EXCELERATE Deliverable D11.1

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1. Executive Summary

This document (D11.1 - Deliver the identified evaluation systems and good practice guidelines for training. Deliver a TeSS platform and identify e-learning solutions) reports the efforts undertaken in the last 2 years by the ELIXIR Training Platform, subtask leaders, ELIXIR Training Coordinators and ELIXIR training colleagues to build the underlying structure of the ELIXIR Training Platform and bring it up to speed. It describes the achievements within the Task 11.1 of the WP11, Building the ELIXIR infrastructure.

The deliverable in fact touches upon 3 subtasks (11.1.1, 11.1.2 and 11.1.3). "Deliver the identified evaluation systems and good practice guidelines for training" belongs to **Subtask 11.1.1: Assessing training quality, good practice and impact**. In order to ensure that ELIXIR Training needs are met (see training activities reported in the MTR report) and the training delivered is impactful, of high quality and at scale, we have worked together with multiple stakeholders to define specifications, standards, metrics and key performance indicators for ELIXIR training. It resulted in a harmonized mechanism, and its companion good practice guidelines, that allow to capture and report on ELIXIR training efforts and their impact, across Nodes. This mechanism has been so far adopted by approximately 12 Nodes, and over 2254 short-term feedback surveys have been collected to date. We are currently in the process of introducing long-term feedback surveys, which will allow to collect complementary and invaluable information of ELIXIR training impact in the long term.

"Deliver a TeSS platform" belongs to **Subtask 11.1.2: TeSS Training Portal**. TeSS has been developed and improved since 2014 to become the ELIXIR central hub for aggregating and disseminating information on ELIXIR, and EXCELERATE, training activities, materials, and cross-reference to ELIXIR's resources. It was built on the TeSS prototype piloted by ELIXIR-UK as an open resource, and has received contributions from and has been shaped by the ELIXIR community, in synergy with GOBLET, Bioschemas, bio.tools and FAIRsharing. TeSS automatically harvests information from several resources (ELIXIR Nodes and 3rd party providers) as well as allowing for manual curation. As of today, it displays over 260 future training events and , 829 training materials from 46 content providers. Users may now readily discover ELIXIR-EXCELERATE training events and resources in one single portal. We can confidently say that TeSS is becoming the world reference portal for training, which is our main aim for this resource. Through two ongoing ELIXIR Implementation Studies, we are currently working on constructing training workflows in TeSS, and defining learning paths to guide users in identifying courses which are most relevant to their needs and existing competency level. The results of both IS will be implemented and integrated into TeSS.

"Identify e-learning solutions" belongs to **Subtask 11.1.3: eLearning**. Distance learning has become essential to reach large audiences spread over many countries, as is the case for the ELIXIR community. In 2016, we have surveyed the technological and pedagogical options, as well as the e-learning expertise and technology available across the Nodes, which resulted in the publication of an article summarizing our first recommendations for a cost-effective approach for supporting training and capacity-building[1]. Since then, we used the ELIXIR-SI eLearning Platform (EeLP), a Moodle-based learning platform and Learning Management System to store and provide access to education resources in ELIXIR's face-to-face and distance courses. During this reporting period, the EeLP platform has been tested in deploying 16 ELIXIR synchronous[2] courses, in topics related to the WP6 to 9 Use Cases, to WP10 Capacity building and to ELIXIR resources.

The Virtual Coffee Room (VCR), although not part of task 11.1, completes and complements the construction of the technical infrastructure of the ELIXIR Training Platform. This web-based platform was released in 2017 and created to ease the exchange of information among ELIXIR developers and trainers. It can be used to share questions, tasks and issues about software development among developers and also to more quickly identify training needs. In the future, additional uses for the VCR will be explored by other ELIXIR communities e.g. as a help-desk platform for ELIXIR services.

The activities and tools described in this deliverable have corroborated the usefulness and fitness of the concepts outlined in the ELIXIR-EXCELERATE grant proposal. These tools are part of the ELIXIR training toolkit that is now available to all ELIXIR Nodes to facilitate organisation, communication and delivery of training. Over the next year and a half, we aim at promoting and increasing adoption, by all ELIXIR Nodes, and use, by the ELIXIR training community, of the training resources developed so far. These resources and activities will continue to be expanded both in scope and coverage, as well with the participation of a growing number of ELIXIR Nodes. We will thus ensure that ELIXIR and Node trainings are coherently delivered following a common set of quality standards and are impactful.

2. Impact

The achievements described in this document impact ELIXIR, its communities, its users and their research.

