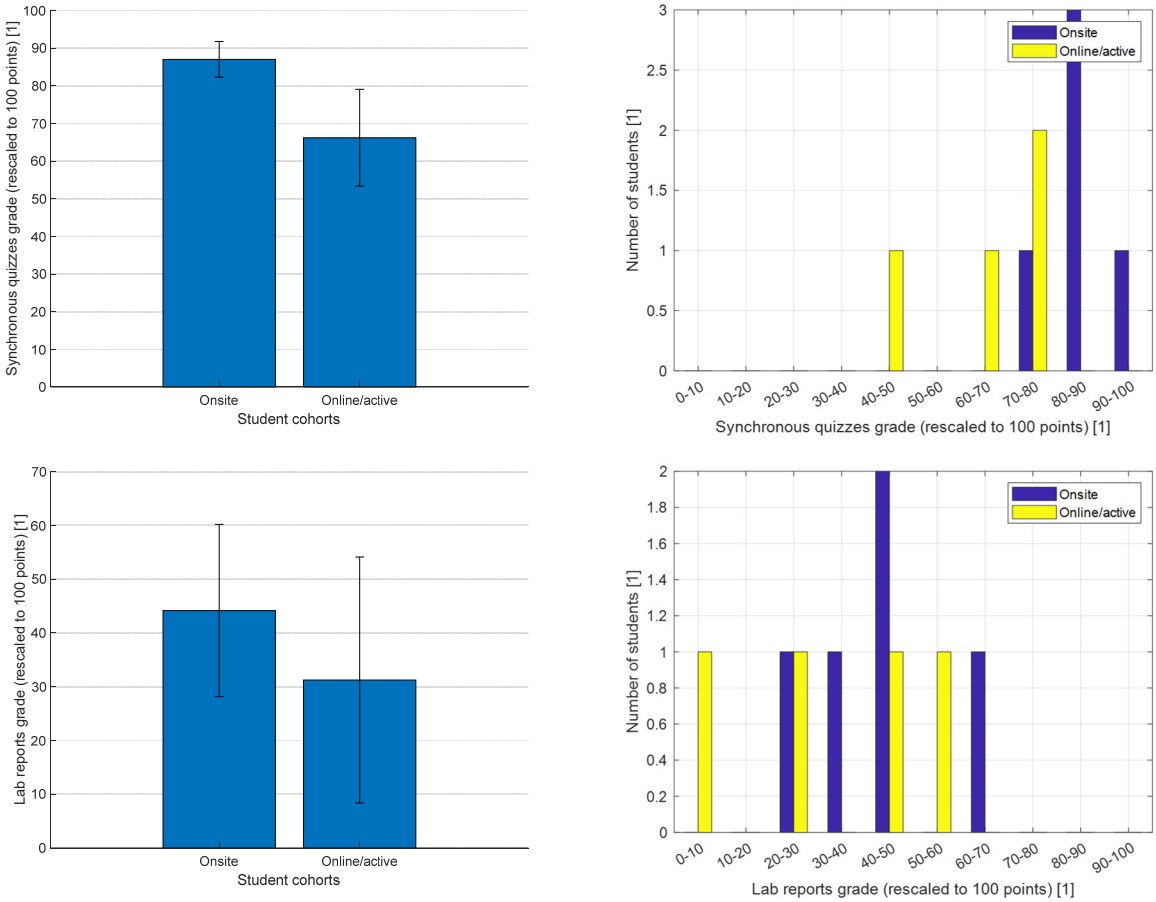

Figure 10. Grades averaged on each student group (left figures) and corresponding student distribution depending on the grades (right figures). The synchronous quizzes (top figures) and the lab reports (bottom figures) are separately analysed. The grades on the left figures are also given with their respective standard deviations.

