



## **Educational portfolio document**

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## Executive Summary

The European Center of Excellence in Exascale Computing “Research on AI- and Simulation-Based Engineering at Exascale” (CoE RAISE) aims to accelerate the knowledge transfer to academia, industry, and among the partners. It will support communities having less developed expertise. Education and training are important components to reach these aims and to foster the development of Europe’s competitiveness on the global market.

Task 6.1 “*Training and education as services*” of Work Package 6 “*Outreach and Service*” of CoE RAISE aims to develop an education and training platform and to build a portfolio of courses and training material related to Artificial Intelligence, High-Performance Computing, and domain-specific and interdisciplinary topics. The platform with collected courses will serve the existing and potential user communities to close the knowledge gap in application and development of relevant tools.

The portfolio of educational and training resources is established and uploaded to the platform. The portfolio development process, as well as the upgrade of the platform criteria are presented in this Deliverable. This is complemented by the review of the classification criteria (European Credit Accumulation and Transfer System and European Qualification Framework) and sources from where educational resources were collected for the portfolio. The educational portfolio will be periodically updated.

## 1 Introduction

The European network of the European Center of Excellence in Exascale Computing “Research on AI- and Simulation-Based Engineering at Exascale” (CoE RAISE) will develop and provide best practices, support, and education for industry, Small- and Medium-Sized Enterprises (SMEs), academia, and High-Performance Computing (HPC) centers, attracting new user communities. CoE RAISE’s Task 6.1 *“Training and Education as Services”* is one of the essential elements in reaching these objectives. The task started with the development of the Educational services platform (project month M6) and this platform was described in Deliverable D6.1. The Educational service platform<sup>1</sup> is operational now. The users can find information on forthcoming training events and also can search for courses already uploaded into the platform. Upgrades and extensions of the Educational service platform are ongoing.

The Deliverable D6.2 describes a next step in the development of the Educational service platform by intensifying the collection and update processes of the course portfolio. It is planned once in a year (M12, M24, M36) to report on achievements describing the change of education portfolio in accordance with the CoE RAISE developments and industrial/academic needs.

Working on this task it was recognized that the diversity of different educational resources was larger than expected and to enable an efficient search in the Educational service system, the existing classification of the resources had to be upgraded and extended. Degree programs, separate courses and other Artificial Intelligence (AI), HPC, domain-specific and interdisciplinary educational resources from the project partners were collected. The CoE RAISE project partners are also involved in the Partnership for Advanced Computing in Europe (PRACE)<sup>2</sup>, Network of the Centers of Excellence in HPC (FocusCoE net)<sup>3</sup>, European High-Performance Computing (EuroHPC)<sup>4</sup>, as well as in other projects and networks. Education and training resources on AI and HPC topics available in these projects and networks were also searched and information was collected. Global cloud service companies such as Amazon<sup>5</sup>, Google<sup>6</sup>, International Business Machines Corporation (IBM)<sup>7</sup>, and Microsoft<sup>8</sup> are also organizing training events and these resources could be included in the portfolio. And last, but not least, there are Open Educational Resources (OER) provided by FutureLearn<sup>9</sup>, Udemy<sup>10</sup>, Coursera<sup>11</sup> etc.

Based on the community requirements and the developments in the project, courses and training events organized by CoE RAISE partners will be advanced to be tailored for the communities’ special needs. Based on the user needs and to close the knowledge gap, courses will be offered as a knowledge transfer to the scientific and industrial communities of the RAISE network. This also includes the development of special workshops for the

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<sup>1</sup> Educational service platform <https://raise.learning.lv/courses>

<sup>2</sup> PRACE <https://prace-ri.eu>

<sup>3</sup> FocusCoE net <https://www.hpccoe.eu>

<sup>4</sup> EuroHPC <https://eurohpc-ju.europa.eu>

<sup>5</sup> Amazon <https://www.amazon.com>

<sup>6</sup> Google <https://www.google.com>

<sup>7</sup> IBM <https://www.ibm.com>

<sup>8</sup> Microsoft <https://www.microsoft.com>

<sup>9</sup> FutureLearn <https://www.futurelearn.com>

<sup>10</sup> Udemy <https://www.udemy.com>

<sup>11</sup> Coursera <https://www.coursera.org>

communities. The courses, trainings, and workshops will be offered via webinars and e-learning courses, as well as on-site at the contributor's location if conditions allow.

First, an overview of the diversity of educational resources and the upgrade of the classification system that CoE RAISE proposes are presented in Sec. 2. Then, the educational resource portfolio available from the project partners is discussed in Sec. 3, from other projects and networks in Sec. 4, from cloud service providers in Sec. 5, and from OER portals in Sec. 6.

## 2 General overview of course classification and system upgrade

Education and training systems are developing and becoming more flexible and open, but diversity also increases. These changes are partly related to the development of digital technologies and the internet. Online teaching and online learning are widely used nowadays instead of the traditional face-to-face education. Distance learning and also online-teaching-based degree programs are becoming more popular, as well as individual courses and other OER resources.

Openness of education started with the development of distance education and the establishment of the Open University<sup>12</sup> (the United Kingdom) in 1969 could be mentioned as a milestone. Science and innovation are also becoming open, as Open Science and Open Innovation.

Diversity of the educational offer due to digitalization, openness, and globalization forces the education system to adapt by introducing some quality standards and course classification by the number of hours spent by a student in the course or equivalent credits, for example, European Credit Accumulation and Transfer System (ECTS).

All educational resources in RAISE's Educational service platform are classified into four levels: courses for *Potential Users*, for *Beginners*, for *Intermediate*, and for *Advanced Users*. To choose a higher-level course some knowledge and skills prerequisites are needed. In the European Higher Education Area (EHEA) there are defined education cycles and qualifications awarded according to the European Qualification Framework (EQF).

