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Coordination and Support for National Competence Centres on a European Level

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D3.1

The CASTIEL Report
Initial Training, Twinning and Mentoring Opportunities and the Needs of NCCs

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List of abbreviations

AI	Artificial Intelligence
CC	Competence Centre
CoE	Centre of Excellence
DoA	Description of Action
DL	Deep Learning
GPU	Graphics Processing Unit
HPC	High-Performance Computing
HPDA	High-Performance Data Analytics
ICM	Initial Competence Map
IPR	Intellectual Property Rights
KPI	Key Performance Indicator
LE	Legal Entity
ML	Machine Learning
MPI	Message Passing Interface
NCC	National Competence Centre
OpenMP	Open Multi-Processing
PMT	Project Management Team
PTC	PRACE Training Centre
RIA	Research and Innovation Action
TTM	Training, Twinning and Mentoring
WP	Work Package

Executive Summary

The mission of CASTIEL [1] is to contribute to the success of the activities of the National Competence Centres within the EuroCC project [2] by tackling both the maintenance and strengthening of excellence, while identifying and closing gaps due to the diverse levels of maturity between the different nations. CASTIEL will therefore bring together a core consortium to set up a framework of activities that will support the evolution of each single NCC and enable them step by step to get closer together in terms of capabilities and expertise.

Training, twinning and mentoring is the topic of Work Package 3 (WP3) in CASTIEL. The objectives of this work package are:

- To establish a cross-Competence Centre working group on Training, Twinning and Mentoring (TTM)
- To provide an overview of existing (and upcoming) training activities in close interaction with similar initiatives, such as the PRACE Training registry [3], the FocusCoE training registry [4] and others
- To identify training gaps and the needs of support of the different Competence Centres
- To organise Twinning and Mentoring to support the inter-Competence-Centre interactions on training.

One of the first tasks was to set up a working group with the appropriate expertise to identify and catalogue the current state-of-the-art in HPC, HPDA and AI training in Europe. Followed by the task of cross-checking the obtained training catalogue with the initial competence map developed by WP2 "Competence Mapping and Networking" and identification of gaps and needs.

To identify the current state-of-the-art in HPC, HPDA and AI training, the results from the training mapping survey, the questionnaire for the NCC representatives in the area of training chosen within the NCC at the beginning of the project (i.e. the Champions for TTM), and the first meeting with the Champions for TTM were taken as the starting point. We also identified the key players and similar initiatives. This initial overview was then cross-checked with the competence map done by WP2. Based on this work, the first identification of training competences, opportunities, as well as constraints, gaps and needs related to training, twinning and mentoring was carried out.

During M1-5 of this project, the European panorama of training on HPC, HPDA and AI per country was obtained from the work of this WP and a database with information on training was established that is ready for a more detailed analysis. The initial training mapping survey provided very useful information, however, the current picture is incomplete as the mapping work is still ongoing, and will continue for some time as a living document. There will be further iterations of the training map within the project. The initial constraints, gaps and needs related to TTM on the European and national level have been identified and they will be addressed in the next work of this WP in the training plan. Also, the initial opportunities for twinning and mentoring were identified and they will be developed in more detail. Twinning and mentoring will be encouraged among NCCs in the remaining one and a half years of the project.

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1 Introduction

The mission of CASTIEL [1] is to contribute to the success of the activities of the National Competence Centres within the EuroCC project [2] by tackling both the maintenance and strengthening of excellence, while identifying and closing gaps due to the diverse levels of maturity between the different nations. CASTIEL will therefore bring together a core consortium to set up a framework of activities that will support the evolution of each single NCC and enable them step by step to get closer together in terms of capabilities and expertise.

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One of the first tasks was to set up a working group with the appropriate expertise to identify and catalogue the current state-of-the-art in HPC, HPDA and AI training in Europe. Followed by the task of cross-checking the obtained training catalogue with the initial competence map developed by WP2 "Competence Mapping and Networking" and identification of gaps and needs.

This deliverable will present the results from the training mapping survey, from the questionnaire for the NCC Champions for TTM (i.e. the representatives in the area of training chosen within the NCC at the beginning of the project), the initial overview of available training competences of NCCs, initial TTM opportunities, and a first identification of the needs for TTM of NCCs.

Section 2 looks at the training mapping survey, its methodology, structure and it shows the results in more detail.

The third section describes the methodology and individual results to the questions of the questionnaire distributed among the Champions for TTM.

In the fourth section the received information from the Champions is cross-checked with the information received in WP2 through the initial competence mapping.

Section 5 looks at the available competences and initial opportunities in TTM and Section 6 describes the identified needs for TTM of NCCs.

Major achievements are presented in Section 7 and concluding remarks in Section 8.

References and annexes with the used documents and the list of names of key training providers are the final sections of this document.

2 Training Mapping Survey

2.1 Methodology

Part of the Task 3.1: Working Group on Training was a subtask to identify the current state-of-the-art in HPC, HPDA and AI training across Europe. This section describes the used methodology as well as the main findings from the generic part in the initial training mapping survey.

In order to identify the current and future state-of-the-art in HPC, HPDA and AI training across Europe, we started with the identification of key players and similar initiatives in Europe, such as PRACE, FocusCoE and ETP4HPC [5].

A further step was to identify the training offers in each country. We were considering the best way to collect this information and due to the time constraint, we decided to use MS Excel to collect the information. We created the training mapping survey document that was sent to all NCCs for its completion. Before sending the final version, the draft of the mapping document was shared with the Champions for TTM to get their feedback. Feedback related to the time frame and the clarification of the scope of the survey was incorporated into the document. The spreadsheet was sent on October 22, 2020 with the deadline on November 20, 2020.

Amendments to the initial spreadsheet, especially the generic section, were sent by several countries during the period February 8 – 19, 2021 to better reflect the reality in their respective countries. New information was incorporated into the analysis and the results are shown in the next sub-sections.

In the future, all training activities available in every participating country will be entered directly in the HPC portal [6] by every NCC with their login details. The HPC portal has been developed by PRACE and it is intended to display all HPC related services in Europe, including training and events. It was decided to use this portal for information collection and visualisation in the form of a map because it is already developed and it serves the needs of CASTIEL. A website called EuroCC ACCESS [7] was created within CASTIEL that aims to present a competence map of the National Competence Centres (NCCs) and their HPC-related activities along with a place for an exchange with other stakeholders. In addition, the NCCs will have a dedicated space to exchange among themselves best practices, guides and collaborations. The HPC portal has been embedded in the EuroCC ACCESS and in the websites of the NCCs that expressed their interest.

Structure of the document – the mapping document had two parts –

1. The generic section with several questions to find out more about the NCC training resources, constraints and needs related to their training activities and whether they would welcome support.
2. The training activities section to find out more information about the training activities.

Scope of the survey – the ultimate goal is to map all HPC, HPDA and AI training activities available in each participating country. We were aware that for some countries this would require more time and effort, therefore we asked for the following: If they were able to provide the complete information for the whole country, they were supposed to do that. If they were not able to provide that information at the moment, we asked the NCCs to focus on HPC, HPDA and AI training activities provided by the NCC and its partners.

We asked to include the information that they had or they could obtain. If they did not have a certain information, they could leave the column empty for the time being, since there will be more checks in the future.

Time frame for the training activities – each NCC was asked to consider the academic year which is for the majority of the countries from September until August. They were supposed to fill in upcoming activities for the period Sep 2020 – Aug 2021 (all training activities since September 2020 and planned activities until August 2021) and past activities for the period Sep 2019 – Aug 2020 (all training activities that happened during that time frame).

The final version of the training mapping survey can be found in Annex 1.

2.2 Results from the Generic Section

The next sub-sections show the results for the questions asked in the Generic part of the mapping survey.

2.2.1 Countries that provided their mapping

All countries involved in the EuroCC project (33) have provided their initial training mapping survey.

Only 24% of countries provided mapping for the whole country as you can see from Figure 1. The remaining 76% provided information mapping the NCC and its partners or only the NCC.

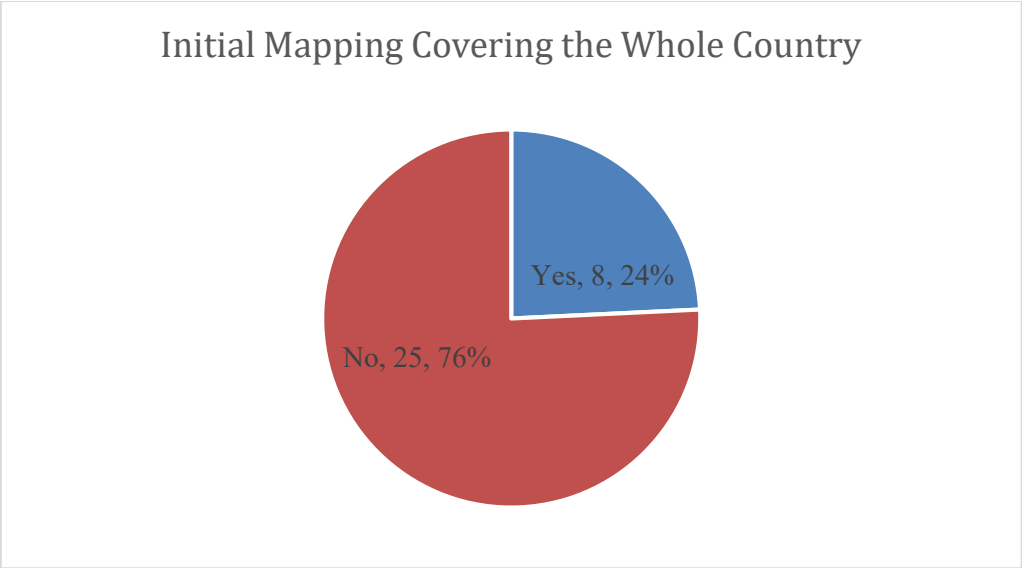


Figure 1: Initial mapping covering the whole country.

Some countries provided information for the past and current academic years and some countries provided information mainly for the past academic year. The level and detail of provided information about each training activity were diverse and heterogeneous. It is important to mention that the mapping work is still ongoing and will continue for some time as a living document. Missing data will be gathered with the future mappings.

2.2.2 Specific education for trainers

2) Do trainers receive specific education on creating and running training activities?

As you can see from Figure 2, the majority of trainers do not receive specific training on creating and running training activities (61% of the NCCs), 6% of the NCCs did not provide this information. In some cases, trainers do not receive any specific education because they already have previous experience or they are professors at university. Few mentioned that they have been working on creating specific training for trainers.