As of March 2017, TeSS displayed 260 future training events, 829 training materials from 46 ELIXIR and other content providers. Thanks to TeSS, the training provided by ELIXIR and its Nodes has global visibility, trainers have access to a large collection of training

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[1] https://zenodo.org/record/166378#.WsOTiWbpOL5

[2] *Synchronous learning*: a mode of learning whose defining characteristic is that trainers and trainees are engaged at the same time, whether face-to-face in a classroom or *online*. Online lessons are typically delivered via video-conferencing equipment or live-streamed podcasts.

course materials, and researchers have a single entry point to easily find the training courses matching their needs.

The number of training events, researchers attending ELIXIR courses and Nodes delivering training have increased in the last two years of the ELIXIR-EXCELERATE project. In the last 2 years, 44 ELIXIR-EXCELERATE (co-)funded training events took place, and many more are planned[3].

Over 510 course participants had access to ELIXIR courses supported by the EeLP platform and also to a video conference system. In addition, 8 Nodes had their course organisation facilitated by the use of EeLP.

The Train-the-trainer program, which has been described in the MTR report, has so far organised 7 workshops, and trained 53 new trainers from 12 Nodes. The number of well-trained ELIXIR trainers will continue to grow in the next years thanks to ELIXIR-EXCELERATE and the recently created ELIXIR Train-the-trainer exchange programme.

The set of metrics and key performance indicators for ELIXIR training, defined in sub-task 11.1.1, allowed to standardize the way we measure the training efforts and assess impact; so far data has been collected from over 2254 short-term feedback surveys across 12 Nodes. Making this set of metrics available not only facilitates capturing the information on the impact of ELIXIR training, but also help other Nodes to more easily adopt this procedure and improve their training organization process. Also organisations outside ELIXIR are interested to learn about ELIXIR's quality and impact approach and we are sharing our expertise and setting up collaborations with for instance EOSCHub and the EJP in rare diseases consortium.

3. Project objectives

With this deliverable, the project has reached or the deliverable has contributed to the following objectives:

No.	Objective	Yes	No
1	Build a sustainable training infrastructure for ELIXIR's community - encompassing both a technical infrastructure and training expertise, as well as mechanisms for guaranteeing quality of training (Task 11.1)	X	
2	Develop and deliver training in topics selected as training gaps within the ELIXIR community in selected application areas (namely WP6 to 9 Use Cases). (Task 11.2)	X	

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[3] List of ELIXIR training events:
https://docs.google.com/spreadsheets/d/1IUVZSarRpvH_3mR5HOKGK9nM1z1njkZdEP_9JHfRVTk/edit#gid=1249062448

4. Delivery and schedule

The delivery is delayed: ☑ Yes • No

5. Adjustments made

The deliverable is slightly delayed because of organizational issues.

6. Background information

Background information on this WP as originally indicated in the description of action (DoA) is included here for reference.

Work package number	WP11	Start date or starting event:	Month 1
Work package title	ELIXIR-EXCELERATE Training Programme		
Lead	Patricia Palagi (SIB); Gabriella Rustici (UCAM); and Celia van Gelder (NBIC)		

Participant number and person months per participant

1 - EMBL (14 PM), 2 - UOXF (12 PM), 4 - UNIMAN (30.80 PM), 5 - UTARTU (42 PM), 6 - NBIC (7.5 PM) (+ VU (2 PM), SARA (2 PM))

11 - UMA (2 PM), 16 - FCG (12 PM), 20 - CSC (10 PM), 24 - UiO (2 PM), 25 - SIB (14 PM), 26 - CNRS (4 PM), 30 - CNR (25.58 PM), 32 - UL (42 PM), 35 - MU (7.20 PM), 40 - HUJ (4 PM), 42 - FORTH (6 PM), 43 - UEDIN (0.44 PM), 44 - UCAM (31.56 PM), 45 - UU (00 PM) (+ SU (4 PM))

Objectives

WP11 has two principal objectives:

• To build a sustainable training infrastructure for ELIXIR's community - encompassing both a technical infrastructure and training expertise, as well as mechanisms for guaranteeing quality of training. (Task 11.1)

• To develop and deliver training in topics selected as training gaps within the ELIXIR community in selected application areas (namely WP6 to 9 Use Cases). (Task 11.2)