When developing the Educational services platform (described in Deliverable D6.1) and choosing the most suitable option for the course description format and appropriate filter options, mainly solutions used in the existing education and training portals have been reviewed. In this section it is described how classification of the degree programs, courses, and other events used in the Education service platform fit to the ECTS system (Sec. 2.1) and how knowledge and skills obtained at the different course levels fit to the EQF (Sec. 2.2). The upgrade of the Education service platform filter content is also described (Sec. 2.3).

### 2.1 Classification of educational events according to ECTS

The RAISE project is planning to offer diverse education and training events and resources and most of them will be at the *Beginner*, *Intermediate*, and *Advanced* level to meet the requirements of higher education. According to the standards applied to the European Union (EU) courses can be evaluated by hours spent by a student during the learning process. In the ECTS, credit points are introduced to the degree programs and 1 ECTS depending on the country is equal to 25 to 30 hours of student work (class attendance, tests, projects, individual work, etc.). The ECTS can be used to evaluate and classify education and training in groups:

- **Degree programs** starting from 60 ECTS in case of a one-year Master program up to 240 ECTS for a four-year Bachelor program. 60 ECTS are equal to 1500 - 1800 hours of study work.
- **Micro-credentials** are short programs like specializations in the Bachelor or Master study programs with a study load from 3 to 15 ECTS accounting from 75 to 450 hours of study work, accordingly.

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<sup>12</sup> Open University <https://www.open.ac.uk/>

- **ExpertTracks** are combinations of three to five short online courses (2-3 ECTS) providing knowledge and skills for professional development in some field.
- **Guided projects** are offered in OER platforms with just 2 hours of learning and they are less than 0.1 ECTS.

This analysis shows that an average study load in some education and training events could be equally evaluated in hours or ECTS. For degree programs with a large study load, the best option is to use ECTS, however, for smaller courses or training events, the evaluation in hours fits better.

## 2.2 Education levels according to the EQF

In order to classify an educational or a training resource into one of the four categories used in RAISE's Educational service platform (*Potential Users*, *Beginners*, *Intermediate*, and *Advanced Users*), there are some outcome criteria needed on how to assign particular resources to an appropriate level. For this reason, the European Qualification Framework (EQF)<sup>13</sup> is used. There are eight reference levels of learning outcomes categorized as obtained knowledge, skills, as well as responsibility and autonomy. An overview<sup>14</sup> of how the EQF system is used in education and training systems of different countries shows that there are still differences.

The *Potential User* level can be associated with Level 1–3 of the EQF and it is very basic education in the subject area. The learner acquires general knowledge of facts, principles, concepts and skills to perform simple tasks using basic methods and tools. It could be treated as an introductory or awareness raising step to encourage a person to continue education.

The *Beginner* level can be associated with the secondary education and basic professional education. It could be related to Level 4 of the EQF when a learner acquires broader knowledge and practical skills required to solve specific problems.

The *Intermediate* level corresponds to the first level higher education, Bachelor and engineering level. These are Levels 5 and 6 of the EQF. At this level, a learner obtains comprehensive knowledge, basic and advanced skills, can be innovative and able to solve complex problems in the field.

The *Advanced* level can be associated with the Master and Doctoral education level or Levels 7 and 8 of the EQF. At these levels, a learner obtains highly specialized knowledge and skills required in research and/or innovation in order to develop new knowledge.

As a conclusion, it can be stated that it is not an easy task to assign education and training resources to the appropriate level because there is a lot of overlap.

## 2.3 Upgrade of the Educational service platform

During the process of searching for new educational and training resources for the course portfolio and evaluating the class they could fit in RAISE's Educational service platform, it was recognized that some upgrades are needed.

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<sup>13</sup> EQF system <https://www.cedefop.europa.eu/en/projects/european-qualifications-framework-efq>

<sup>14</sup> EQF in Europe [https://en.wikipedia.org/wiki/European\\_Qualifications\\_Framework](https://en.wikipedia.org/wiki/European_Qualifications_Framework)

It has been observed that there exist degree programs offered in online teaching/learning format and this option must be included. There are also new formats such as Micro-credentials, ExpertTracks, and Guided Projects. Based on the analysis performed in Sec. 2.1, they have been added to RAISE's criteria system.

The course criteria have been upgraded due to the growing diversity of education and training resources. Changes are presented in Table 1 of Annex 1.

### 3 Courses, degree programs and training resources from the RAISE partners

Among the CoE RAISE project partners in Task 6.1 there are three universities offering degree programs - RWTH Aachen University (RWTH), University of Iceland (UOI), Riga Technical University (RTU), and the Cyprus Institute (CYI). Education and training are offered also by two HPC centers - the Jülich Supercomputing Centre (JSC) at Forschungszentrum Jülich, the Barcelona Supercomputing Center (BSC), and the European Organization for Nuclear Research (CERN). The project partner Flanders Make VZW (FM) represents industry, however, they also have uploaded information on training events in Dutch and English.

#### 3.1 Forschungszentrum Jülich (FZJ)

FZJ is the leading partner of the CoE RAISE project and as a Tier-0 and Tier-1 supercomputing resource provider also a partner in other national and international projects and networks, for example, PRACE. Education and training offered by the Jülich Supercomputing Centre can be found on JSC's website<sup>15</sup>.

Information on upcoming education and training events can be found on the Events website<sup>16</sup>. One such relevant event in the context of CoE RAISE is the "AI for Science Bootcamp"<sup>17</sup>. This is a 2-day bootcamp organized together with other partners and deals with the application of AI tools.

Another platform is the Jülich Data Challenges<sup>18</sup>, which provides scientific data challenges initiated by FZJ. It is offered to host data challenges on the edge of scientific discovery promoting Jülich's unique scientific data and addressing research problems. The platform is oriented to the Machine Learning (ML) researchers, image and data analysts, looking for a new playing field and new and interesting data to work on.