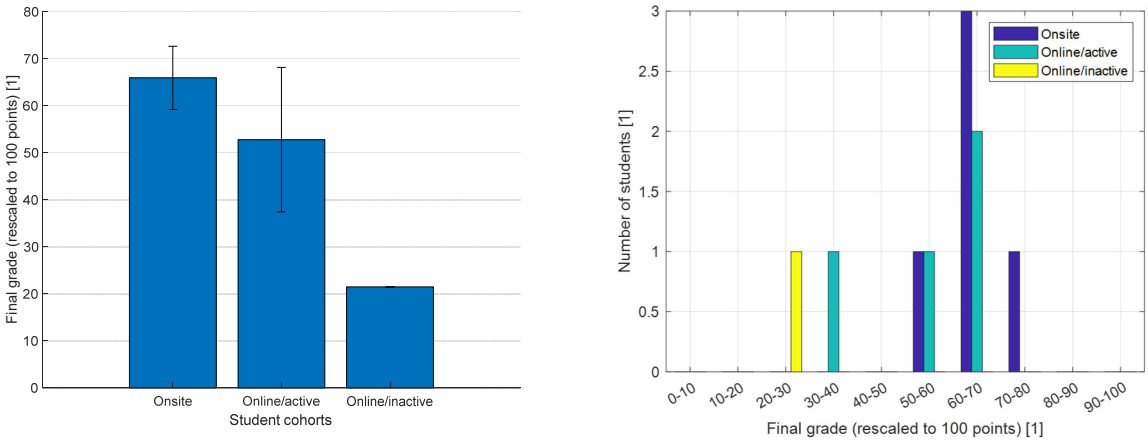

Figure 11. Final grades averaged on each student group (left figure) and corresponding student distribution depending on the grades (right figure). The grades on the left figure are also given with their respective standard deviations.

5.3. Analysis of student satisfaction

A course evaluation questionnaire was given on the last day of the synchronous sessions. Time was allocated to let the student answer the questionnaire on a voluntary basis. The questionnaires were not anonymous. Although the questionnaire contained many parts, only the following four statements that the students had to agree/disagree with on a 5-point Likert scale are analyzed hereafter. Those statements, which give an overview of student satisfaction, were:

- Q1: I gained a deeper understanding of the theoretical concepts.
- Q2: I developed practical skills relevant to the nuclear field.
- Q3: The course content was well-organized and easy to follow.
- Q4: The teaching methods used were effective in facilitating my learning.

The results are presented in Fig. 12. A high average agreement with the statements above can be noticed.

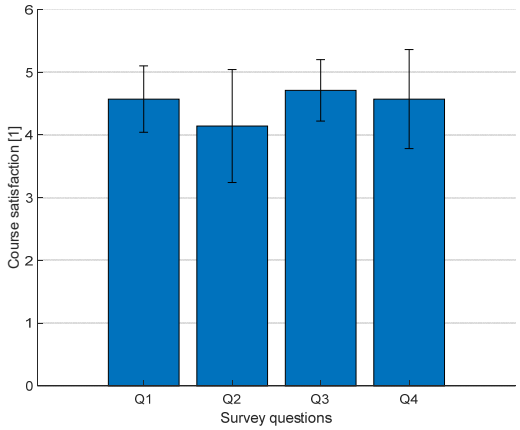

Figure 12. Mean values and associated standard deviations of agreement with the statements regarding course satisfaction (1=strongly disagree – 5=strongly agree). Seven students answered the questionnaire.

6. Feedback from the first edition of the hands-on sessions at CROCUS

The synchronous learning phase took place between May 29 and June 2, 2023, at EPFL, Lausanne, Switzerland. Out of 15 applications received to attend the course, nine were discarded. Only onsite participation was possible. All 6 accepted applications were given access to the LMS.

An analysis of the student participation, performance and satisfaction is presented below in an aggregated manner. In order to better highlight differences, the analysis is made on different categories of students:

- A category called “Rejected” encompassing all students who did not reach the necessary level of completion rate on the asynchronous activities to qualify for the synchronous activities (two students).
- A category called “Onsite – active” encompassing all students who qualified for the synchronous sessions onsite, and who completed at least one activity during those sessions (four students).

It should be noted that all onsite attendees completed at least one activity during the interactive sessions.

6.1. Analysis of student participation

Student participation was measured via the average value of the completion rate on the asynchronous elements (asynchronous quizzes) and on the synchronous elements (reports). This is presented in Figs. 13 and 14 for the asynchronous and synchronous activities, respectively.

As those figures demonstrate, a high completion rate on the asynchronous elements can be noticed.