Work Package Leads: UCAM to replace EUDIN following submission of GA 2nd amendment on 31/1/2018. EUDIN termination following submission of GA 2nd amendment on 31/01/2018. Chris Ponting (up to 1/3/2017), Gabriella Rustici (since 1/3/2017) (UCAM), Celia Van Gelder (since 1/3/2017) (NBIC) and Patricia Palagi (SIB)

Description of work and role of partners

WP11 - ELIXIR-EXCELERATE Training Programme [Months: 1-48]

UCAM, EMBL, UOXF, UNIMAN, UTARTU, NBIC, UMA, FCG, CSC, UiO, SIB, CNRS, CNR, UL, MU, HUJ, FORTH, UEDIN, UU

As medicine and the life sciences become increasingly centred on the generation, analysis and interpretation of big data, most science professionals will need to become more proficient in exploiting bioinformatics data and systems.

The ELIXIR Community is estimated at 500,000 people, drawn from across the spectrum of individuals ranging from life scientists and bioinformaticians, to tool developers and infrastructure operators. This WP will up-skill European researchers focused on the WP6 to 9 Use Cases, who will be empowered to more effectively exploit the data, tools, standards and compute infrastructure provided by ELIXIR, and on ELIXIR-EXCELERATE developers and infrastructure operators.

This Training Programme will be the foundation upon which international bridges will be built, in order to harmonise efforts, to share resources, to avoid duplication/redundancy and to maximise effectiveness. Specific organisations and initiatives with which to collaborate may be (but are not limited to): GOBLET (the Global Organisation for Bioinformatics Learning, Education and Training), ISCB (the International Society for Computational Biology), and Software Carpentry Foundation, and also the training programmes of other ESFRIs such as BBMRI, EATRIS, and ISBE.

Collaboration with GOBLET essentially provides a ready-made global gateway to ELIXIR's training resources, and will ensure that the foundations built by GOBLET are not duplicated – the leader of task 11.1.2 also leads GOBLET, assuring that their distinct roles will evolve in harmony. Close engagement with industry will be sought such as through the ELIXIR Industry Programme.

ELIXIR is a new research infrastructure in its implementation phase. The ELIXIR community as represented in the EXCELERATE consortium is very diverse in a number of aspects, including for example maturity of individual Nodes and level of knowledge and expertise. For workshops held in the context of EXCELERATE, we will always try to identify the relevant expertise from within the consortium; however, as ELIXIR develops cutting-edge infrastructure for life sciences, external experts will need to be invited on a relatively regular basis to contribute to the discussions.

Their travel and subsistence will be supported by the grant.

A robust, high quality training infrastructure supporting ELIXIR resources and services will increase the impact and visibility of ELIXIR as a whole, ensuring that ELIXIR resources are introduced into industry and academia. It will catalyse and support the (self-) training of researchers, increase the impact of ELIXIR services, and facilitate scientific excellence.

All activities in this Training Programme will build on existing national training experience and expertise in the Nodes, and will complement, enhance, and disseminate these activities. Training activities will be closely aligned with the ongoing development of data infrastructure, standards, tools and services in each Node. This work paves the way for a later comprehensive, high quality and sustainable training programme to be rolled out over the entire ELIXIR Community.

The ELIXIR Training Programme targets the following distinct stakeholder groups:

• The ELIXIR community encompassing its partners, associated industry and SMEs (Task: 11.1)

• Developers and Infrastructure operators of ELIXIR's services (Task: 11.2.1)

• Users of ELIXIR's services (Task: 11.2.2)

• ELIXIR's trainers (Task: 11.2.3)

Task 11.1: Building an ELIXIR Training Infrastructure (143.3PM)

Subtask 11.1.1: Assessing training quality, good practice and impact (45PM)

ELIXIR Training needs to be timely, impactful, of high quality, and at scale. It will draw upon existing expertise in member countries that has yet to be combined under a unified structure. A Good Practice Coordinator will identify and deliver a framework of good practices throughout ELIXIR and ELIXIR-EXCELERATE. An initial workshop involving the ELIXIR Training Coordination Group (TrCG), industry/SMEs and other stakeholders will focus on defining specifications, metrics and key performance indicators to ELIXIR training. This subtask will build confidence for those seeking training (whether from academia, industry or other sectors) that ELIXIR training is being delivered to high standards, ensuring "best in class" training provision. It will also provide ELIXIR with a mechanism to capture and report on the impact of its training programme on the European and international level, and will harmonise across Nodes in standards, metrics and sharing of training materials. Development of well- structured training routes – through the use of workflows – embedded in online resources (WP11.1.2 and WP11.1.3) will specifically address urgent needs of WP6 to 9 Users and industry for cost-effective, time-effective, impactful training.