#### 3.2 University of Iceland (UOI)

The University of Iceland offers undergraduate and postgraduate degree programs. There is a course catalogue<sup>19</sup> available that provides descriptions of the offered degree programs. There are also distance learning courses offered, but not in computer science and engineering. In computer science degree programs, there are AI and HPC related courses, for example, course REI505M on Machine Learning<sup>20</sup> and course TÖL506M on Deep Neural Networks<sup>21</sup>.

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<sup>15</sup> JSC trainig [https://www.fz-juelich.de/ias/jsc/EN/Expertise/Workshops/Courses/courses\\_node.html](https://www.fz-juelich.de/ias/jsc/EN/Expertise/Workshops/Courses/courses_node.html)

<sup>16</sup> JSC events [https://www.fz-juelich.de/ias/jsc/EN/News/Events/events\\_node.html](https://www.fz-juelich.de/ias/jsc/EN/News/Events/events_node.html)

<sup>17</sup> Bootcamp <https://www.fz-juelich.de/SharedDocs/Termine/IAS/JSC/EN/events/2022/ai-bootcamp-2022.html?nn=362392>

<sup>18</sup> Jülich Data Challenges <https://data-challenges.fz-juelich.de>

<sup>19</sup> University of Iceland course catalog <https://ugla.hi.is/kennsluskra/index.php?tab=skoli&chapter=content&id=-2021>

<sup>20</sup> University of Iceland course on Machine Learning <https://ugla.hi.is/kennsluskra/index.php?tab=nam&chapter=namskeid&id=70930220216&namskra=0>

<sup>21</sup> University of Iceland course on Deep Neural Networks <https://ugla.hi.is/kennsluskra/index.php?tab=nam&chapter=namskeid&id=71102820216&namskra=0>

There is also a course REI204M High Performance Computing<sup>22</sup> taught by Professor Morris Riedel. Professor Morris Riedel also has a website<sup>23</sup> with more educational and training resources. A “Cloud Computing & Big Data Course“ is also available on YouTube<sup>24</sup>.

### 3.3 RWTH Aachen University (RWTH)

RWTH Aachen University is also a CoE RAISE partner and is offering degree program courses related to AI and HPC. For more information see the website<sup>25</sup>. RWTH Aachen University is fostering education in AI with special offers for students<sup>26</sup> and is planning to develop an AI degree program with MOOCs:

*“The project “bridgingAI: Building Brigdes to AI Across Disciplines” seeks to provide students with relevant AI competencies, regardless of discipline studied. RWTH is thus tackling a challenge currently faced by many universities.*

*Drawing on the University’s AI expertise, the goal is to develop scalable solutions that can be made available to other higher education institutions in the form of Open Educational Resources (OER).*

*The aim of bridgingAI is to provide students with the necessary skills to use, assess, and develop artificial intelligence applications, enabling them to contribute to shaping science, industry and society in the age of artificial intelligence. It is one of the strategic goals of RWTH as an interdisciplinary, integrated university of technology to develop and maintain interdisciplinary AI competencies. Specifically, a bridging course for Bachelor’s graduates who want to take up a Master’s program shall be developed and made available to a broad range of disciplines.*

*This so-called Micro Bachelor’s program seeks to be attractive for as large a number of students as possible. To achieve this, representatives from several RWTH faculties will contribute to the program. Initially, it will consist of ten MOOCs – massive open online courses – and made available through the edX platform.”*

This is a good example to follow and ready-for-use courses will be promoted via CoE RAISE and included in the course portfolio.

### 3.4 Barcelona Supercomputing Center (BSC)

BSC is the leading partner in the CoE RAISE WP6 “Outreach and Services” where one of the tasks is Task 6.1 “Training and education as services”. BSC is also a partner in other projects and networks, for example, PRACE or AI4Media<sup>27</sup>. Education and training offers from BSC can

<sup>22</sup> University of Iceland course on High Performance Computing

<https://ugla.hi.is/kennsluskra/index.php?tab=nam&chapter=namskeid&id=70067120220&namskra=0>

<sup>23</sup> Professor Morris Riedel <http://www.morrisriedel.de/category/teaching>

<sup>24</sup> Course from Prof. Morris Riedel

<https://www.youtube.com/watch?v=iUExQF10KBg&list=PLmJwSK7qduwXodrHuOJhPWY6O2wezXXLh>

<sup>25</sup> RWTH Aachen University <https://www.rwth-aachen.de/go/id/a/?lidx=1>

<sup>26</sup> RWTH Aachen University AI applications in education <https://www.rwth-aachen.de/cms/root/Die-RWTH/Aktuell/Pressemitteilungen/Julii/~pnxwz/Erfolg-in-der-Initiative-Kuenstliche-In/?lidx=1>

<sup>27</sup> AI4Media project <https://www.ai4media.eu/>

be found on the BSC education portal<sup>28</sup>. The offer is large - starting from courses and training events up to Ph.D. programs. There is also a special section with courses for PRACE<sup>29</sup>.

In collaboration with other partners (BarcelonaTech<sup>30</sup> and Intel<sup>31</sup>), BSC has developed a MOOC<sup>32</sup> “AI & Predictive Analytics in Data-Centered Environments” as a “A crash course on Machine Learning and Distributed Computing Frameworks in Data-centers”.

### 3.5 Flanders Make VZW (FM)

The CoE RAISE partner from Belgium Flanders Make VZW does not provide trainings in AI, but they contributed to the portfolio by uploading courses and training events to the Education service platform offered by other providers. One of such upcoming online courses is “From regulating data, algorithms and AI to enabling fundamental rights: turning technology regulation inside out”<sup>33</sup> led by Joris van Hoboken, the University of Brussels, and the University of Amsterdam.

### 3.6 The European Organization for Nuclear Research (CERN)

The European Organization for Nuclear Research (CERN) is organizing education and training events, as well as having educational resources. These resources are located on the CERN website<sup>34</sup>. Schools, seminars and courses can be found in Indico<sup>35</sup>.