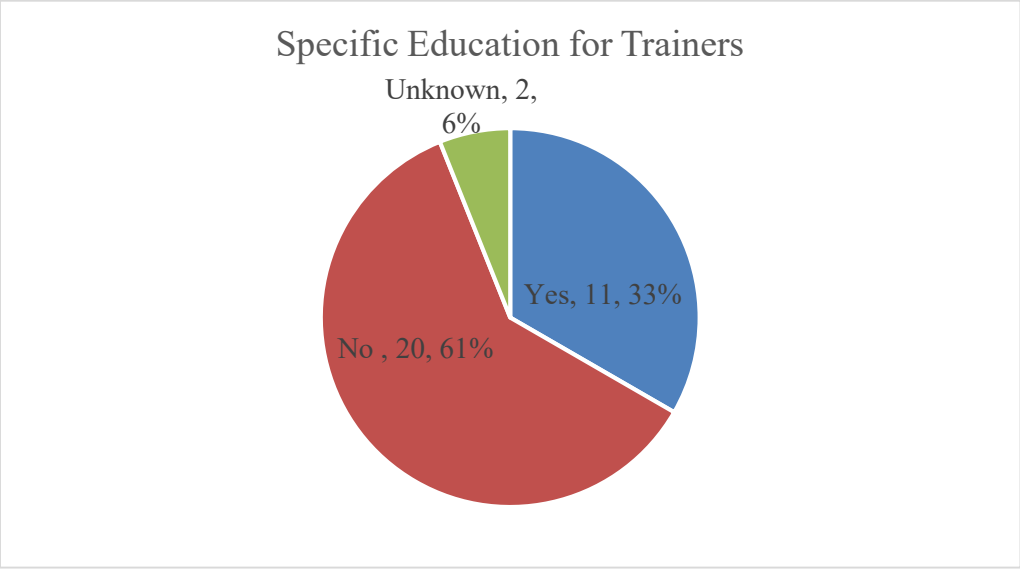


Figure 2: Trainers receiving specific education

2.2.3 Own space for training activities

3) Do you have your own space for hosting your training activities?

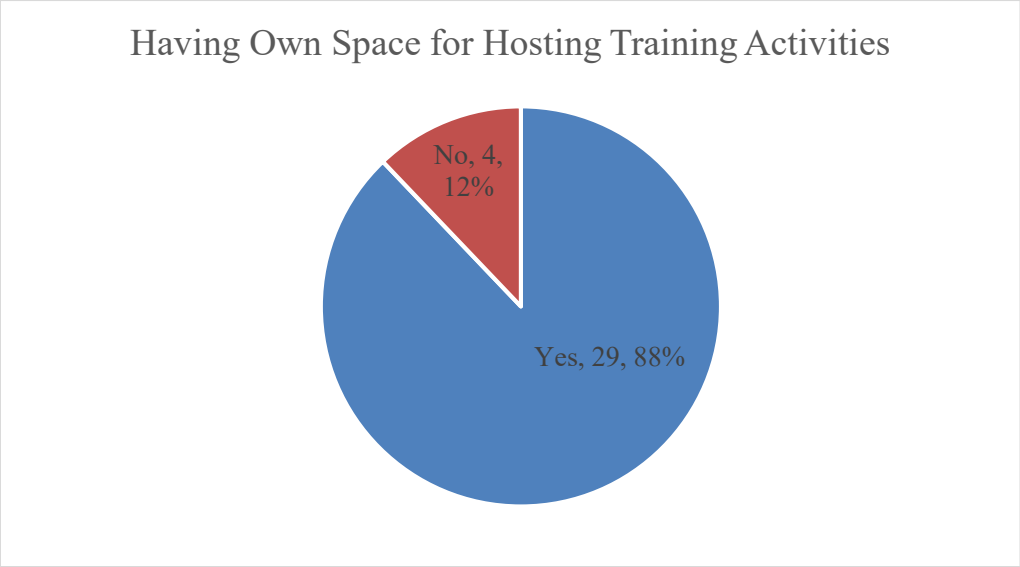


Figure 3: Having own space for hosting training activities

As you can see from Figure 3, 88% of countries have their own space to host their training activities or they use lecture rooms at the university.

2.2.4 A specific training IT infrastructure

4) Do you have a specific training IT infrastructure?

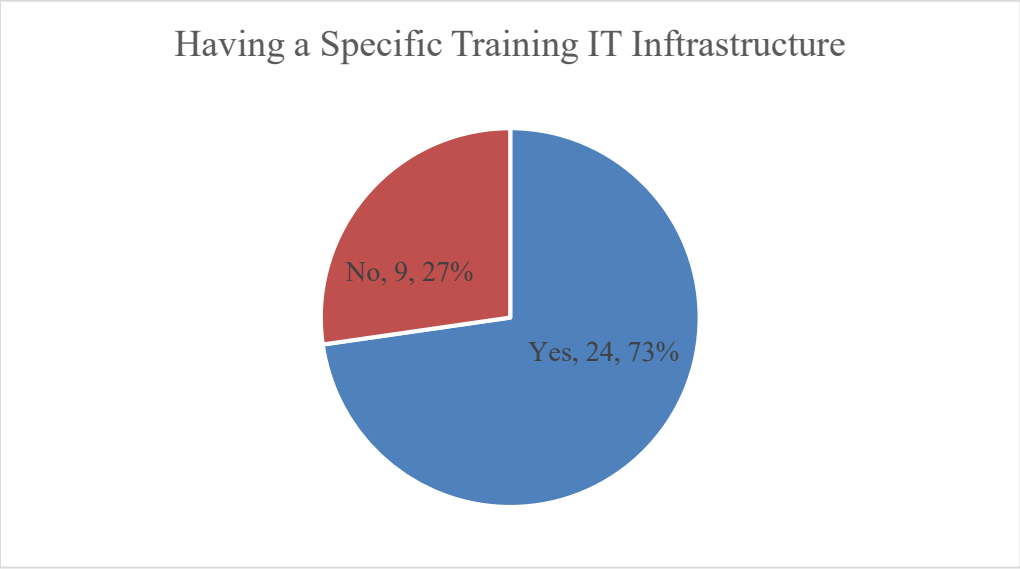


Figure 4: Having a specific training IT infrastructure

As you can see from Figure 4, 73% of the countries have a specific training IT infrastructure.

2.2.5 Dissemination channels for training

5) What are the advertising/promotional channels for your training activities?

The channels to promote and/or advertise training activities are mentioned in Table 1.

Dissemination channels for training activities	Number of mentions
Centre's website	23
Email, mailing lists	22
Social media (LinkedIn, Twitter, Facebook, YouTube)	20
University(ies) website(s)	8
Newsletter	6
Other websites (PRACE training portal, other training portals)	5
Direct contacts, word-of-mouth	3
Print media	2
University weekly journal	1
Events	1
Press releases	1

Table 1: Advertising/promotional channels for training activities

The most used promotional channels at NCCs for training activities (at least 20 mentions) are NCC websites, emails and mailing lists, followed by social media, such as LinkedIn, Twitter, Facebook and YouTube. The university website, newsletter and other websites, such as PRACE training portal or other training portals, direct contacts and other channels are less used by the NCCs.

2.2.6 Constraints/obstacles related to training

6) What constraints or obstacles related to the training offers/activities do you have? Please explain in detail.

The constraints or obstacles related to the training offers/activities that the countries experience are shown in Table 2.

Constraints related to training activities/offer	Number of mentions
Number of trainers and their time is limited	6
Hard to find presenters for specialized HPC/HPDA/AI topics	5
Insufficient number of attendees	4
Covid-19 complicating onsite trainings, conversion to online takes time, it makes it difficult for practical/hands-on courses	4
Inadequate or lack of cooperation with the industry	3
The establishment of quality criteria from the Ministry, legislative change, licence prohibiting offering courses outside university	3
Budget constraints	2
Many activities and time needed with the organization of the training	2
Bigger, better equipped training facilities would be better	2
Targeted outreach to specific communities/new audience	2
No constraints	5
Other	14

Table 2: Constraints related to training activities/offer

The main constraints related to training concern the trainers and the attendees. With regard to trainers, there is an insufficient number of trainers, their time is limited and it is hard to find presenters for specialised HPC/HPDA/AI topics. With regard to attendees, some countries have issues with finding sufficient number of attendees for their training activities. Further constraints refer to the COVID-19 pandemic that is complicating on-site trainings and hands-on courses, and to the cooperation with the industry that is sometimes seen as lacking or insufficient. Several countries mentioned specific constraints that are subsumed into the category Other.

2.2.7 Training activities needs

7) What needs do you have in connection with the training offers/activities? Please explain in detail.

The needs related to the training offers/activities that the countries have are shown in Table 3.

Training activities needs	Number of mentions
Need for trainers for new or advanced topics	6
Increasing the out-reach to industry, SMEs	5
A more reliable access to training resources, training material, sharing experience	5
Train the (potential) Trainers	4
Access to (training) HPC infrastructure	3
A specialized online training event for our community organized by CASTIEL	2
Budget for EuroCC training	2
Harmonization, coordination/collaboration on contents across countries for different training topics, Joint degrees with European partners	2
Other	8
No specific needs noted	7

Table 3: Needs related to training activities/offer

The need for trainers for new or advanced topics and the need to train the current or potential trainers are the main needs related to this area that were mentioned by the NCCs (6 and 4 mentions respectively). Also, the need to collaborate more with the industry, especially SMEs, is evident among NCCs (5 mentions). Access to training resources, material and (training) HPC infrastructure is also needed by the NCCs (5 and 3 mentions).

2.2.8 Welcoming support and guidance in the area of training

8) Would you welcome support and guidance in the area of training from more experienced/mature organisations?

The next figure (Figure 5) shows the interest in support and guidance from more experienced/mature organisations.

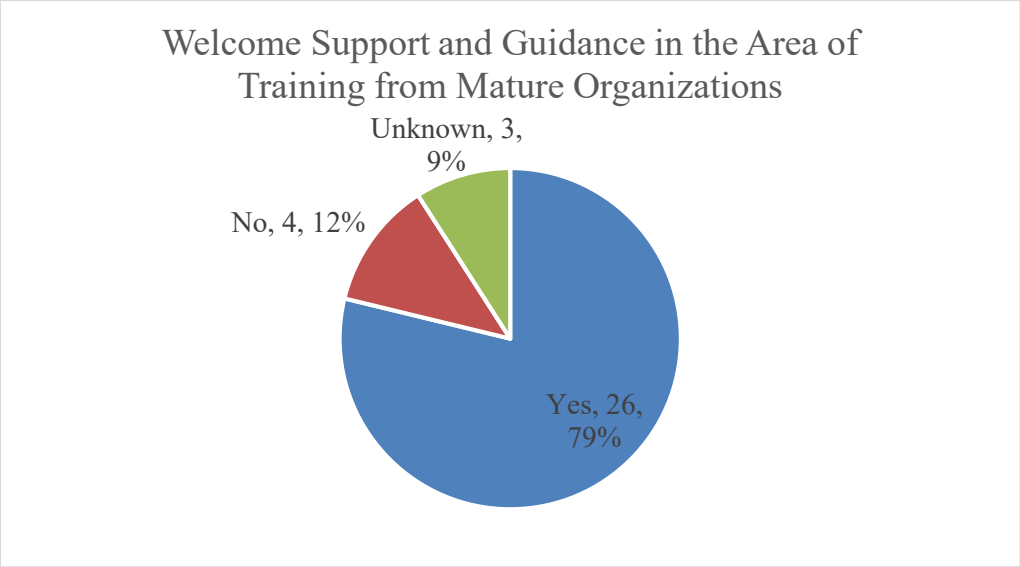


Figure 5: Welcoming support & guidance in the area of training from mature organisations

The majority of NCCs (79%) would welcome support and guidance in the area of training from more experienced/mature organisations. In two cases the NCCs already collaborate with more

experienced organisations. 12% of NCCs said that they do not need any support or guidance because they already consider themselves being experienced.

Support that was mentioned specifically was related to:

- help with trainers for non-academic training
- industry-related
- peer-network
- learn from others to improve training offering internally, nationally

2.2.9 National/local key training providers

9) Who are the national/local key training providers in the areas of HPC, HPDA and AI in your country? Please write down the names.

The number of mentioned key training providers in each country is shown in Figure 6.