Partners: UK, EMBL-EBI

Additional resources required: Workshops €20,000

Subtask 11.1.2: TeSS Training Portal (51.3PM)

A training portal, TeSS, will be developed in this task to be an active forum for aggregating, disseminating and coordinating information on ELIXIR-EXCELERATE's training activities/materials, including those relating to ELIXIR's Core Resources. Building on the TeSS prototype being piloted by ELIXIR-UK, this task will 'harden' the prototype, harness the outputs from WP6 to 9's Use Cases and 3rd-party content providers, and synergise globally with GOBLET. Importantly, training information from all Nodes will be pulled into the TeSS, ensuring ELIXIR-wide coverage. The TeSS will enable registration and discovery of training activities/materials through multi-centre information aggregation, it will allow users to collect ('package') sets of materials/tools/data required for training, and offer workflows that allow related resources to be identified and harvested from source. The roles of GOBLET and TeSS are complementary: the former (a materials/course repository and trainer directory) acts as a feed to the latter (a resource aggregator and dissemination hub), obviating the need for ELIXIR-EXCELERATE to build its own repository.

No mechanism currently exists via which users may either readily discover ELIXIR-EXCELERATE training events/resources (many of which are dispersed on websites across ELIXIR member states and beyond) and/or determine their relevance (e.g., what is the audience of this course (beginner, advanced, etc.), what is its duration, where is it

being held, which course should I take next, etc.?). The added value of this task is therefore in coordinating and making discoverable ELIXIR-EXCELERATE training activities/materials, and surfacing information in ways that support user decisions and choices. We will ensure wide uptake by all stakeholders (from trainers and trainees, to resource providers and developers, including those across industry/SMEs) via community-building events. This subtask will result in the release of the TeSS as an open resource, contributed to by the community, and shaped both by the community and by the outputs of ELIXIR- EXCELERATE's Use Cases (WP6 to 9).

Partners: UK, CH, PT, NL

Subtask 11.1.3: eLearning (47PM)

Distance training has become essential to reach large audiences spread over many countries, as is the case for the ELIXIR community. This task will survey the current technological and pedagogical options, the existing e- learning expertise and technology in the Nodes, and possible international partners (Coursera, edX, Udacity, GOBLET etc.). In concert with the ELIXIR training community, we will decide for the best and suitable e-learning strategy for ELIXIR and then proceed into implementing this strategy, which will complement the TeSS training portal. During this process we will develop ELIXIR e-learning expertise, which will be exploited to create guidelines and recommendations for future trainers. A major part of this task will be devoted to derive scalable training materials related to the WP6 to 9 Use Cases and ELIXIR resources, which will all be made available to the ELIXIR community of trainers, developers and users. The trainers will benefit when delivering their courses; developers and users will benefit from the availability of materials.

Partners: SI, NL, CH, PT, IL

Additional resources required: Workshops €20,000

Task 11.2: Delivering training to the ELIXIR-EXCELERATE community (116PM)

Subtask 11.2.1: Train the Developer and Infrastructure Operator (40PM)

This subtask targets all developers and infrastructure operators who are developing and maintaining ELIXIR services, distributed over all Nodes and ELIXIR WPs (most notably WP3, WP4, WP6 to 9, and WP10). The main activities are:

a) mapping the competences across the Nodes and analysing collected training needs from the technical people through internet queries, discussion rounds at the annual ELIXIR All Hands Meeting and within the technical coordinators group;

b) providing targeted training based on the mapped needs as face-to-face workshops or webinars where applicable;

c) implement a dedicated virtual community space to ease the communication between the developers and infrastructure operators across the Nodes. The aim is to have a virtual coffee room where issues regarding resource development and ELIXIR services can be shared and re-occurring problems can be easily noticed and solved. The virtual community will allow buddying up individual developers across the Nodes who are working on similar tasks but otherwise would not meet nor have discussion possibilities. On top of all the information gathered, specific training can be quickly delivered in response to identified needs. Improving developers' skills and enabling easy knowledge

exchange across the community will have immediate impacts on the quality of tools provided by the ELIXIR community. With substantial competition among analysis tools and databases in the life sciences, better designed and executed services obtain greater visibility not only in Europe but worldwide thus further raising the awareness of ELIXIR services.