### 3.7 The Cyprus Institute (CYI)

The Cyprus Institute performs research in the fields of AI and HPC, and also offers degree programs therein. There is the Master’s program<sup>36</sup> “Simulation and Data Sciences” and the Ph.D. program “Computational Sciences”<sup>37</sup>.

Workshops and schools, as well as other educational and training resources are publicly available at the Supercomputing Training Portal<sup>38</sup>. CYI also organizes an online seminar series and all seminars have been recorded and are available on their website<sup>39</sup>.

Information on courses and other educational material provided by CYI are also available on CoE RAISE’s Educational service platform.

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<sup>28</sup> BSC education portal <https://www.bsc.es/education>

<sup>29</sup> BSC PATC section <https://www.bsc.es/education/training/patc-courses>

<sup>30</sup> BarcelonaTech <https://www.upc.edu/en>

<sup>31</sup> Intel <https://www.intel.com>

<sup>32</sup> BSC MOOC <http://dcai.bsc.es/>

<sup>33</sup> Online AI course <https://www.flemish-ai-academy.be/calendar/from-regulating-data-algorithms-and-ai-to-enabling-fundamental-rights-turning-technology-regulation-inside-out-2/#inschrijven>

<sup>34</sup> CERN Resources <https://home.cern/events/remote-robotics-activities-cern-enhanced-reality-user-interfaces-and-artificial-intelligence>

<sup>35</sup> CERN courses <https://indico.cern.ch/category/6745/>

<sup>36</sup> Cyl Master program <https://www.cyi.ac.cy/index.php/education/masters-programs/simulation-and-data-sciences/masters-sds-program-overview.html>

<sup>37</sup> Cyl PhD program <https://www.cyi.ac.cy/index.php/education/phd-programs/computational-sciences/phd-cos-program-overview.html>

<sup>38</sup> Cyl portal <http://supercomputing.cyi.ac.cy/>

<sup>39</sup> Cyl seminar recordings <https://castorc.cyi.ac.cy/news-and-events#PastSeminars>

### 3.8 Riga Technical University (RTU)

As an academic institution, Riga Technical University offers AI courses within study programs. Overall, 13 study courses on AI have been gathered.

In Latvia, there is a possibility for people outside the university to join almost all courses as listeners. Listeners should be prepared to study one course for 16 weeks, mostly a few hours per week. Upon successful completion, a certificate is awarded. Most of the courses are offered in two languages - Latvian and English.

In addition to this, the RTU High-Performance Computing Center<sup>40</sup> offers courses available not only for academia but also for the industry, for example CUDA courses<sup>41</sup> in Latvian. Apart from study program courses, these are shorter courses – 8 hours only.

It should be noted that RTU has adapted a course “Elements of AI” for the Latvian audience<sup>42</sup>. The course was originally created by Reaktor<sup>43</sup> and the University of Helsinki<sup>44</sup>. This course is offered in 30 languages.

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<sup>40</sup> RTU HPC Center <https://hpc.rtu.lv/?lang=en>

<sup>41</sup> CUDA courses <https://hpc.rtu.lv/training-courses/?lang=en#cuda>

<sup>42</sup> Elements of AI in Latvian <https://www.elementsofai.lv>

<sup>43</sup> Reaktor <https://www.reaktor.com>

<sup>44</sup> University of Helsinki <https://www.helsinki.fi/en>

## 4 Courses from the PRACE, FocusCoE net, EuroHPC

Large HPC-related networks in Europe are offering education and training resources that are also related to AI topics. The CoE RAISE project partners are also members of these and other networks. In this section, the main education and training resources of these networks (PRACE, see Sec. 4.1; FocusCoE net, see Sec. 4.2, and EuroHPC, see Sec. 4.3) will be described.

### 4.1 PRACE

Many CoE RAISE partners are also involved in PRACE; it is a project that organizes training events and develops courses. Education and training resources are available from the PRACE training portal<sup>45</sup>; the portal consists of several sections (Figure 1):

- Upcoming Training Events;
- Materials;
- PRACE Tutorials;
- PRACE Code Vault;
- PRACE MOOCs.

Upcoming training events (courses) are listed indicating the date and start time, as well as the format, for example, online. A link to full description of the event is also provided. Materials, Tutorials, Code Vault, and MOOCs can be interpreted as collections of training resources in diverse formats.

The screenshot shows the PRACE Training Portal interface. At the top, there is a logo for PRACE (Partnership for Advanced Computing in Europe) and a navigation menu with links for Training Events, Materials, Tutorials, Code Vault, MOOCs, and About. Below the navigation is a section titled "PRACE Training Portal" with a search bar and five circular icons representing Training Events, Materials, PRACE Tutorials, PRACE Code Vault, and PRACE MOOCs. A section titled "Upcoming PRACE Training Courses" provides a detailed list of events, including dates, times, and online/offline status. The list includes:

Country	Instruction Level	Presence	Project	Scientific Domain	Target audience	Technical Domain
MAY 25	Tue	[ONLINE]	@ SURF	Advanced topics in scientific visualization with Blender: geometry, scripts, animation, action!		
JUN 7	Mon	[ONLINE]	@ JSC	High-performance computing with Python		
JUN 8	Tue	[ONLINE]	@ENCCS/intel	OpenMP Hackathon		

Figure 1: PRACE project training portal.

<sup>45</sup> PRACE training portal <https://training.prace-ri.eu/>

There is also an upgraded PRACE training portal<sup>46</sup> providing links to 14 PRACE training centers, Summer Schools, and some additional features, however, the presentation format of the upcoming training events and repositories of training resources is quite similar.

The structure and functionality of the portal has been analyzed already in Deliverable D6.1. This portal will be analyzed to identify AI- and HPC-related content, which may be considered appropriate for RAISE's course portfolio.

## 4.2 FocusCoE net

FOCUSCoE net is the network of the European HPC CoEs and CoE RAISE is also a partner in this network. The network can be accessed from the website<sup>47</sup>, which provides access to the Training Registry<sup>48</sup> of the network partners. The website also provides information on the training events related to AI and HPC. There is also a page<sup>49</sup> listing the training offers provided by each of the CoEs. Some CoEs provide access to the computational infrastructure, along with the resources developed, aggregated and coordinated by them.