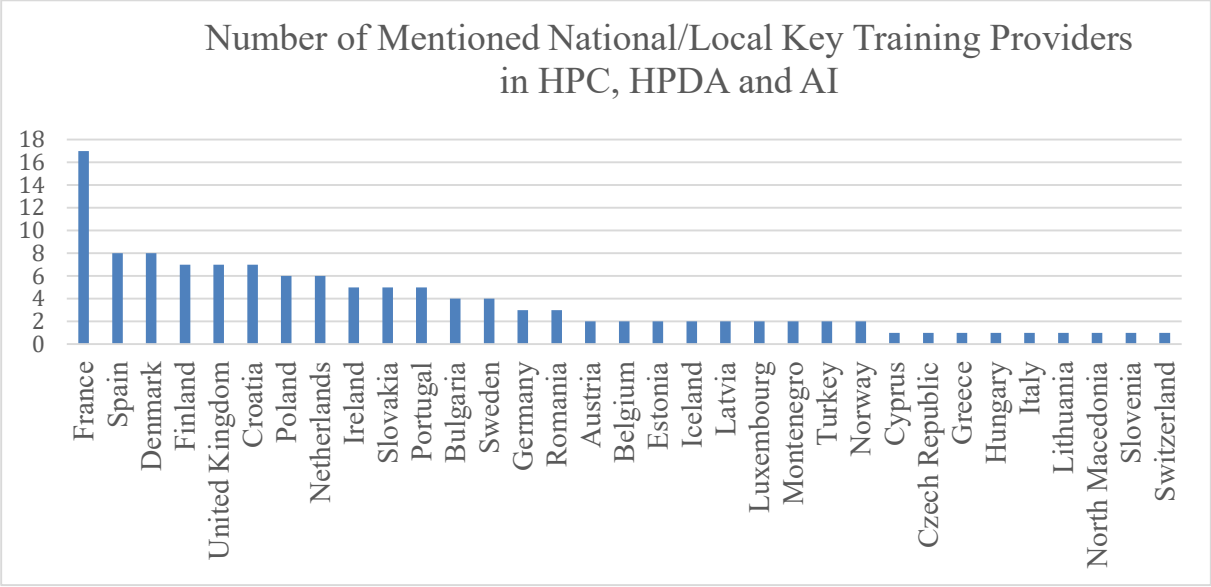


Figure 6: Number of mentioned national/local key training providers

It is important to mention that this is not a final number of key training providers in each country – this figure reflects the responses provided by the NCCs in the initial mapping. For some countries it is the final number of the key training providers at the moment of writing this document, however, for the majority the graph only shows the NCC and its partners, or the NCC alone. The data is incomplete as the mapping work is still ongoing and will continue for some time. The list of names of the national/local key training providers mentioned by the NCCs in the initial mapping can be found in Annex 3.

2.3 Results from the Training Activities Section

Nearly every NCC provided information about their past and/or ongoing training activities. The level of detail was very diverse. Consequently, the analysis of this section is to be seen as a very first preliminary assessment rather than a conclusive final evaluation. Moreover, due to tight schedules and an anticipated increased level of technical complexity, it was decided to just provide a brief summary at this stage, highlighting the most evident characteristics. A much more profound analysis will be provided in an upcoming document called the Training plan which will be developed within the Task 3.2 and which will be part of the deliverable D3.2 Training, Twinning and Mentoring Plans and Achievements.

Despite the very preliminary nature of our analysis, **a few general trends can already be identified**:

- It is interesting to observe that the majority of countries primarily offer their courses to academia and only a limited number of nations have already developed a balanced offer for both industry and academia.
- In terms of target audience, most of the countries seem to provide courses to a subset of experience levels, e.g. beginners or potential users and less to advanced users.
- Classic HPC continues to be the main subject in most of the countries, with occasional exceptions where AI or HPDA are starting to become the major subjects of training activities.
- English is pretty much standard nowadays and only a minor fraction of countries offers their training in local language only.

More insights from this analysis and this section will be obtained by a uniform analysis over all the NCCs, and by comparing each NCC's training offer with their expressed training needs (Section 6), which will give rise to mentoring and twinning opportunities. It will also be interesting to analyse the details of the HPC topics taught across the NCCs (available in the training mapping survey) as well as the other attributes from the survey.

3 Questionnaire for TTM Champions

3.1 Methodology

In order to get more input on the topics related to TTM from the Champions for TTM, we decided to create an additional questionnaire that was sent after the deadline of the training mapping survey.

A questionnaire with 11 questions was created using the online platform called Typeform [8]. The link to the questionnaire was sent via email and the Slack workspace [9] to all Champions and deputies for TTM on November 26, 2020. The deadline to complete the questionnaire was on December 1, 2020.

We decided to use the Slack workspace to facilitate conversations among NCCs and between WP3 partners and the Champions for TTM, to promote training events of the NCCs and other information.

The questions were related to the following points:

- Country
- Topics for future workshops
- Knowledge/experience sharing with others
- Filters and descriptors on the new HPC portal
- Interest to hear from NVIDIA and its programmes
- Date for the first meeting with the Champions
- How we can support NCCs
- Any other comment

The final version of the questionnaire can be found in Annex 2.

3.2 Results

This section shows only results for questions relevant to the areas of TTM. The question about the presentation from NVIDIA was not included as well as the question about the date for the first meeting with the Champions since they are not related to the topic of this deliverable. NVIDIA had approached the project management team with an offer to present their training programmes to the NCCs to see whether there was an interest among NCCs to hear from NVIDIA. The aim of the second unaddressed question was to find out whether the Champions were available for a meeting before Christmas break.

3.2.1 Countries

1. *Which country do you represent?*

In total, 34 responses were received from 29 countries – in some cases there were two responses from the same country.

3.2.2 Topics for future workshops

2. *Which topics related to training, twinning and mentoring would you like to discuss in a workshop? If choosing Other, please specify.*

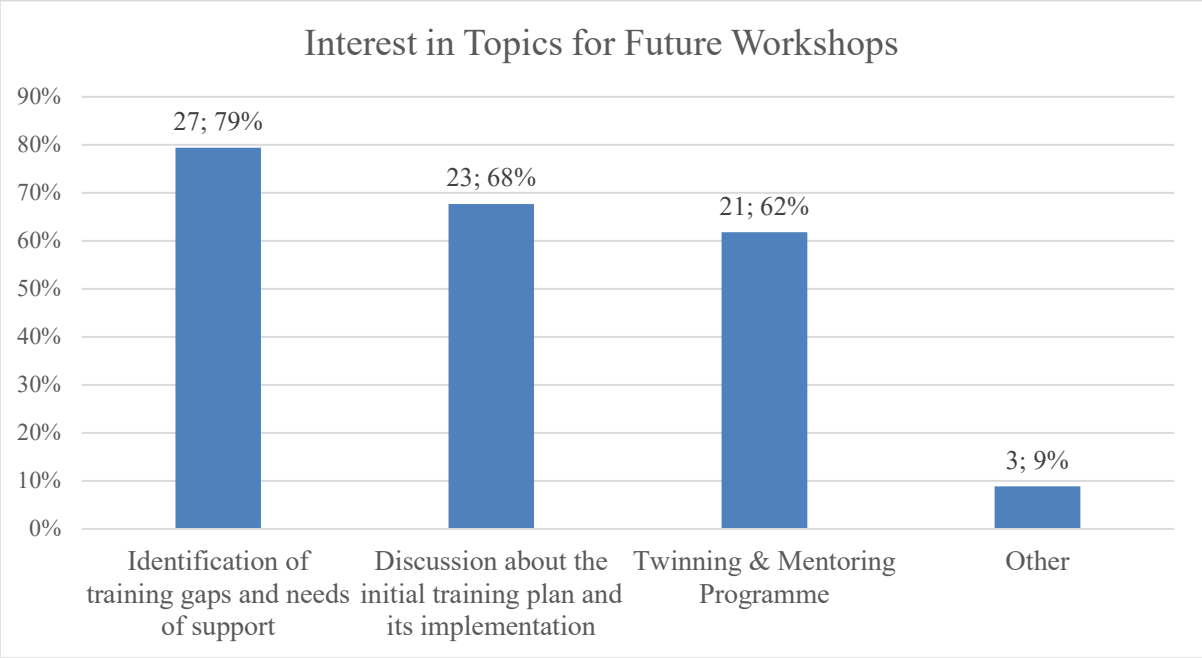


Figure 7: Interest in topics for future workshops

Overall, the majority of the respondents (79%) indicated that the most interesting topic for future workshops was the identification of training gaps and needs of support, followed by the discussion about the initial training plan and its implementation, selected by twenty-three respondents (68% of the total responses). The twinning & mentoring programme was selected by 62% of the total responses (see Figure 7).

Three respondents suggested other topics to be discussed in future workshops:

- Trainer exchange programme (might be considered under mentoring).
- Creation of dedicated education/training activities for users.
- Harmonisation of levels and certification of achievement.

3.2.3 Knowledge sharing

3. *Would you or someone from your NCC like to share with others your knowledge and experience related to training, twinning and mentoring at one of the future workshops?*

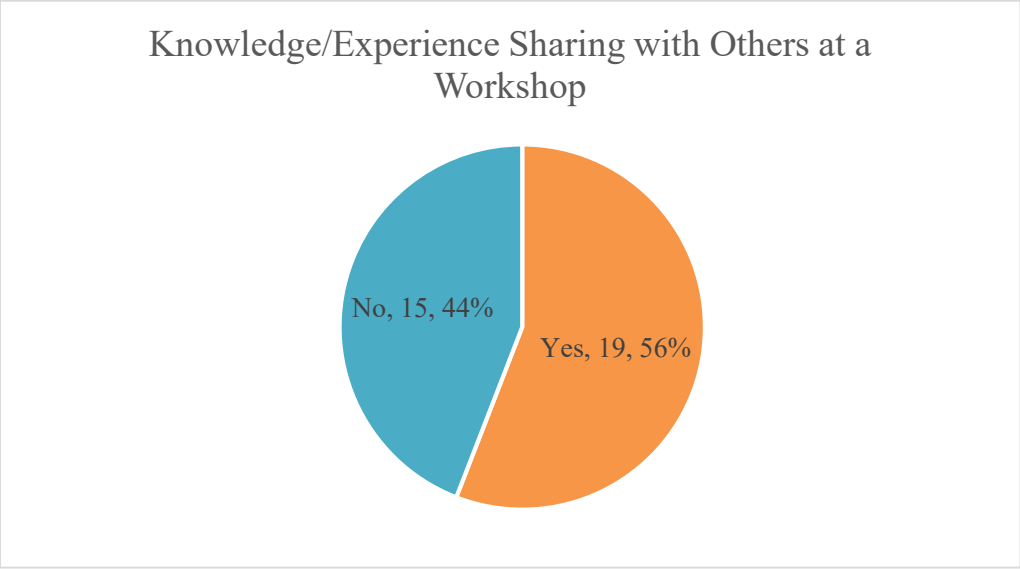


Figure 8: Willingness to share knowledge and experience with other NCCs

As for the knowledge sharing shown in Figure 8, more than half of the respondents (19 out of 34) indicated that they are willing to share their knowledge and experience related to TTM with other NCCs in future workshops.