Partners: EE, EMBL-EBI, SE, IL, FI

Additional resources required: Training Procurement €60,000

Subtask 11.2.2: Train the Researcher (43PM)

It is essential that ELIXIR-EXCELERATE Users (e.g. in WP6 to 9) acquire skills that empower them to transform big data into meaningful knowledge. This Subtask will plug the training gaps using HPC facilities and expertise, specific cloud computing workflow training needs (WP4) and existing solutions, and the provision of training workshops.

Life scientists, computational biologists, and bioinformaticians engaged in Marine Metagenomics, Plant Genotype-Phenotype interactions, Rare Disease and Biological Sample Collection research will be trained in domain-specific knowledge. To become independent and savvy users of the ELIXIR resources training will be given in: scientific programming, statistics, HPC, ontologies, workflows, data curation and annotation (WP3), as well as in the effective use of standards and FAIR data. Reproducibility in the life sciences is a rapidly growing problem. Targeted training is anticipated to improve experimental reproducibility, to empower scientists to address new avenues of research requiring big data analysis, and to cross-pollinate diverse disciplines with innovative analytical approaches. Training opportunities will be prioritised, in consultation with Industry/SMEs, and training delivery will be monitored (WP11.1).

Partners: ES, CH, UK, NL, SI, NO, PT, EL

Additional resources required: Workshops €140,000

Subtask 11.2.3: Train the trainer (33PM)

For the ELIXIR training to achieve maximum impact, adequate capacity to train in all Nodes is required. This task will train the trainer pool that already exists – albeit in a fragmented manner – across ELIXIR Nodes and to identify and train new trainers. It will build a highly skilled and coherent community of training instructors by initially surveying available training capacity and developing an appropriate train the trainer (TtT) framework. Using targeted surveys and drawing upon knowledge and skills from Nodes with greater experience (and with WP11.1), expertise will be developed in Nodes, for ELIXIR Core Resources and Use Cases, where training opportunities have hitherto been scarce. The task will deliver a framework and associated material and guidelines for training new trainers across ELIXIR, from both industry and academia. To enhance delivery, training will take advantage of ready-to-run virtual machines (VMs, developed within ELIXIR and/or in collaboration for instance with BioImg.org) and clouds, assisted by a workshop that gathers both trainers and infrastructure specialists from WP4.2. TtT sessions will accompany training courses in Marine Metagenomics (WP6), Plant Genotype-Phenotype (WP7) and Rare diseases (WP8) providing good practice, and guidance for prospective new trainers. TtT will build capacity whilst stimulating collaborations spanning ELIXIR Nodes and other stakeholders, including industry/SMEs which represent a currently unexplored resource.

Partners: IT, EMBL-EBI, SE, CH
Additional resources required: Workshops €154,000

7. Appendices

7.1. Appendix 1: Quality and Impact

A comprehensive report on the Quality & Impact subtask was prepared for the face-to-face meeting of this subtask that took place in November 2017. The report is available here. This includes an introduction to the subtask, major results to date and steps moving forward.

7.2. Appendix 2: TeSS

7.2.1. Introduction

The ELIXIR Training Portal, TeSS, was created to allow scientists to browse, discover and organise life-science training events and resources, aggregated from ELIXIR Nodes and a variety of third-party content providers. During the first reporting period of EXCELERATE, a production beta version of the platform was released (January 2016). Since then, the number of content providers that TeSS aggregates has significantly increased, and the number of training events and materials has grown accordingly. The developments and activities of the TeSS Team during the past year, and the plans moving forward, are detailed in the sections that follow.

7.2.2. Growth of TeSS

Expanded resource aggregation
The content of TeSS is currently sourced from 46 different content providers. Of these, 21 are now automatically aggregated, requiring no human intervention to present the latest, most up-to-date training materials and events.