## 4.3 EuroHPC

EuroHPC has created a portal<sup>50</sup> for different services including education and training. In the portal, several options appear under "Training and Events":

- Training events
- On-demand training offers
- Online training
- Training materials
- Academic programs

As the portal is still under development, the offer in some parts is very limited. However, many AI-related events offered mainly by the partners of EuroCC<sup>51</sup> and CASTIEL<sup>52</sup> projects can be found in the section "Training events".

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<sup>46</sup> Upgraded PRACE training portal <https://prace-ri.eu/training-support/training/>

<sup>47</sup> FOCUSCoE website <https://www.hpccoe.eu/about/>

<sup>48</sup> FOCUSCoE Training Registry <https://www.hpccoe.eu/coe-training-calendar/>

<sup>49</sup> CoEs training list <https://www.hpccoe.eu/technological-offerings-of-the-eu-hpc-coes-2-training/>

<sup>50</sup> EuroHPC portal <https://hpc-portal.eu/>

<sup>51</sup> EuroCC <https://www.eurocc-access.eu>

<sup>52</sup> CASTIEL <https://www.castiel-project.eu>

## 5 Courses from cloud service providers

The dominating cloud service providers such as Amazon Web Services (AWS), Google, Oracle, Microsoft Azure, and others, actively advocate for ubiquitous usage of their services and some of them are based on emerging AI technologies. The AI services available for the customers utilize basic and advanced ML principles, emerging technologies, and HPC algorithms. Such services are used in various research scenarios via the Application Programming Interfaces (APIs). Therefore, education of potential service users for cloud service providers becomes topical as never before. Service vendors are interested in working with more engaged and educated customers.

This section presents course offers of the cloud service providers Amazon (Sec. 5.1), IBM (Sec. 5.2), Google (Sec. 5.3), and Microsoft (Sec. 5.4).

### 5.1 Amazon Web Services (AWS)

Amazon Web Services<sup>53</sup> is one of the leading cloud service vendors. AWS Training and Certification Program helps individuals build and validate skills. The AWS provides activities related to education events such as Online Conferences, Online Tech Talks, as well as Training and Certification Events and Webinars<sup>54</sup>. These are online and in-person events that help the builders of today and tomorrow leverage the power of the cloud-based services.

Training at AWS is organized in the following forms:

- Digital training that allows users to learn online at their own pace;
- Classroom training learning best practices from an expert instructor;
- Virtual training lets users take courses from anywhere.

#### AWS Machine Learning University (MLU)

In the context of ML, the AWS Machine Learning University has been established<sup>55</sup>.

AWS and Udacity have been collaborating for years to educate individual developers of all skill levels in ML concepts. Individuals can participate in education programs earning a scholarship for the AWS Machine Learning Engineer Nanodegree Program. Within this program<sup>56</sup>, students apply ML techniques and algorithms, including deployment to the AWS production environment.

Since 2021, the foundation course includes new topics:

- Introduction to Machine Learning;
- Introduction to Reinforcement Learning (RL) with AWS DeepRacer;
- Introduction to Computer Vision with AWS DeepLens;
- Two new generative AI models.

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<sup>53</sup> Amazon Web Services <https://aws.amazon.com/free/machine-learning>

<sup>54</sup> AWS training <https://aws.amazon.com/training/>

<sup>55</sup> AWS MLU <https://aws.amazon.com/machine-learning/mlu/>

<sup>56</sup> AWS and Udacity <https://www.udacity.com/scholarships/aws-machine-learning-scholarship-program>

## 5.2 IBM

The well-known International Business Machines Corporation (IBM)<sup>57</sup> is another strong player in the field of AI-related education. IBM provides online training and instructor-led training. Within AI Experiences, students will visit IBM labs for two days to learn and apply data science to their real-world business problems. After passing the exam, students receive IBM issued AI certificate, also known as a professional certification badge.

IBM has signed a collaboration contract with Coursera, see Sec. 6.5, on organizing and hosting its learning program “IBM AI Enterprise Workflow Specialization”<sup>58</sup>. IBM has a six-course specialization that has been designed by data scientists for data scientists. Within the training program, students will have to undergo 40 hours of training covering best practices in data science in today’s large enterprises, from identifying business priorities to operationalization. Students will use real-world scenarios and will connect business priorities to technical implementations. To be more specific, students will connect machine learning to specialized AI use cases utilizing Python and IBM Cloud technologies.

IBM provides learning opportunities and testing objectives on eight aspects:

- Scientific, mathematical, and technical essentials for Data Science and AI;
- Applications of Data Science and AI in Business;
- Data understanding techniques in Data Science and AI;
- Data preparation techniques in Data Science and AI;
- AI techniques and models;
- Evaluation of AI models;
- Deployment of AI models;
- Technology Stack for Data Science and AI solutions.

Coursera hosts IBM AI-related 100% online courses that are open for new learners to join and start learning immediately. An Assessment Exam is an online test that results in a score report to help students gauge their preparedness<sup>59</sup>.

## 5.3 Google

Google provides Professional Certificates mainly on its own cloud services in the specialization of a Professional Machine Learning Engineer<sup>60</sup>.

Google Cloud technologies also permit the design of ML models to solve business challenges using proven ML models and techniques. However, practitioners should be proficient in all aspects of model architecture, data pipeline interaction, and metrics interpretation, as well as with foundational concepts of application development, infrastructure management, data engineering, and data governance. Through an understanding of cloud-based training, the engineers learn to design and create scalable solutions for optimal performance.