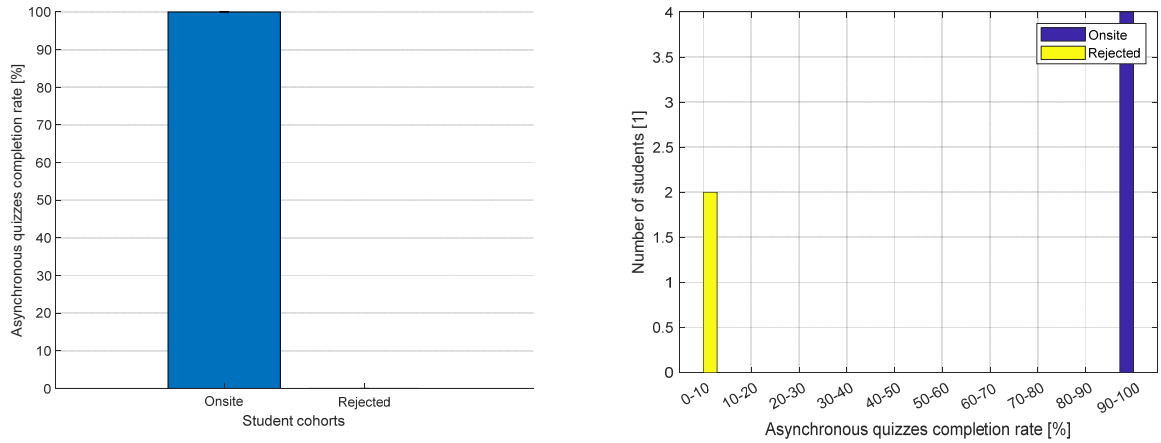

Figure 13. Asynchronous quizzes average completion rate (left figure) and corresponding student distribution depending on the completion rates (right figure). The completion rate on the left figure is also given with its respective standard deviation.

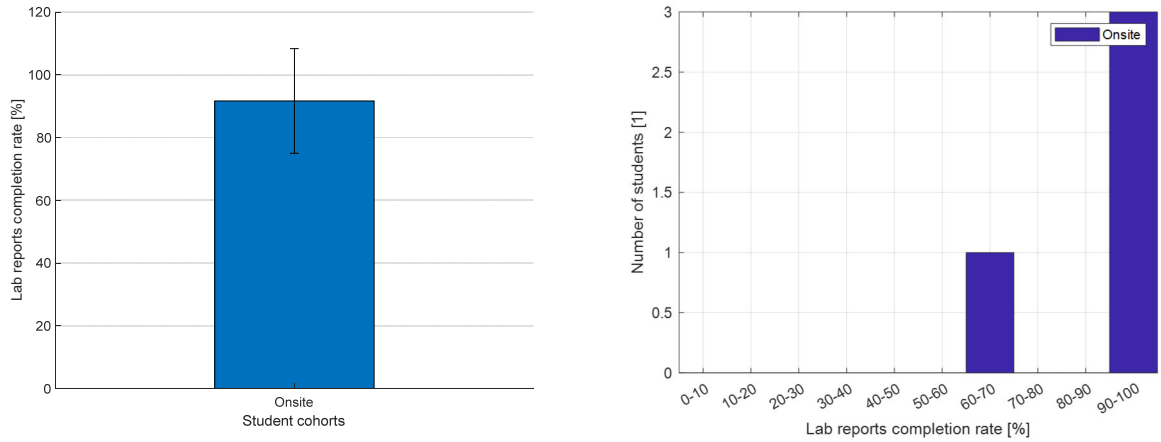

Figure 14. Lab report average completion rate (left figures) and corresponding student distribution depending on the completion rates (right figures). The completion rate on the left figure is also given with its respective standard deviation.

6.2. Analysis of student performance

Student performance was measured by the average value of the grades for each of the categories of graded activities (irrespective of whether those activities were taken or not – a non-taken activity was given a grade of zero). This is presented in Figs. 15 and 16 for the asynchronous and synchronous activities, respectively.

The final grade is also reported in Fig. 17. The final grade was estimated with a relative weight of 25% on the asynchronous quizzes and a relative weight of 75% on all synchronous activities.

As shown in those figures, a high success rate was achieved.