Expanded user base
Over the last year (February 2017-2018), TeSS has seen a total of 4,934 unique users, across Europe and the rest of the world. Although it is difficult to differentiate genuine from bogus usage, the map shown in Figure 1 nevertheless gives a broad overview of the global pattern of TeSS usage; Table 1 provides a more detailed breakdown of the usage per country of origin. This represents a 32.5% increase on last year (February 2016-2017), when 3,723 unique users were recorded. Overall, during the last year, TeSS had a monthly mean user-base of 411.
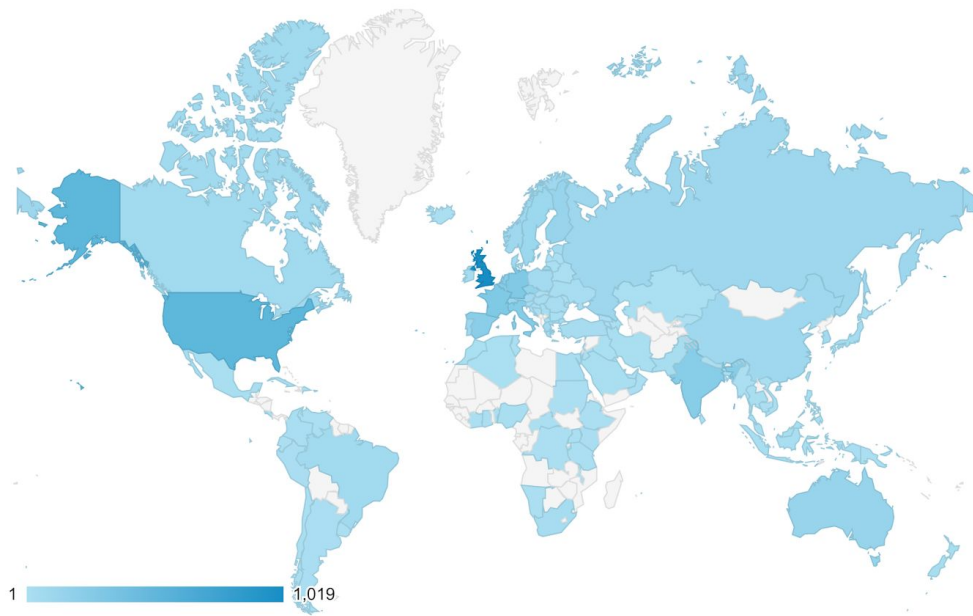
Figure 1. *Geographical distribution of unique users of TeSS between 20 February 2017 and 20 February 2018.*

Table 1. *Breakdown of TeSS usage (Feb 2017-2018) per country - the top 20 countries are shown.*

1.	🇬🇧	United Kingdom	**1,019** (19.45%)	11.	🇫🇮	Finland	**127** (2.42%)
2.	🇺🇸	United States	**497** (9.49%)	12.	🇦🇺	Australia	**123** (2.35%)
3.	🇫🇷	France	**278** (5.31%)	13.	🇨🇭	Switzerland	**106** (2.02%)
4.	🇩🇪	Germany	**275** (5.25%)	14.	🇸🇪	Sweden	**98** (1.87%)
5.	🇧🇪	Belgium	**246** (4.70%)	15.	🇵🇹	Portugal	**87** (1.66%)
6.	🇮🇹	Italy	**228** (4.35%)	16.	🇷🇺	Russia	**82** (1.57%)
7.	🇮🇳	India	**217** (4.14%)	17.	🇨🇳	China	**77** (1.47%)
8.	🇳🇱	Netherlands	**216** (4.12%)	18.	🇳🇴	Norway	**72** (1.37%)
9.	🇪🇸	Spain	**207** (3.95%)	19.	🇧🇷	Brazil	**65** (1.24%)
10.	🇨🇿	Czechia	**143** (2.73%)	20.	🇨🇦	Canada	**61** (1.16%)

Coverage of ELIXIR Nodes and integration with other portals

In the last year, 15 of 23 ELIXIR Nodes have had training resources displayed in TeSS. Of these, 9 are automatically scraped; the rest have been manually entered. There are 4 ELIXIR Node material scrapers, and 9 ELIXIR Node event scrapers.

Additionally, integration with the FAIRsharing portal (a curated resource on data and metadata standards, inter-related to databases and policies) has also been enhanced. Previously, we created associations between training materials and FAIRsharing (formerly, BioSharing) resources by creating a mapping of related resources and bulk importing them into TeSS. This year, we utilised the FAIRsharing API to create a

searchable interface, making it easier to find and link training in TeSS with relevant databases, standards and policies.

TeSS has also had a long-standing association with ELIXIR's tools registry (bio.tools). This year, the method of integration has been updated to reflect the new bio.tools API format. To further expose to trainees the relationship between training resources and the tools they invoke, TeSS and bio.tools have been awarded Implementation Study funds to enhance *ELIXIR integration from a user perspective.* This study will combine the training resources and tools of common data-analysis pipelines, visualising them as abstract 'concept maps' to facilitate navigation (see Workflow section below).

Cooperation with ELIXIR Nodes & international organisations

Much of TeSS' routine work and innovative feature development is supported by partner ELIXIR Nodes. Many are currently contributing, or plan to contribute, training content; others are collaborating (*e.g.*, via designated Implementation Studies) on the development of different types of training workflow, and/or on the articulation of minimal standards for describing and discovering training resources. Some of these activities and new features are highlighted in the sections below.