The Professional Machine Learning Engineer exam assesses students’ ability to:

- Frame ML problems;

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<sup>57</sup>IBM <https://www.ibm.com/community/datascience/ai-certification/>

<sup>58</sup>IBM with Coursera <https://www.coursera.org/specializations/ibm-ai-workflow>

<sup>59</sup> Pearson VUE <https://home.pearsonvue.com/>

<sup>60</sup> Google Certificate <https://cloud.google.com/certification/machine-learning-engineer>

- Architect ML solutions;
- Design data preparation and processing systems;
- Develop ML models;
- Automate and orchestrate ML pipelines;
- Monitor, optimize, and maintain ML solutions.

Coursera, see Sec. 6.5, is also one of the learning content distributors for Google<sup>61</sup>.

## 5.4 Microsoft Azure

Microsoft is another giant on whose shoulders Azure company stands. Needless to say that Microsoft also promotes its products and supports people's education. AZ-900 Courses on Udemy<sup>62</sup> is one of the examples of educational activities of Microsoft towards AI/ML fluency.

In summary, the most popular Microsoft Azure course categories:

- Blockchain: University at Buffalo;
- Microsoft Azure Data Fundamentals DP-900 Exam Prep: Microsoft;
- Azure: Create a Virtual Machine and Deploy a Web Server: Coursera Project Network;
- Getting Started with Azure: LearnQuest.

To conclude this section, it can be said that cloud service providers have extensive course offers and close cooperation with the Open Educational Resource providers that CoE RAISE will review in the following section.

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<sup>61</sup> Google with Coursera <https://www.coursera.org/google-career-certificates>

<sup>62</sup> Microsoft Azure <https://docs.microsoft.com/en-us/learn/certifications/exams/az-900>

## 6 Open Educational Resources

Since education has become more open, there is a growing number of educational and training resources made open to users in comparison to classical degree programs at the universities, where students should meet specific conditions to be registered. This section presents a review of the course offerings in AI by some of the most popular Massive Open Online Course (MOOC) providers. To be more specific, FutureLearn (Sec. 6.1), Udacity (Sec. 6.2), Udemy (Sec. 6.3), edX (Sec. 6.4), and Coursera (Sec. 6.5) are discussed.

### 6.1 FutureLearn

The FutureLearn<sup>63</sup> portal contains e-learning courses, MOOCs, and degree programs. At the FutureLearn portal, diverse course search options are used. Courses can be searched for by 16 different subjects, four course types, and by using a keyword. One can choose from the following course types:

- Short online courses;
- ExpertTracks (for mastering new skills);
- Micro-credentials and programs;
- Online degree courses.

When the course of interest is found, a detailed description of the course parameters is provided. There is a list of topics that are covered by the course, however, there is no access to detailed course topics and materials. Information on certificate accreditation, developer of the course, etc. is also available.

Although there is a section *Requirements* that specifies what user the course is intended for, there are no course prerequisites. The information available includes course duration and hours per week needed to complete the course.

### 6.2 Udacity

Amongst different programs, Udacity<sup>64</sup> offers AI program that includes 18 courses. The courses are sorted by the starting date. Description of each program features estimated course duration and hours per week needed to complete the course, as well as the next enrollment date and prerequisites.

Udacity also offer eight different schools. The School of Artificial Intelligence<sup>65</sup> is one of them. The first thing that is stated is the number of programs, number of courses and unique projects. The programs have downloadable content.

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<sup>63</sup> FutureLearn <https://www.futurelearn.com/>

<sup>64</sup> Udacity <https://www.udacity.com/>

<sup>65</sup> Udacity school of AI <https://www.udacity.com/school-of-ai>

### 6.3 Udemy

When searching for AI courses on Udemy<sup>66</sup>, one can choose from 20 topics in total, including AI. Udemy divides courses by three levels – *Beginner*, *Intermediate*, and *Expert*. For a specific course, a course creator is shown, date of last updates, language (including subtitles), learning outcomes, requirements, as well as course content. It should be noted that course duration is specified only in terms of length of online videos. There is a number of articles included in the course, however, the time needed for reading them is not included in the overall course length. One can find useful information about the target audience, however, it is not arranged by *Fields* but rather by topics and job titles, such as *Software Engineer* and *Data Scientist*.

### 6.4 edX

Platform edX<sup>67</sup> offers courses by subjects as well as programs and degrees. For each course, a provider is given, learning outcomes, program overview, and courses included in the program (if a professional certificate can be earned). For a professional certificate, more than one course should be taken from a given set. All courses are self-paced, however, hours per week and the estimated course length are specified. The difficulties in finding an appropriate course with professional certificate are mainly caused by the lack of visible information on course prerequisites, levels and clearly defined field. This information can be found only looking at the description of an individual course.

### 6.5 Coursera

In Coursera<sup>68</sup>, courses can be found depending on one's goal (e.g., earning a degree or a certificate) or subject. Depending on the subject, degree courses or degree programs can be offered. Some subjects offer courses by popular skills.

All courses are divided by three levels – *Beginner*, *Intermediate*, and *Advanced*. Unfortunately, levels are not given for all courses. To reach a broader audience, some courses have subtitles, however, it is not clear whether they provide lecture materials only in English or also in other languages before one enrolls.

The information on prerequisites is missing. *Fields* are not clearly understandable from the description. At the same time, the learners can find *Learner Career Outcomes*, that is, a percentage of applicants who have started a new career after completing the course and/or a percentage of applicants who got a tangible career benefit from the course. In section *Syllabus*, one can find information on the weeks needed to complete the course, the number of hours per week, as well as the number of videos and their duration, reading tasks, and quizzes.

To conclude this section, there are a lot of Open Educational Resources, each one of them created with a specific course offering. There are a lot of similarities, however, each of them has something unique that RAISE should consider when adding courses to RAISE's Educational service platform. Mostly, it is upon the person who adds a course to the platform to decide what category from our criteria the course should have. This means, an update will be needed at some point to adjust course criteria.