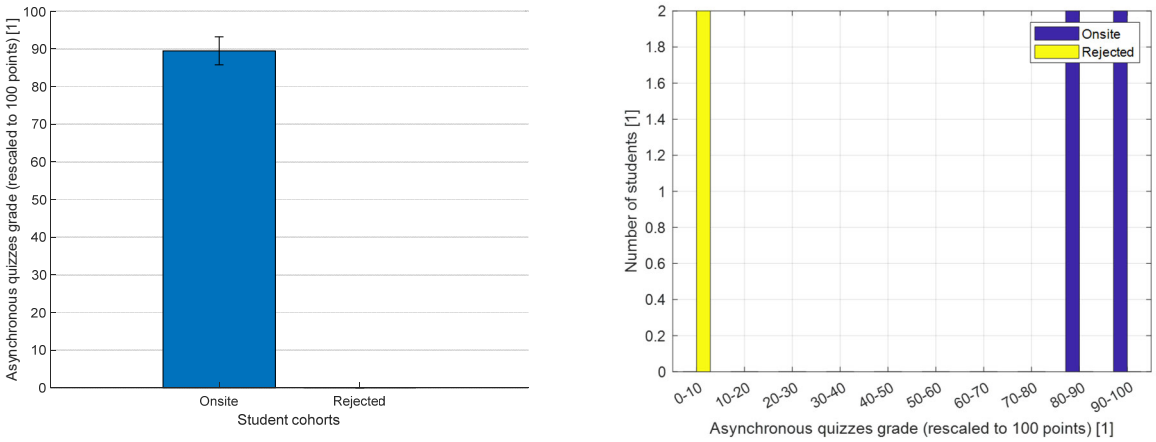

Figure 15. Average grade on the asynchronous quizzes (left figure) and corresponding student distribution depending on the grades (right figure). The grade on the left figure is also given with its respective standard deviation.

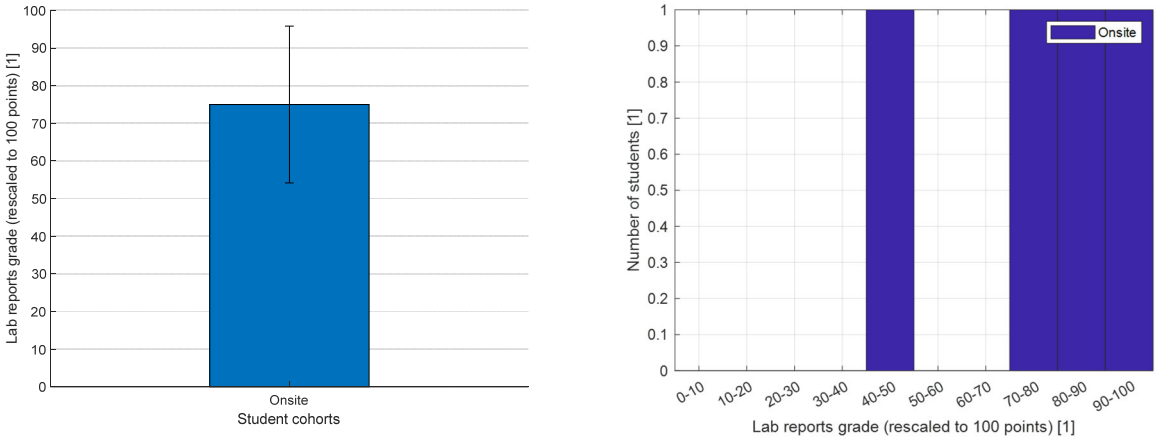

Figure 16. Average grade on the lab reports (left figure) and corresponding student distribution depending on the grades (right figures). The grade on the left figure is also given with their respective standard deviation.