During the year, the Team attended, and presented TeSS at, an International Workshop on Data Science Training, held at the Hyatt Regency Huntington Beach, hosted by the BD2K Training Coordinating Center (TCC) - other participating organisations included GOBLET, H3Africa, EMBL-ABR, BIOCADDIE and NIH. The BD2K TCC is developing ERuDIte, an educational resource discovery index for data science, which has clear synergies with TeSS. The workshop therefore aimed to review existing standards and schemas, to explore commonalities across these and other international training efforts, and highlight standards and practices in which the participating organisations could collaborate: themes included training metadata standards, 'FAIRification' of educational resources, software APIs and licences, and training personalisation (via workflows, knowledge maps and learning paths). Outcomes of the various discussions were documented throughout the meeting, and may ultimately be compiled in a white paper.

7.2.3. New features

Metadata features

In addition to increasing the quantity of content, the TeSS team has also strived to improve the quality of the content. Features have been developed to semi-automatically add metadata to existing resources: this enhances the associated information that TeSS stores, rendering the resources more findable within the search interface, and thereby improves the user experience.

Location Information: TeSS can find the latitude, longitude and postal addresses of an event's venue where these are not given by the content provider. This both improves searchability by location and allows the visualisation of event locations on a map.

Scientific Topic: TeSS uses the topic branch of the EDAM ontology to categorise resources, making it easier for users to search and filter according to their interests. To improve the number of topic annotations available, and improve the search interface, the BioPortal Annotator Web service (https://bioportal.bioontology.org/annotator) has been used. Given textual descriptions of the resources (*i.e.*, all events and materials in TeSS), this service returns appropriate EDAM topic suggestions. Curators can then approve or reject these suggestions, ensuring no false-positive annotations are added. To galvanise

user engagement with this facility, we will provide future training online - see *Conclusion and future plans*.

Authentication

TeSS has integrated the ELIXIR Authentication and Authorisation Infrastructure (AAI; https://www.elixir-europe.org/services/compute/aai) to facilitate user registration and access to the portal. ELIXIR members and affiliates will be able to choose either their Google login or their institutional login to sign in. The existing account registration and login functionality is still available for those not wishing to use AAI, or for those who are not members of ELIXIR.

TeSS Widgets

Several organisations and institutes expressed interest in displaying lists of upcoming training events in their own websites. To facilitate this, a fully accessible JSON-API has been created, as has a suite of embeddable javascript widgets. This allows organisations to access TeSS information and display it in an interface of their own design, or to embed a pre-built widget within their site. Currently, TeSS content is being displayed in ABACBS (Australian Bioinformatics and Computational Biology Society - https://www.abacbs.org/Calendar), GOBLET (Global Organisation for Bioinformatics Learning, Education & Training - https://www.mygoblet.org), and the ELIXIR website (https://elixir-europe.org/events). More details and examples of TeSS widgets can be found here: https://elixirtess.github.io/list_widget

Subscription features

To help users stay informed about courses, workshops and conferences that may be of interest to them, subscription features have been implemented in TeSS (see Figure 2). Within the portal, users can simply select filters that match their interests, and click a subscribe button, as shown in Figure 2. They may then choose to receive email notifications about new events or materials that match their selected criteria, or have them automatically added to their preferred calendar application (*e.g.*, Google calendar or iCal).
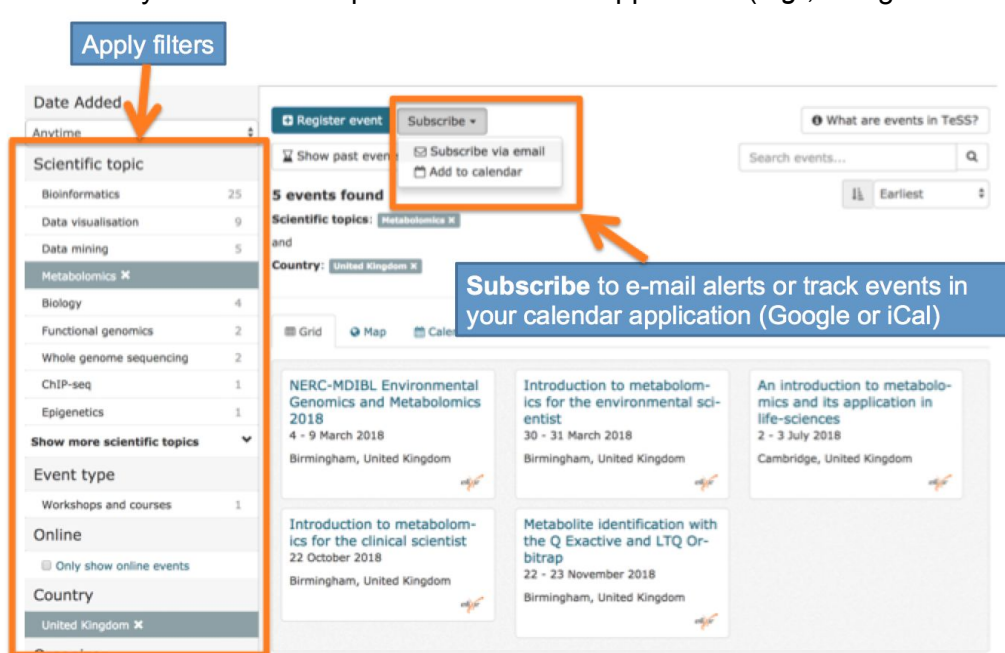