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<sup>66</sup> Udemy <https://www.udemy.com/>

<sup>67</sup> edX <https://www.edx.org/>

<sup>68</sup> Coursera <https://www.coursera.org/>

## 7 Conclusions

There exist a lot of platforms dedicated to training and education events, therefore, Task 6.1 tried to filter out only the courses and events relevant to the CoE RAISE needs. In addition, the differences, positive aspects, as well as some drawbacks and compatibility issues were considered when adding the courses to RAISE's Educational service platform. Courses, training events and other educational resources in AI, HPC, and Exascale Computing were searched for. The selected resources have been added to the Educational service platform database to expand the course portfolio.

Functionality of the Educational service platform was also tested during the course search process, and therefore some functions were added and course filter criteria got slightly upgraded.

At the next stage of the project, more education and training activities are foreseen, and information collected on available resources from the cloud companies and OER providers might be useful for the RAISE partners to incorporate in their training activities.

The extension of the course portfolio and eventual upgrade of the Educational service platform will be continued. The courses created during the CoE RAISE project will be added to the Educational portfolio as soon as they are ready.

## Annex 1

### A.1 Upgraded course filter criteria

Certain criteria for the search of courses at the Educational services platform were developed. These criteria were described in Sec. 2.2 of Deliverable D6.1. The upgraded criteria (in red) are presented in Table 1. Upgrading of the criteria was necessary to better categorize the courses in the appropriate group when information is uploaded.

	<b>First level choice</b>	<b>Second level choice</b>	<b>Comment</b>
<b>Topic:</b>	Artificial Intelligence - general Machine Learning Deep Learning Reinforcement Learning Neural Networks Robotics Computer Vision Natural Language Processing Recommender Systems Algorithmic Game Theory Computational Mechanism Design Other		
<b>Level:</b>	Potential users Beginners Intermediate Advanced		For the potential users, there could be organized attractive lectures and introductory courses with no demand of any previous knowledge in the field. For higher levels, some prerequisites are demanded.
<b>Field:</b>	Fundamental Science Engineering and Mathematics IT and Computer science Industry applications Nature and Environment Healthcare and Medicine Education		

	Business and Management Other		
<b>Format:</b>	Face-to-Face	Lecture Lecture with hands-on (practice) Workshop/Tutorial Hands-on/ <b>Guided project</b> Project/Teamwork/Hackathon Summer School <b>Micro-credential/Expert Track</b> Degree programme	Traditional training format
	Online teaching/training	Lecture Lecture with hands-on (practice) Workshop/Tutorial Hands-on/ <b>Guided project</b> <b>Micro-credential/Expert Track</b> <b>Degree programme</b>	Remote synchronous online lectures and training events using appropriate technologies
	Distance learning	e-learning course MOOC <b>Guided project</b> <b>Micro-credential/Expert Track</b> Degree programme	Traditional distance education technology and methodology with mainly asynchronous learning with tutor support
	Self-learning	Video recording of training event Tutorials Podcast Course material <b>Book</b> Open Educational Resource	Self-learning without tutor support
<b>Language:</b>	English German Spanish Dutch French Icelandic Italian Latvian		

Table 1: Course filter criteria.

## A.2 List of courses

The total number of courses and other educational and training resources collected per-partner and from other sources within the project's first year is presented in Table 2. In Table 3, short information about the collected portfolio with the course level, format, title, and partner is presented. Detailed information on each resource can be found at the Educational service platform<sup>69</sup>.

<sup>69</sup> Educational service platform <https://raise.learning.lv/courses>

CoE RAISE partner organization	Number of proposed resources
Riga Technical University (RTU)	19
Barcelona Supercomputing Center (BSC)	5
Forschungszentrum Jülich (FZJ)	4
The Cyprus Institute (CYI)	3
<b>From CoE RAISE partners:</b>	<b>31</b>
From other sources:	47
<b>Total number:</b>	<b>78</b>

Table 2: Number of education and training resources collected.

Id	Course Level	Course Format	Course Title	CoE-RAISE partner organization
1	Potential users	Distance learning	Ethics of AI	
2	Potential users	Distance learning	Elements of AI	
3	Potential users	Distance learning	Elements of AI	RTU
4	Potential users	Face-to-Face	Introduction to High Performance Computing Technology CUDA	RTU
5	Potential users	Not defined	Introduction to genetic algorithms	RTU
6	Potential users	Online teaching/training	Interactive High-Performance Computing with Jupyter	FZJ
7	Potential users	Online teaching/training	A.I. as a Tool for Change	
8	Potential users	Online teaching/training	Sense & Sensibility of AI	
9	Potential users	Online teaching/training	Data Analysis and Plotting in Python with Pandas	FZJ
10	Potential users	Online teaching/training	On-Demand Webinar: Bootcamp Warm-Up: AI Literacy	
11	Potential users	Online teaching/training	Business Implications of AI	
12	Potential users	Online teaching/training	Ievads augstas veiktspējas skaitļošanas tehnoloģijā CUDA	RTU
13	Potential users	Self-learning	What is Artificial Intelligence?	
14	Potential users	Self-learning	AI For Everyone	

Id	Course Level	Course Format	Course Title	CoE-RAISE partner organization
15	Beginners	Distance learning	Artificial Intelligence in Bioinformatics	
16	Beginners	Distance learning	AI&Predictive Analytics in Data Center Environments	BSC
17	Beginners	Face-to-Face	High Performance Computing Technology CUDA	RTU
18	Beginners	Face-to-Face	Cybersecurity Solutions in High Performance Computing Environment	RTU
19	Beginners	Face-to-Face	Introduction to genetic algorithms	RTU
20	Beginners	Face-to-Face	AI Academy	
21	Beginners	Face-to-Face	A.I. Developer - DATA Operator	
22	Beginners	Online teaching/training	AI and Segmentation in Radiotherapy	
23	Beginners	Online teaching/training	BSC GPU Hackathon - HPC+AI	BSC
24	Beginners	Online teaching/training	Augstas veiktspējas skaitļošanas tehnoloģijas CUDA lietišķais lietojums	RTU
25	Beginners	Online teaching/training	Bioinformatics and AI	
26	Beginners	Online teaching/training	AI Training	
27	Beginners	Self-learning	Learn To Create AI Assistant (JARVIS) With Python	
28	Beginners	Self-learning	Machine Learning	
29	Beginners	Self-learning	AI for Materials Industry	
30	Beginners	Self-learning	Artificial Intelligence (AI) for Earth Monitoring	
31	Beginners	Self-learning	HPC Beginner Training Event	Cyl