3.2.4 Proposed topics

4. *If YES: Please let us know which topic(s) you would like to share:*

Topics to share with others	Number of mentions
Best practices for training (e.g. PRACE perspective, online training, HPC programmes, course organisation, setting up training programmes, best practices in teaching technical topics)	8
Technical training (e.g. GPU programming, preparation of computing time applications, parallel computing and its application to different fields of science, software refactoring and acceleration, etc, MPI and OpenMP, Data Science, Big Data)	3
Other	12

Table 4: Proposed topics to share with other NCCs in a workshop

All respondents willing to share their knowledge and experience related to TTM proposed different topics that they would like to share in a workshop (see Table 4). Best practices for training, e.g. PRACE perspective, course organisation, online courses, were the most mentioned topic, with a total of eight mentions. The second most mentioned topic was technical training – these countries provided specific topics of technical training that they are willing to share, such as MPI and OpenMP, Data Science and Big Data. Finally, 12 respondents proposed one specific topic that they would like to share with other NCCs in future workshops.

3.2.5 Filters on the new HPC portal

5. *We would like to check with you the filters that you would like to have on the future HPC portal showing the training activities in Europe. If choosing Other, please specify.*

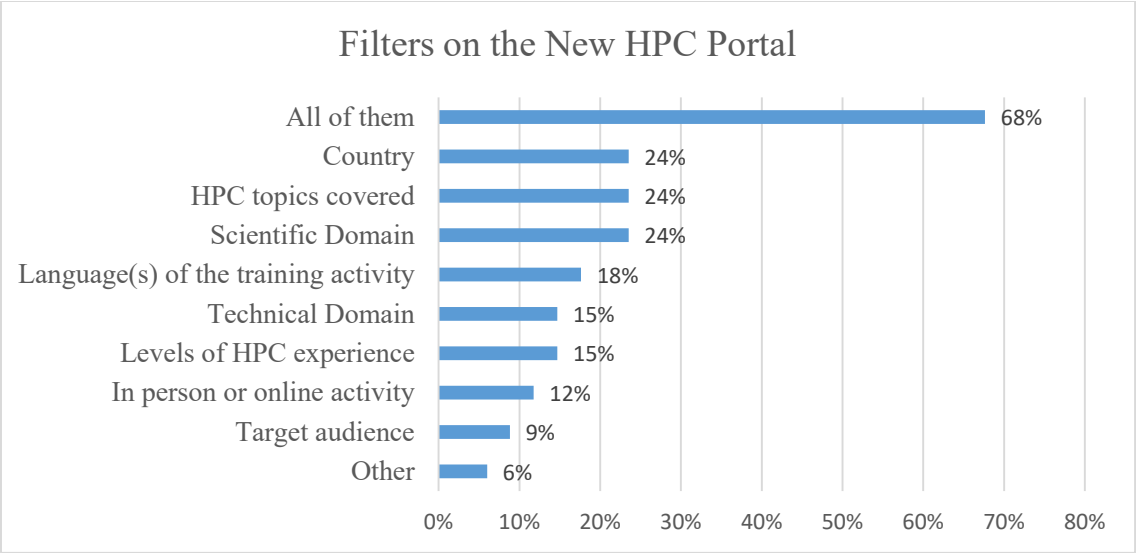


Figure 9: Desired HPC portal filters

Regarding the HPC portal that will be used to show all training activities, we proposed eight filters related to training activities (see Figure 9). A total of 23 respondents (68%) indicated the wish to display all of them in the new HPC portal. The individual filters selected by respondents (24%) were country, HPC topics covered and scientific domain, followed by language(s) of the training activity (18%), technical domain and levels of HPC experience (both 15%). 6% of the total respondents specified other filters to be displayed in the portal, such as duration and prerequisites.

3.2.6 Information displayed on the new HPC portal

6. *We would like to check with you the information that you would like to display in the future HPC portal about the training activities in Europe. If choosing Other, please specify.*

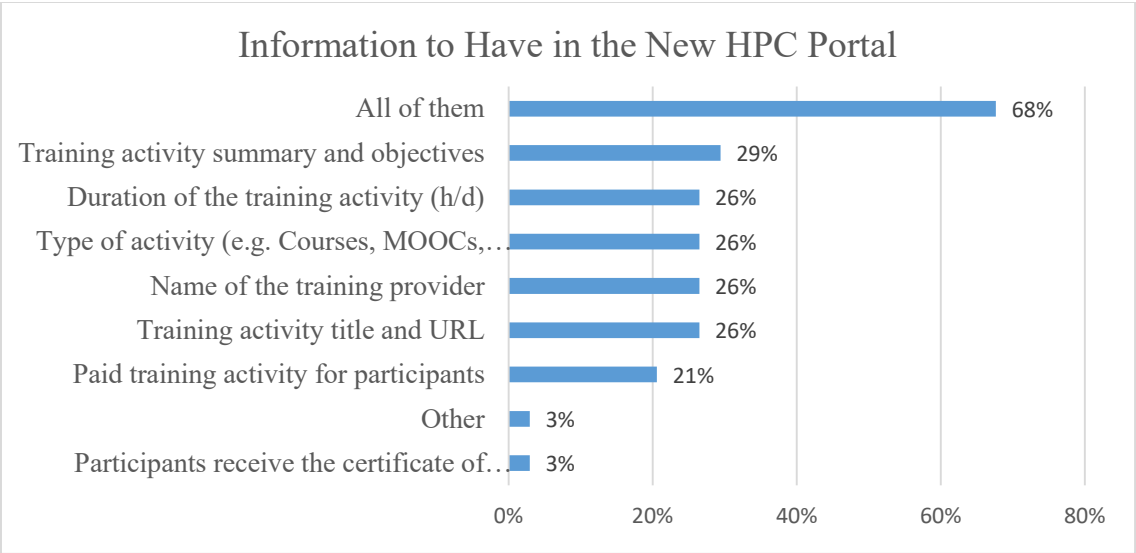


Figure 10: Desired HPC portal information

With regards to the information related to training activities to be displayed in the new HPC portal, seven categories were suggested (see Figure 10). More than half of the respondents

(68%) agreed that they would like all of the information to be displayed in the portal; 29% of the respondents agreed that, from the recommended topics, they would like the training activity summary and objectives to be shown in the portal. Furthermore, 26% of the respondents would like the information related to the duration of the activity, type of activity, name of the training provider and training activity title and URL information to be displayed. The information related to receiving the certificate of attendance was seen as unimportant by the vast majority of the NCCs. Other information to be displayed was related to the transfer of information between portals, rather than any other category of information.

3.2.7 Support from CASTIEL WP3

9. *In what ways could we support you with your training, twinning and mentoring planning, activities and evaluation?*

Ways to support NCCs	Number of mentions
Enabling sharing of experiences among NCCs	9
Providing information, key findings, best practices, high-novel cases, KPIs and other relevant material, future plans, resources, training events available in other countries	9
No support/help needed at this moment	9
Opening a discussion about a process to exchange trainers, train the trainers events, share training material	5
Allowing participation in activities	1
Building a collaboration group among countries in the pre-exascale consortiums to support industrial action.	1
Centrally organised training events from commercial vendors	1
Consultation in implementation of the new training programme in our country	1
Effective dissemination	1
Having a core set of KPIs across all NCC and few focal collaboration goals	1

Table 5: Ways to receive support in TTM suggested by NCCs

In order to receive support for the TTM planning, activities and evaluation, the respondents proposed areas where they would like support from CASTIEL (see Table 5). There is an interest to share experiences among NCCs and they would also welcome relevant information, best practices, training materials, resources and other information. Opening a discussion about processes of trainers exchanging, train the trainers' events and sharing material would also be appreciated. Six more topics were suggested by respondents, each of them mentioned one time, as shown in Table 5.

3.2.8 Additional comments at the end of the questionnaire

10. *Would you have anything else to add or comment?*

Comments related to the topic of TTM were the following: a request for support, a proposal to organise an event about different types of software and their use and using synergies across all NCCs when developing new training material. One comment was related to the possibility of using the EuroCC/CASTIEL project brands as training quality certification institutions for HPC training in Europe.

4 Cross-checking with the Initial Competence Map from WP2

This section shows the cross-checking between the initial competence map provided by WP2 of CASTIEL and the initial training map collected by WP3 at M3. Data have been collected in two different ways: for training data was collected by NCC/country, while for the competence map data was collected by the Legal Entities (LE) that belong to each NCC. In the competence map some data are missing: we have 25 out of 33 answers, while we have received answers from every NCC/country for the training map. Therefore, the cross-checking will be partial for two reasons: first, it is based on the initial competence map, which does not include all legal entities for each country; second, there are missing answers from some countries and legal entities.

Concerning the needs, in general the analysis of the initial training map shows that the majority of countries have some common needs: training the trainers to cover all topics (32%) and enhancing the outreach to industry (16%). These needs are also highlighted by the request emerging from the competence map as shown in Figure 11.

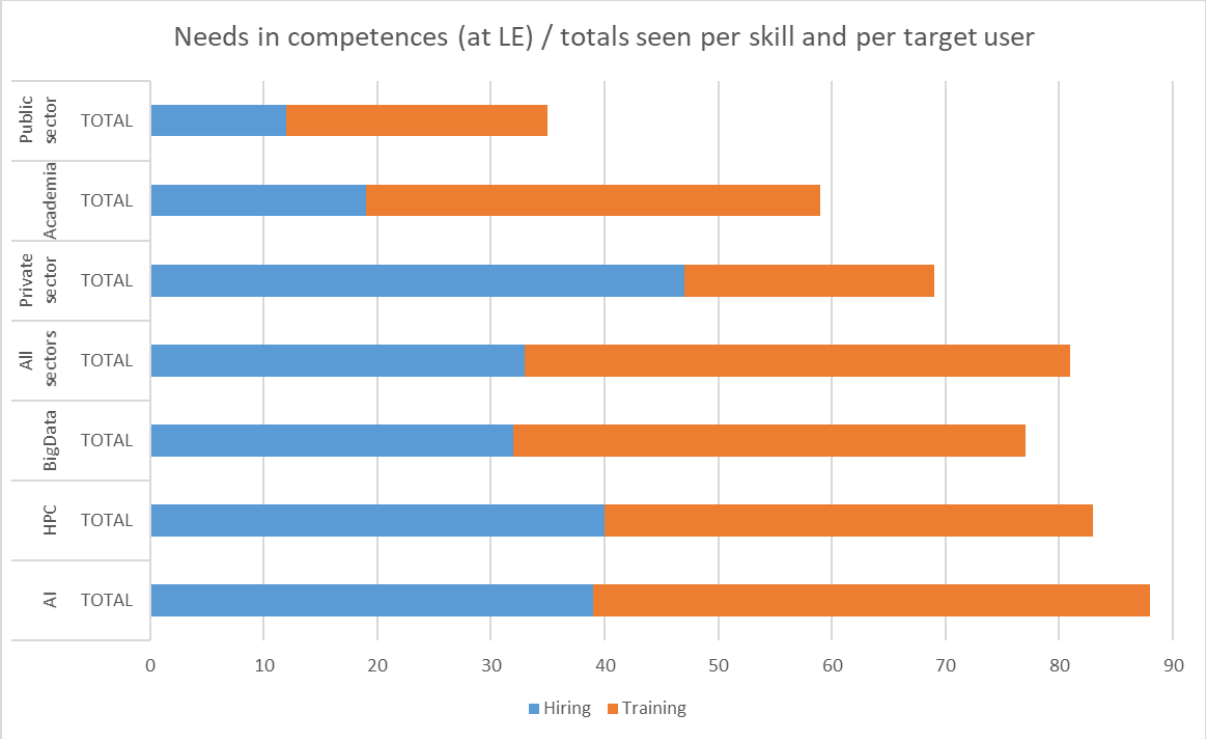


Figure 11: Needs in competences by target user sector and topics

The Figure 11 counts the number of needs expressed by the legal entities, grouped by target user sector (Public sector, Academia, Private Sector, any sector) and family of topics (Big Data, AI, HPC). Source of this figure: CASTIEL WP2 – Analysis ICM.