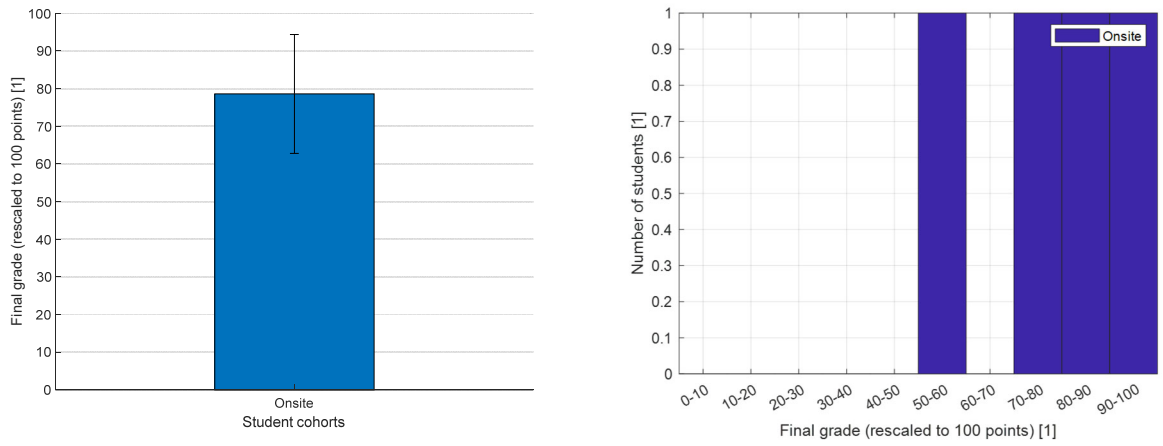

Figure 17. Average final grade (left figure) and corresponding student distribution depending on the grades (right figure). The grade on the left figure is also given with its respective standard deviation.

6.3. Analysis of student satisfaction

A course evaluation questionnaire was given on the last day of the synchronous sessions. Time was allocated to let the student answer the questionnaire on a voluntary basis. The questionnaires were not anonymous. Although the questionnaire contained many parts, only the following four statements that the students had to agree/disagree with on a 5-point Likert scale are analyzed hereafter. Those statements, which give an overview of student satisfaction, were:

- Q1: I gained a deeper understanding of the theoretical concepts.
- Q2: I developed practical skills relevant to the nuclear field.
- Q3: The course content was well-organized and easy to follow.
- Q4: The teaching methods used were effective in facilitating my learning.

The results are presented in Fig. 18. A high average agreement with the statements above can be noticed.

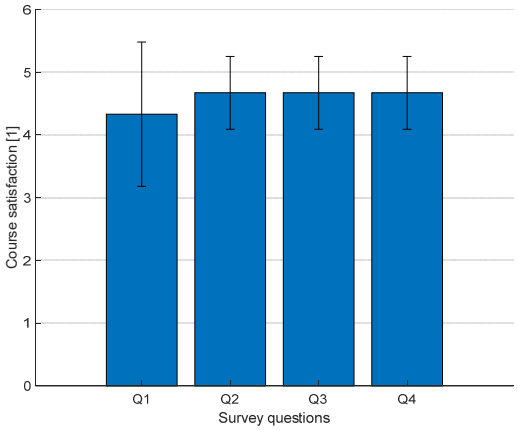

Figure 18. Mean values and associated standard deviations of agreement with the statements regarding course satisfaction (1=strongly disagree – 5=strongly agree). Three students answered the questionnaire.

7. Conclusions

As demonstrated in this analysis, the onsite students and the online active students are actively engaged in both the asynchronous and synchronous activities. As expected, the success rates on the asynchronous activities are higher than on the synchronous activities, as the former ones target lower order thinking skills. Concerning the synchronous activities, a lower success rate for the online students is noticeable. Although a more thorough analysis is required, it is believed that the LMS providing immediate update on the grades when an activity is completed might be responsible for the lower success rate. As the online participants combine their synchronous participation with other duties (job, other studies, family, etc.), they most likely tend to simply pass the course, i.e., to get a grade of just 50 points. The onsite participants, on the other hand, by the nature of their onsite attendance, are more dedicated to the synchronous activities.

In terms of course satisfaction, the students are overwhelmingly satisfied with the course. A thematic analysis of the participants' answers to the open questions on what they liked and disliked about the courses is on-going.

The course design aimed at engaging the students in various activities, and at making sure the students learnt the various concepts and could apply them properly. In terms of successful course completion rate for the active students (onsite and, when relevant, online), the following was achieved:

- For the course on Neutron transport at the fuel cell and assembly levels, 82.1% of the active students successfully passed the course (23 students).
- For the hands-on at AKR-2, 80% of the active students successfully passed the course (eight students).

- For the hands-on at CROCUS, 100% of the active students successfully passed the course (four students).

8. References

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