Id	Course Level	Course Format	Course Title	CoE-RAISE partner organization
32	Intermediate	Distance learning	AI for healthcare	
33	Intermediate	Distance learning	Master in Artificial Intelligence	
34	Intermediate	Distance learning	Professional Certificate in Inteligencia artificial aplicada	
35	Intermediate	Face-to-Face	Introduction to artificial neural networks	RTU
36	Intermediate	Face-to-Face	Intelligent computer technologies	RTU
37	Intermediate	Face-to-Face	Data mining and knowledge discovery	RTU
38	Intermediate	Face-to-Face	Artificial neuron and neural networks	RTU
39	Intermediate	Face-to-Face	Posgrado en Artificial Intelligence with Deep Learning	
40	Intermediate	Face-to-Face	Evolutionary and genetic algorithms	RTU
41	Intermediate	Face-to-Face	Intelligent computer technologies and systems	RTU
42	Intermediate	Face-to-Face	Basics of data processing and data mining	RTU
43	Intermediate	Face-to-Face	Artificial neural systems in information processing	RTU
44	Intermediate	Face-to-Face	Introduction to artificial neural networks	RTU
45	Intermediate	Face-to-Face	Ontology in data retrieval	RTU
46	Intermediate	Not defined	Data Stories	
47	Intermediate	Online teaching/training	Directive-based GPU programming with OpenACC	FZJ
48	Intermediate	Online teaching/training	PATC: Introduction into the Big Data Analytics @ BSC	BSC
49	Intermediate	Online teaching/training	ACM Europe Summer School on HPC Computer Architectures for AI and Dedicated Applications	BSC
50	Intermediate	Online teaching/training	Introduction to Scalable Deep Learning	FZJ
51	Intermediate	Online teaching/training	Energy reduction for AI workloads	
52	Intermediate	Online teaching/training	EXCELLERAT Training on Nek5000	
53	Intermediate	Online teaching/training	PUMPS+AI Summer School 2021	BSC
54	Intermediate	Online teaching/training	ENCCS OpenACC Bootcamp	
55	Intermediate	Self-learning	Lex Fridman Podcast	
56	Intermediate	Self-learning	Modelling/Simulations of Molecular Systems	Cyl
57	Intermediate	Self-learning	Data Skeptic - Podcasts	
58	Intermediate	Self-learning	AI Foundations for Everyone Specialization	
59	Intermediate	Self-learning	Machine Learning Specialization	
60	Intermediate	Self-learning	Professional Certificate in Data Engineering Fundamentals	
61	Intermediate	Self-learning	SuperDataScience	
62	Intermediate	Self-learning	Linear Digressions	
63	Intermediate	Self-learning	Professional Certificate in Tiny Machine Learning (TinyML)	
64	Intermediate	Self-learning	Deep Learning Specialization	
65	Intermediate	Self-learning	Talking Machines	
66	Intermediate	Self-learning	Professional Certificate in Python Data Science	
67	Intermediate	Self-learning	Professional Certificate in Computer Science for Artificial Intelligence	
68	Intermediate	Self-learning	Professional Certificate in Applied AI	
69	Intermediate	Self-learning	Professional Certificate in Foundations of AI	
70	Intermediate	Self-learning	Professional Certificate in AI in Practice	
71	Intermediate	Self-learning	Professional Certificate in Deep Learning	
72	Intermediate	Self-learning	Neural Networks and Deep Learning	
73	Intermediate	Self-learning	AI in Business	
74	Intermediate	Self-learning	The TWIML AI Podcast (formerly This Week in Machine Learning & Artificial Intelligence)	
75	Intermediate	Self-learning	Machine Learning Guide	
76	Intermediate	Self-learning	Professional Certificate in Fundamentals of Google AI for Web Based Machine Learning	
Id	Course Level	Course Format	Course Title	CoE-RAISE partner organization
77	Advanced	Online teaching/training	Upscaling A.I. with Containers	
78	Advanced	Self-learning	HPC Advanced Training Event	Cyl

Table 3: Course portfolio.

## List of Acronyms and Abbreviations

AI	Artificial intelligence
AWS	Amazon Web Services
API	Application Programming Interface
BSC	Barcelona Supercomputing Center
CERN	European Organisation for Nuclear Research / Organisation Européenne pour la Recherche Nucléaire, International organization, Switzerland
CoE RAISE	European Center of Excellence in Exascale Computing “Research on AI- and Simulation-Based Engineering at Exascale
CYI	The Cyprus Institute
ECTS	European Credit Accumulation and Transfer System
EHEA	European Higher Education Area
EQF	European Qualification Framework
EU	European Union
EuroHPC	European High-Performance Computing
FZJ	Forschungszentrum Jülich
FM	Flanders Make VZW
FocusCoE	Network of the Centers of Excellence in HPC
HPC	High-Performance Computing
HPDA	High-Performance Data Analytics
IBM	International Business Machines Corporation
IT	Information technologies
LMS	Learning Management System
ML	Machine Learning
MLU	AWS Machine Learning University
MOOC	Massive Open Online Course
OER	Open Educational Resource
UOI	University of Iceland
PRACE	Partnership for Advanced Computing in Europe
PMT	Project Management Team
RAISE	see CoE RAISE
RL	Reinforcement Learning
RTU	Riga Technical University
RWTH	Rheinisch-Westfälische Technische Hochschule Aachen, Germany
SME	Small- and Medium-Sized Enterprise