Figure 11 shows that for all sectors there is a need of at least 30% for hiring and a need of around 70% for training. There seems to be a bigger need for hiring people with new competences in the private sector, whereas in academia there is a preference to train the current workers. Academia and the public sector need more training, probably due to the minor turnover. Looking at the topics, we can say that for all of them there is a need for training and new-skilled workers who can integrate the most advanced technological topics in the legal entity. The competence map highlights that there are some countries which do not have projects for HPC and AI in the private sector. This confirms the need to enhance the outreach to industry which emerged above in the training map.

In terms of knowledge sharing, we have 56% of NCCs willing to share knowledge, experiences, best practices in a workshop with others and 79% of NCCs are well-disposed towards participating in twinning and mentoring activities, as it emerged from the training mapping survey. The need for training, mentoring and twinning is also noticeable in the competence map results. The following figures are taken from CASTIEL WP2 – Analysis ICM. Data shown in Figure 12 confirm the situation of knowledge sharing – data are summed up by NCC. Indeed, it shows that only around half of the countries have excellent skills in HPC, Big Data and AI for academia, industry and the public sector.

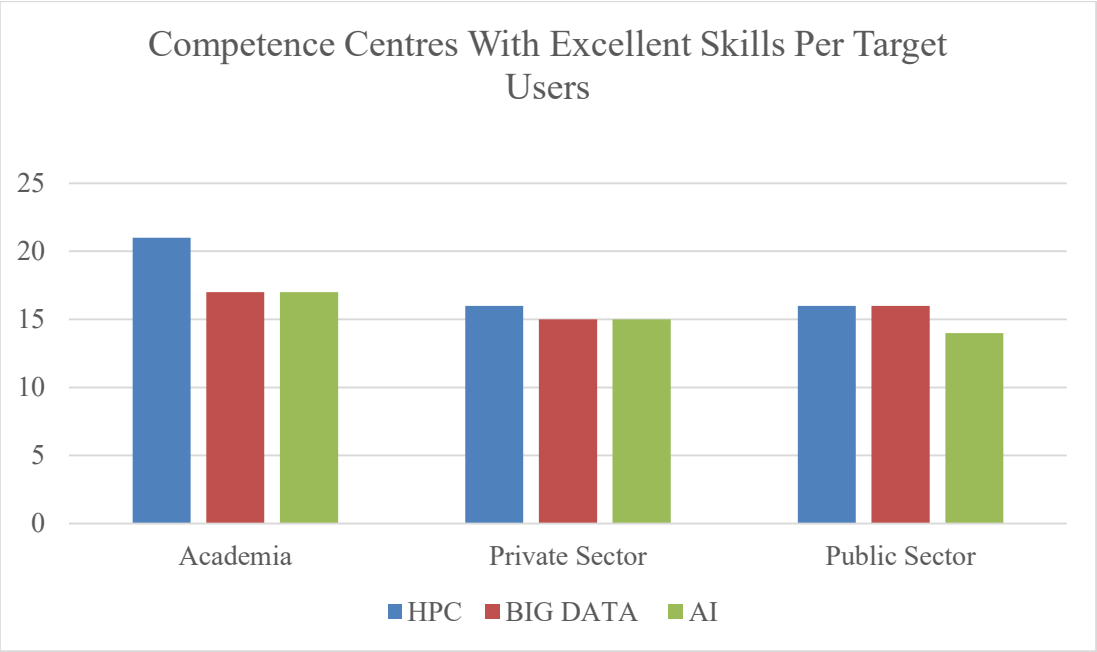


Figure 12: Competence centres with excellent skills divided by target users

With regard to the offer of training courses, most of the countries offer training courses on HPC, HPDA and AI. The results from the competence map are shown in Figure 13 - data are summed up per NCC: if at least one legal entity of the NCC is managing a training course, then the NCC is accounted as providing that training course. Figure 13 shows that at least 80% of all NCCs provide training activities on each topic. As mentioned before, not all NCCs provided their input for the competence map which explains the difference regarding the information obtained from the training mapping. In the training mapping we could see that, although the majority of countries offer training activities on HPC, HPDA and AI, the percentages are lower.

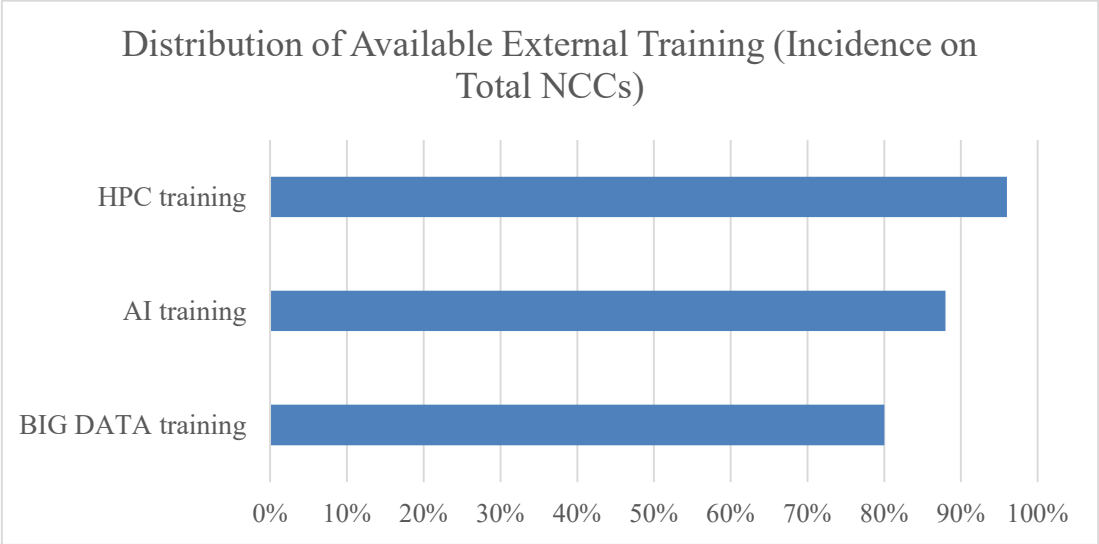


Figure 13: NCCs offering a training program or training course

The training mapping will be adjusted for the next round in Q4 2021 and, if needed, it will be cross-checked with the competence map again.

5 Available Training Competences and Initial TTM Opportunities

Competences and opportunities for TTM have been collected in M1-5 of the project, with the tools analysed in the previous sections (Training Mapping Survey in Section 2, Questionnaire for Champions for TTM in Section 3), as well as during the first meeting of the Training Working Group. The meeting, held on December 11, 2020, was attended by around 50 NCC Champions. Further communication among the NCCs took place via the dedicated mailing list and the Slack Channel, established on November 10, 2020.

The training mapping survey allowed WP3 to gather extensive information on **training competences** across the NCCs. In particular, for this section's purposes, we considered the training performed or planned by the NCCs in the two academic years 2019-2020 and 2020-2021 in terms of *Technical Domain* of the courses. Due to the survey's thoroughness, the results of the first analysis are presented (see Figure 14).

For 19 out of 33 countries, we could evaluate the exact number of courses in each Technical Domain, for 13 other countries we identified for now the most represented domains in the course portfolio. Such a preliminary analysis led to the results in Figure 14 and Figure 15. Among selected categories in Computer Science, the areas of AI, HPDA and HPC are the most represented across the NCCs in the academic years 2019-2020 and 2020-2021. Scientific and parallel programming are also among the most widely offered courses.

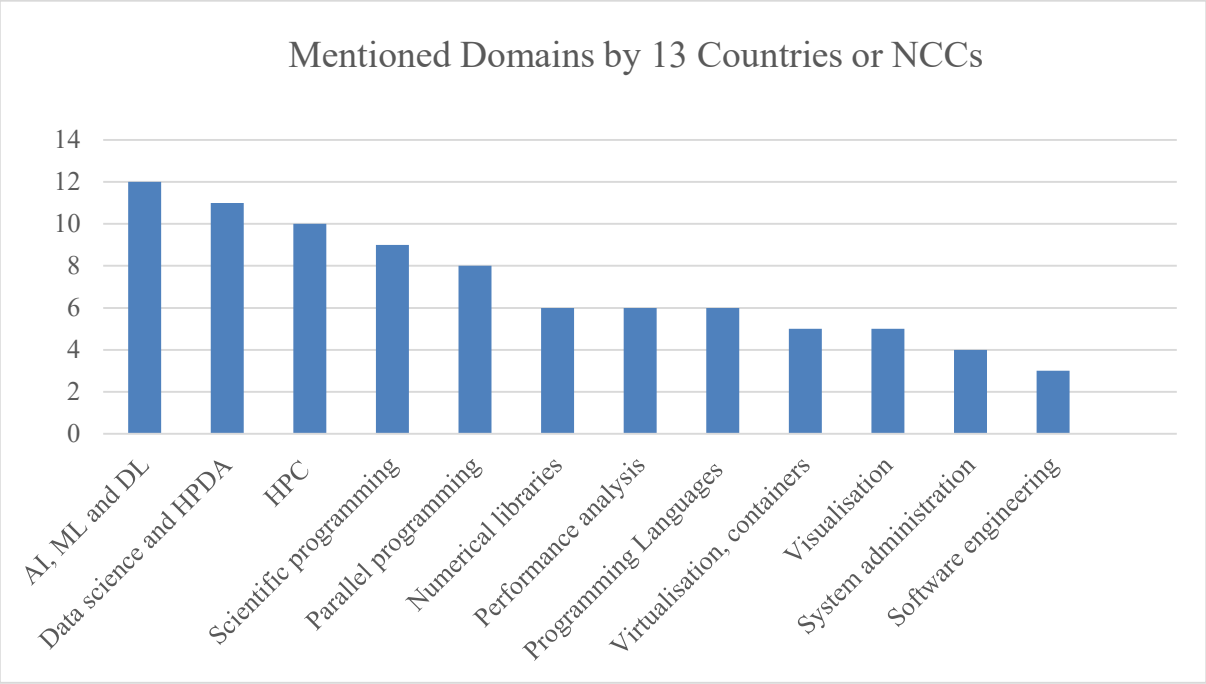


Figure 14: Training domains of the courses for a subset of 13 countries or NCCs

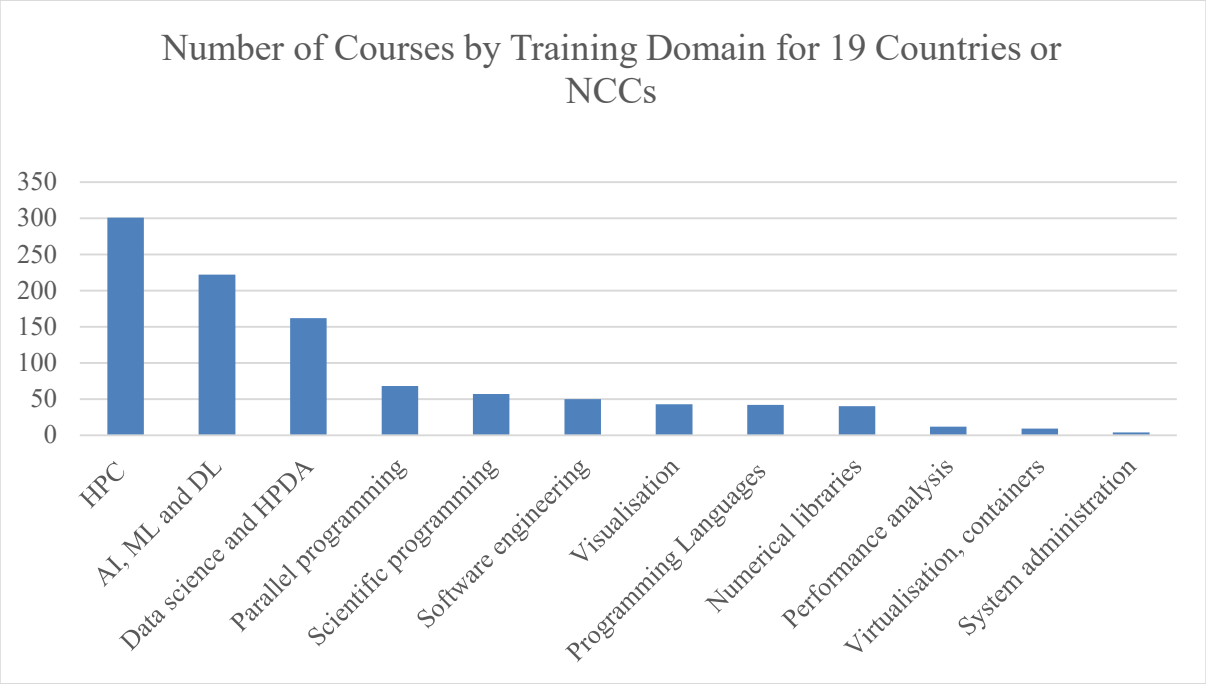


Figure 15: Number of courses by training domain for a subset of 19 countries or NCCs

During the Working Group Meeting, available training competences beyond the NCCs themselves were mentioned, such as pedagogy courses offered by CoEs (especially FocusCoE), and tools and best practice courses by organisations such as Software Carpentry. An event on January 15, 2021 on "Delivering Live Online Courses" by PRACE, in collaboration with FocusCoE, has been promoted via the CASTIEL and EuroCC mailing lists, as well as on the Slack channel. Additionally, the mailing lists and the Slack channel have been deemed efficient communication tools for sharing competences and upcoming initiatives among the NCCs in this first phase of the project (see also the Section 6).

In M1-5 of the project, a detailed plan for **twinning and mentoring** has not been developed yet. However, **opportunities** in this regard could be collected via the training mapping survey, the questionnaire, the working group meeting and the competence map from CASTIEL WP2, and they are discussed in the following paragraphs.

Through the training mapping survey, it was indicated that 88% of the NCCs can host on-site training events, and that 73% of them have an IT infrastructure at their disposal. The NCCs which instead need those facilities, still a minority of them, could take advantage of the available infrastructures by exchanging their trainers or participants across the centres, either virtually or in person. Such a need for mobility is also expressed in the section 6.

According to the questionnaire, eight countries are willing to share their best practices in training in upcoming NCC exchange workshops, which will accelerate the planning of twinning and mentoring activities. One country in particular has already specific experience in mentoring to share. Further, several countries also indicated that they have a lot of experience, therefore they will act as the mentors in the twinning and mentoring activities. Moreover, three countries proactively expressed their availability to share training competences in technical domains[1], which is a significant asset that adds to the competences collected through the training mapping survey. Finally, further eleven countries are already willing to share their experience in various technical or organisational domains (e.g. industry collaboration, learning platforms) which will also be a step towards twinning and mentoring activities.

During the working group meeting, together with the needs described in the next section, existing Train-the-Trainer activities have been pointed out as already successful mentoring initiatives, to be explored and possibly extended by CASTIEL WP3.

6 First Identification of the Needs for TTM of NCCs

The needs in TTM, similarly to the competences, could be retrieved in M1-5 of the project via the training mapping survey, the questionnaire, the competence map of CASTIEL WP2, as well as during the first meeting of the Training working group. The Slack channel and the Champions mailing list are also ways for the NCCs to continuously express wishes and point to gaps concerning TTM.

Through the first analysis of the training mapping survey, CASTIEL WP3 gathered extensive information on training competences across the NCCs, as shown in the Sections 2, 4 and 5. On the other hand, a few course-independent "generic" questions provided an insight into training needs of each responding NCC. For example, the need or, respectively, availability of training infrastructure, which could lead to mentoring activities, was already mentioned in the previous section. Among the most mentioned issues in providing training, we can mention the lack of trainers (and, in some cases, of attendees), and their lack of specialisation in some specific areas of HPC/HPDA/AI, especially advanced topics. At the same time, even by existing competences, the ability to provide training is difficult to achieve by some NCCs. Other issues include the difficulty of expanding the training portfolio to industry participants and SMEs, and an efficient conversion to or extension of the online offer. This is a crucial step since the pandemic outbreak in early 2020, especially because in the HPC/HPDA/AI domains, hands-on sessions are a fundamental step of the training, and at the same time, one of the most difficult parts to handle remotely. The overview and summary of identified constraints and needs in training is shown in Figure 16.

[1] GPU programming; preparation of computing time applications, parallel computing and its application to different fields of science, software refactoring and acceleration; MPI and OpenMP, Data Science, Big Data.

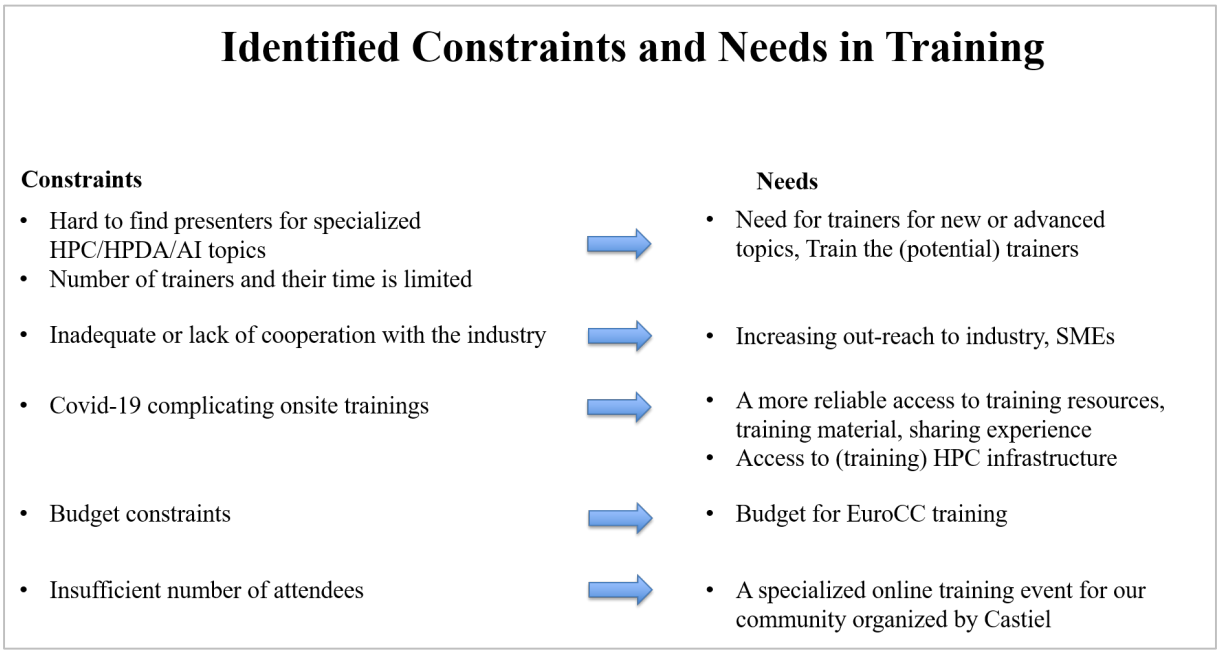


Figure 16: Summary of identified constraints and needs in training

In the working group meeting, the wish for a uniform repository of online training material, best practices, resources and other relevant material was expressed. Several NCCs already make use of their own repositories of training videos, either internal ones or relying on external services, e.g., YouTube or GitHub. A comprehensive NCC repository will be established, based on the EuroCC ACCESS.

Regarding twinning and mentoring, the training mapping survey gave an initial insight on needs and wishes of the NCCs. 88% of the responding NCCs are in favour of support and guidance from more mature or experienced organisations (among them, 79% actively asks for such a support). At least ten countries mentioned their wish for a harmonisation of training topics and resources, including tools for sharing and collaborating on training (such a need also emerged in the questionnaire). To this purpose, as it was mentioned in Section 2, available courses will be gathered and made visible on the HPC portal that is being developed by PRACE and from there they will be fed to the EuroCC ACCESS and the websites of NCCs, if of interest. Help in accessing the HPC infrastructure of other NCCs is both a need and an opportunity for mentoring that has already been mentioned in the previous section.

From both the training mapping survey and the questionnaire, a high demand emerged regarding sharing experiences among NCCs in order to create a peer-network. This has already been partly realised through the mailing list and the Slack channel. It will also be addressed by workshops on training related topics, such as identification of training gaps and needs of support, and by the twinning and mentoring programme. Additionally, in the questionnaire results, sharing experiences and projects with the public sector would require support from CASTIEL.

Other specific needs that emerged from the questionnaire include: Finding examples of AI applied to industrial use cases; mentoring and support in attracting external expertise and specialists towards a specific NCC for education and training purposes; in general, enhance the (virtual) mobility of trainers. Reversely, CASTIEL support would also be appreciated to direct one country's users to centres where the desired training is available and to provide useful information, best practices and training materials.

Finally, the issue of a uniform certification of both courses and trainers was raised by the NCCs, but, given the extreme diversity of courses across the NCCs, it will be a long-term goal of the

project. The online course registry (HPC Portal) will display in any case information on whether each NCC course offers a centre-specific certification or not. A uniform certification would enable the standardisation of the HPC knowledge representation, and to establish internationally recognised certificates attesting the acquired knowledge.

7 Major Achievements

The following main achievements and contributions to the overall work of CASTIEL, presented in this deliverable, were identified:

- The European panorama of training per country for each of the following topics: HPC, HPDA and AI. A very rich database with information on training ready for more detailed analysis was established.
- Establishment of the Working Group for Training and the collaboration among the key players as well as the collaboration with other initiatives, mainly PRACE and FocusCoE.
- The initial constraints, gaps and needs related to TTM on the European and country level have been identified and they will be addressed in the next work of this WP in the training plans.
- There is interest for future workshops on training related topics, to share knowledge and experience with other NCCs with many suggested topics. This will help to organise workshops for the NCCs. There is also interest to get support from WP3 by enabling sharing experiences among NCCs, by providing information, key findings, best practices and other relevant material, training events available in other countries and by opening discussions on training topics.
- The initial definition and proposal of twinning and mentoring activities: There is interest to get support and guidance in training related areas from more experienced NCCs. This will be addressed in the upcoming work of this WP via mentoring and twinning.

8 Concluding Remarks

During M1-5 of this project, the European panorama of training on HPC, HPDA and AI per country was obtained from the work of this WP and a database with information on training was established that is ready for a more detailed analysis. The initial training mapping survey provided very useful information, however, the current picture is incomplete as the mapping work is still ongoing and will continue for some time as a living document. This will be adjusted during further iterations of the training map within the project. The initial constraints, gaps and needs related to TTM on the European and national level have been identified and they will be addressed in the next work of this WP in the training plans. Also, the initial opportunities for twinning and mentoring will be developed in more detail and twinning and mentoring will be encouraged among NCCs in the remaining one and a half years of the project. The evolution of training, twinning and mentoring plans and corresponding activities within the first and second years of CASTIEL will be reported in the deliverables D3.2: Training, Twinning and Mentoring Plans and Achievements and D3.3: Final Report on Training, Twinning and Mentoring Activities.

9 References and Applicable Documents

[1] CASTIEL project, https://www.castiel-project.eu
[2] EuroCC project, https://www.eurocc-project.eu/
[3] PRACE training registry, https://training.prace-ri.eu/
[4] FocusCoE training registry, https://www.hpccoe.eu/index.php/coe-training-calendar/
[5] ETP4HPC, https://www.etp4hpc.eu/events.html
[6] HPC portal - High-Performance Computing in Europe. The portal for European HPC services, https://hpc-portal.eu/
[7] EuroCC ACCESS, https://www.eurocc-access.eu/
[8] Typeform, https://www.typeform.com/
[9] Slack, https://slack.com

Annex 1 - The Training Mapping Survey

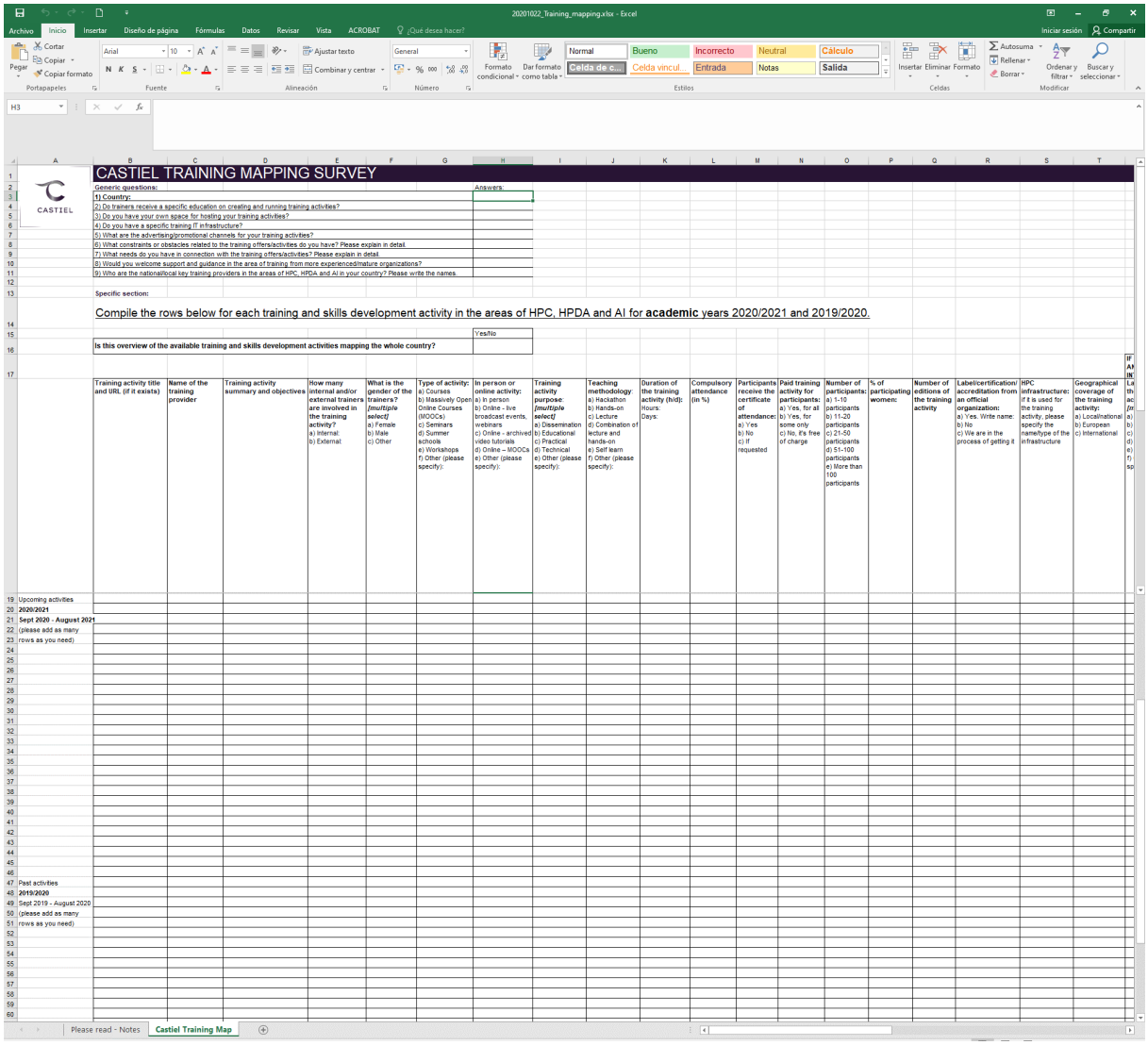
Instructions

	A
1	**Scope of the survey** - the ultimate goal is to map all HPC, HPDA and AI training activities available in your country. We are aware that for some countries this will require more time and effort. Thus **if you are able** to provide this information now, **focus on the whole country**. **If you are not able** to provide this information at the moment, focus on HPC, HPDA and AI training activities provided **by the NCC and its partners**.
2	Please include the **information that you have or you can obtain**. If you don't have a certain information, leave the column empty. There will be more checks in the future.
3	**Time frame** for the training activities - please consider ACADEMIC year (September - August), not the calendar year
4	**Upcoming activities** for the academic year Sep 2020 - Aug 2021 - include all training activities since September 2020 and planned activities until August 2021
5	**Past activities** for the academic year Sep 2019 - Aug 2020 - include all training activities that happened in the last academic year
6	**Gender** - this question is asked to reflect the gender equality topic that is promoted by the EU. If you don't have this information at the moment, leave it empty. However, it would be useful to have this information for the future courses.
7	

Please read - Notes | Castiel Training Map

Listo

Training Mapping Survey



CASTIEL TRAINING MAPPING SURVEY

Generic questions: Answers:

1) Country:
2) Do trainers receive a specific education on creating and running training activities?
3) Do you have your own space for hosting your training activities?
4) Do you have a specific training IT infrastructure?
5) What are the advertising/promotional channels for your training activities?
6) What constraints or obstacles related to the training offers/activities do you have? Please explain in detail.
7) What needs do you have in connection with the training offers/activities? Please explain in detail.
8) Would you welcome support and guidance in the area of training from more experienced/mature organizations?
9) Who are the national/local key training providers in the areas of HPC, HPDA and AI in your country? Please write the names.

Specific section:

Compile the rows below for each training and skills development activity in the areas of HPC, HPDA and AI for **academic** years 2020/2021 and 2019/2020.

Is this overview of the available training and skills development activities mapping the whole country? Yes/No

Training activity title and URL (if it exists)	Name of the training provider	Training activity summary and objectives	How many internal and/or external trainers are involved in the training activity? a) Internal: b) External:	What is the gender of the trainers? *[multiple select]* a) Female b) Male c) Other	Type of activity: a) Courses b) Massively Open Online Courses (MOOCs) c) Seminars d) Summer schools e) Workshops f) Other (please specify):	In person or online activity: a) In person b) Online - live broadcast events, webinars c) Online - archived video tutorials d) Online – MOOCs e) Other (please specify):	Training activity purpose: *[multiple select]* a) Dissemination b) Educational c) Practical d) Technical e) Other (please specify):	Teaching methodology: a) Hackathon b) Hands-on c) Lecture d) Combination of lecture and hands-on e) Self learn f) Other (please specify):	Duration of the training activity (h/d): Hours: Days:	Compulsory attendance (in %)	Participants receive the certificate of attendance: a) Yes b) No c) If requested	Paid training activity for participants: a) Yes, for all b) Yes, for some only c) No, it's free of charge	Number of participants: a) 1-10 participants b) 11-20 participants c) 21-50 participants d) 51-100 participants e) More than 100 participants	% of participating women:	Number of editions of the training activity	Label/certification/ accreditation from an official organization: a) Yes. Write name: b) No c) We are in the process of getting it	HPC infrastructure: If it is used for the training activity, please specify the name/type of the infrastructure	Geographical coverage of the training activity: a) Localinational b) European c) International
Upcoming activities																			
2020/2021																			
Sept 2020 - August 2021																			
(please add as many rows as you need)																			
Past activities																			
2019/2020																			
Sept 2019 - August 2020																			
(please add as many rows as you need)																			

Please read - Notes | Castiel Training Map

	IF EUROPEAN AND/OR INTERNATIONAL		IF ACADEMIA	IF INDUSTRY						IF HPC	
Geographical coverage of the training activity: a) Local/national b) European c) International	**Language(s) of the training activity:** ***[multiple select]*** a) English b) French c) German d) Italian e) Spanish f) Other (please specify):	**Target audience:** ***[multiple select]*** a) Academia, Research b) Industry c) Public administration d) Personnel of NCC e) Other (please specify):	**Target audience from the Career stage point of view:** ***[multiple select]*** a) Undergraduate students b) Early-stage researchers (postgraduates and post-docs) c) Experienced researchers d) Other (please specify): **e) Not relevant**	**Target audience from the point of view of the company size:** ***[multiple select]*** a) Small and medium enterprises (SMEs) b) Large enterprises with 251 – 1000 employees c) Large enterprises with 1001 – 5000 employees d) Large enterprises with 5001 – 10000 employees e) Large enterprises with more than 10000 employees	**Target audience from the point of view of providers of HPC experience:** ***[multiple select]*** a) Data scientists, analysts b) HPC application developers c) HPC application users d) Programmers e) System administrators f) Other (please specify): **g) We do not focus on providers**	**Target audience from the point of view of levels of HPC experience:** a) Existing users –beginners, b) Existing users – intermediate c) Existing users – advanced d) Potential users e) Other (please specify):	**Participants prerequisite knowledge:** ***[multiple select]*** a) C/C++ b) Fortran c) Python d) HPC tools (e.g. profiler, scheduler) e) MPI f) OpenMP g) Machine/Deep Learning concepts h) Numerical methods (linear algebra, statistics) i) Domain-specific background knowledge j) Other (please specify): **k) No prerequisite knowledge**	**Scientific Domain:** ***[multiple select]*** a) Biochemistry, bioinformatics and life sciences b) Chemical sciences and materials c) Computer sciences, Computer Engineering, Electrical Engineering, Telecommunications d) Earth system sciences e) Economics, finance and management f) Engineering g) Fundamental constituents of matter h) Fundamental physics i) Linguistics, cognition and culture j) Mathematical sciences k) Physiology and medicine l) Universe sciences m) Other (please	**Technical domain:** ***[multiple select]*** a) Artificial intelligence, machine and deep learning b) Data science and high performance data analytics c) HPC (please specify in the next column) d) Numerical libraries and methods e) Parallel programming f) Performance analysis g) Programming Languages h) Scientific programming i) Software engineering j) System administration k) Virtualisation, containers l) Visualisation m) Other (please specify): **n) Not relevant**	**HPC topics covered:** ***[multiple select]*** a) Artificial Intelligence, Machine and Deep Learning b) Big Data, Data Science and High-Performance Data Analytics c) Data Visualization d) Domain Specific Languages for HPC e) Embedded Supercomputing f) Fault Tolerance and Resilience g) Heterogeneous Programming on Accelerators h) HPC on Exascale Architectures i) HPC Systems Administration, Operations and Maintenance j) HPC Technology - Architecture, Hardware k) HPC Technology - Accelerators (GPUs, FPGAs…) l) HPC Technology - Networking m) HPC Technology - Storage n) Parallel Algorithms o) Parallel Libraries (Linear Algebra, FFT…) p) Parallel Programming Models (MPI, OpenMP…) q) Performance Engineering and Co-design r) Power Management (Power Wall issues) s) Programming Languages and Methods for HPC t) Quantitative Performance Analysis of HPC Architectures, Algorithms and Software u) Real-time Supercomputing	**Comment**

Please read - Notes | Castiel Training Map

Annex 2 - The Questionnaire for Champions for TTM

a. The questionnaire template

CASTIEL

WP3 - Training, Twinning and Mentoring Questionnaire
Dear Champions, we would like to ask you several questions to get your feedback and opinion. Thank you for your collaboration!

1. Which country do you represent?

(drop down menu to choose from)
Austria
Belgium
Bulgaria
Croatia
Cyprus
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy
Latvia
Lithuania
Luxembourg
Montenegro
Netherlands
North Macedonia
Norway
Poland
Portugal
Romania
Slovakia
Slovenia
Spain
Sweden
Switzerland
Turkey
United Kingdom

2. Which topics related to training, twinning and mentoring would you like to discuss in a workshop? If choosing Other, please specify and click Enter to save your answer:

a) Identification of training gaps and needs of support
b) Discussion about the initial training plan and its implementation
c) Twinning & Mentoring Programme
d) Other:_____

3. Would you or someone from your NCC like to share with others your knowledge and experience related to training, twinning and mentoring at one of the future workshops?

a) Yes [GO TO Q4]
b) No [GO TO Q5]

IF YES:

4. Please let us know which topic(s) you would like to share:_____

IF NO:

5. We would like to check with you **the filters** that you would like to have on the future HPC portal showing the training activities in Europe. If choosing Other, please specify and click Enter to save your answer:

a) Target audience
b) Levels of HPC experience
c) Scientific Domain
d) Technical Domain
e) HPC topics covered
f) Language(s) of the training activity
g) In person or online activity
h) Country
i) All of them
j) Other:_____

6. We would like to check with you **the information** that you would like to display on the future HPC portal about the training activities in Europe. If choosing Other, please specify and click Enter to save your answer:

a) Training activity title and URL
b) Name of the training provider
c) Training activity summary and objectives
d) Type of activity (e.g. Courses, MOOCs, Seminars, Summer Schools, Workshops)
e) Duration of the training activity (h/d)
f) Participants receive the certificate of attendance
g) Paid training activity for participants
h) All of them
i) Other:_____

7. NVIDIA sent a proposal about the Deep Learning Institute offering, the Deep Learning Institute Ambassador programme and the NVIDIA GPU bootcamps that they would like to present to all NCCs. Would you be interested in hearing more from NVIDIA?

a) Yes [GO TO Q8]
b) No [GO TO Q9]

IF YES:

8. When would you like to hear from NVIDIA?

a) Mid December 2020
b) January 2021
c) Later in spring 2021

IF NO:

9. In what ways could we support you with your training, twinning and mentoring planning, activities and evaluation?_____

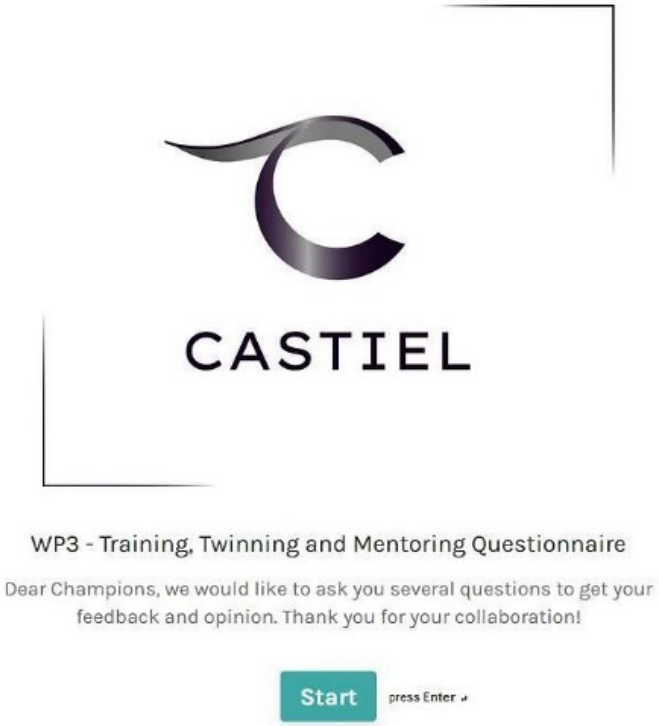
10. We would like to organise the first meeting with you all. Please let us know if Friday 11th December at 1pm would work for you:

a) Yes
b) No

11. Would you have anything else to add or comment?_____

Thank you for your opinions and time! We will share the results with you in the following weeks.

b. Screenshots from Typeform



1→ Which country do you represent? *

Type or select an option

2→ Which topics related to training, twinning and mentoring would you like to discuss in a workshop? If choosing Other, please specify and click Enter to save your answer: *

Choose as many as you like

- A Identification of training gaps and needs of support
- B Discussion about the initial training plan and its implementation
- C Twinning & Mentoring Programme
- D Other

3→ Would you or someone from your NCC like to share with others your knowledge and experience related to training, twinning and mentoring at one of the future workshops? *

- Y Yes
- N No

4→ Please let us know which topic(s) you would like to share:

Type your answer here...

Shift ⇧ + Enter ↵ to make a line break

5 → We would like to check with you **the filters** that you would like to have on the future HPC portal showing the training activities in Europe. If choosing Other, please specify and click Enter to save your answer: *

Choose as many as you like

- A Target audience
- B Levels of HPC experience
- C Scientific Domain
- D Technical Domain
- E HPC topics covered
- F Language(s) of the training activity
- G In person or online activity
- H Country
- I All of them
- J Other

6 → We would like to check with you **the information** that you would like to display on the future HPC portal about the training activities in Europe. If choosing Other, please specify and click Enter to save your answer: *

Choose as many as you like

- A Training activity title and URL
- B Name of the training provider
- C Training activity summary and objectives
- D Type of activity (e.g. Courses, MOOCs, Seminars, Summer Schools, Workshops)
- E Duration of the training activity (h/d)
- F Participants receive the certificate of attendance
- G Paid training activity for participants
- H All of them
- I Other

7 → NVIDIA sent a proposal about the Deep Learning Institute offering, the Deep Learning Institute Ambassador programme and the NVIDIA GPU bootcamps that they would like to present to all NCCs. Would you be interested in hearing more from NVIDIA? *

- Y Yes
- N No

8 → When would you like to hear from NVIDIA?

- A Mid December 2020
- B January 2021
- C Later in spring 2021

9 → In what ways could we support you with your training, twinning and mentoring planning, activities and evaluation?

Type your answer here...

Shift ⇧ + Enter ↵ to make a line break

10 → We would like to organize the first meeting with you all. Please let us know if Friday 11th December at 1pm would work for you: *

- Y Yes
- N No

11 → Would you have anything else to add or comment?

Type your answer here...

Shift ⇧ + Enter ↵ to make a line break

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Thank you for your opinions and time! We will share the results with you in the following weeks.

Annex 3 - The list of Mentioned National Key Training Providers in HPC, HPDA and AI

Country:	Who are the national/local key training providers in the areas of HPC, HPDA and AI in your country? Please write the names.	Number of providers
Austria	VSC Research Center, TU Wien Know-Center GmbH, Graz	2
Belgium	CECI VSC	2
Bulgaria	Sofia University Parallel computational centre, the HPC laboratory at the Sofia tech park, IICT-BAS; Two BigData centers of competences (GATE Horizon 2020 twinning project is at the Sofia University, the centre of competences Big Data for economics is at the UNWE). The Technical University - Plovdiv, Bourgas University, Shumen University.	4
Croatia	University of Zagreb, Faculty of Electrical Engineering and Computing; University of Zagreb, University Computing Centre; J.J. Strossmayer University of Osijek, Faculty of Electrical Engineering, Computer Science and Information Technology; Ruđer Bošković Institute; University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture; University of Rijeka, Faculty of Engineering; University of Rijeka;	7
Cyprus	NCC	1
Czech Republic	IT4Innovations	1
Denmark	DTU KU AAU RUC AU CBS SDU ITU	8
Estonia	University of Tartu Taltech	2
Finland	CSC Universities Reaktor	7

France	Telecom ParisTech, l'ENSTA ParisTech, Laboratoire d'Informatique de l'Université Pierre & Marie Curie, Université de Dijon, ISAE SupAéro, Centrale Marseille, Maison de la Simulation, CNRS (Groupe Calcul), Universoté Fédérale de Toulouse, Triscal innov, IRT, IDRIS, CINES, CRIANN, CIMENT, GENCI, CERFACS	17
Germany	GCS (HLRS, JSC, LRZ)	3
Greece	GRNET	1
Hungary	KIFÜ	1
Iceland	UoIceland UoReykjavik	2
Ireland	Irish Centre for High-End Computing (ICHEC), NUI Galway (NUIG), Trinity College Dublin (TCD), University of Limerick (UL), University College Dublin (UCD)	5
Italy	CINECA	1
Latvia	Riga Technical University University of Latvia	2
Lithuania	NCC	1
Luxembourg	University of Luxembourg University of Luxembourg Competence Center	2
Montenegro	University of Donja Gorica University of Montenegro	2
Netherlands	SURF (NCC) The ResearchData facility from the 4TU collaboration (https://data.4tu.nl) The Data Archiving facility from the Royal Dutch Academy of Sciences (https://dans.knaw.nl) The Netherlands eScience Center (https://www.esciencecenter.nl) The Dutch Techcentre for Life Sciences (https://www.dtls.nl). Universities and research centres in the Netherlands	6
North Macedonia	FCSE-UKIM	1
Norway	Metacenter - Sigma2 CodeRefinery	2

Poland	Cyfronet, PSNC, WCSS, ICM UW, CI TASK, NCBJ	6
Portugal	University of Coimbra University of Evora/Operational Center HPC_UE University of Lisbon University of Minho University of Porto	5
Romania	Politechnics University of Bucharest, West university of Timisoara, Babes-Bolyai University	3
Slovakia	Slovak University of Technology in Bratislava, Comenius University in Bratislava, Technical University of Košice, University of Žilina, Matej Bel University in Banská Bystrica.	5
Slovenia	University of Ljubljana	1
Spain	BSC UPC UNICAN SCAYLE CSUC COMPUTAEX CESGA IAC-ULL	8
Sweden	ENCCS, SNIC, RISE, SeRC	4
Switzerland	CSCS (ETH Zurich),	1
Turkey	UHeM (http://en.uhem.itu.edu.tr/) TRUBA(www.truba.gov.tr)	2
United Kingdom	EPCC STFC-Hartree Centre Nvidia University of Bath NobleProg (UK) Ltd Wellcome Sanger Institute HPC Autumn Academy, Centre for Scientific Computing, University of Cambridge	7