Figure 2. How to subscribe to TeSS

Workflows (UCL, EE ISs)

Significant effort has gone into developing TeSS graphical training workflows. A prototype application has been created that allows trainers to encapsulate different types of and/or approaches to training, at different levels of granularity, within easy-to-use visual displays. To further develop and refine workflow 'concepts' and the workflow application itself, ELIXIR awarded an Implementation Study funds to the TeSS team and partner ELIXIR Nodes (EE, UK, NL) to support the construction of 3 different types of workflow:

Educational Resources - these provide trainees with sets of practical tasks, linked to associated online tools and/or databases, within self-contained 'modules'. Each module includes a series of questions or 'Reflections' to provoke critical thinking about the tasks trainees have completed. Workflows of this type are also accompanied by succinct statements of teaching aims and learning outcomes, to convey to trainees what they will be able to do once they have completed a given module. Multiple Choice Quiz questions are also provided to verify trainee understanding at the end of a module; and additional background information and further reading are included to help support trainee learning and enquiry. Educational Resources for introductory sequence and structural bioinformatics are currently being developed by ELIXIR TeSS, ELIXIR-UK and the UK Structural Bioinformatics group (as part of a wider collaboration with the FunPDBe project).

Learning Paths - trainees wishing to learn new skills essentially need to embark on a path, or developmental trajectory, in order to advance from one competency level to another. Learning paths aim to structure relevant training modules within simple, visual workflows that highlight the set of resources users need to study in order to advance to higher competency levels and hence accomplish their learning objectives. Learning paths are being developed by ELIXIR TeSS, ELIXIR-NL and ELIXIR UK in the context of the ELIXIR Implementation Study on "*Learning Paths".* Further work on Learning Paths will be carried out during a forthcoming workshop in Amsterdam (5-6 April 2018), hosted by ELIXIR-NL and organised by ELIXIR-NL, ELIXIR-UK, ELIXIR-IT and BioExcel (to build on our existing collaboration, especially given the TCC's plans to derive learning paths from ERuDIte, a representative from the BD2K TCC will also attend);

Concept Maps - ELIXIR has developed several registries that contain and promote resources that end-users can exploit: training resources in TeSS; software tools in bio.tools; databases, standards and policies in FAIRsharing. Concept maps provide overviews of typical data-analysis pipelines, surfacing the relevant tools and databases, and showing how these resources fit together. Concept maps are being developed by ELIXIR TeSS, ELIXIR-EE and ELIXIR-BE, in the context of the ELIXIR Implementation Study "*Integration from a user perspective*".

TeSS workflow concepts were presented during a recent workshop on "*Best training for implementation of data management"*, organised under the auspices of the CHARME COST Action in Ljubljana (SI), 6 February 2018. The aim was to encourage wider engagement with TeSS within the CHARME community, and to galvanise development of new workflows for training in data management. Members of ELIXIR-UK, ELIXIR-SI, ELIXIR-NL and ELIXIR-IT were active workshop participants.

Bioschemas

A core part of TeSS' success in acquiring content automatically has been through work with the Bioschemas community. Bioschemas focuses on making online resources more

findible and interoperable, by designing and advocating the adoption of lightweight specifications to describe scientific concepts in the **schema.org** format. Training providers can hence annotate their websites using simple schemas, and subsequently have their content automatically extracted and included in the TeSS portal. Members of the ELIXIR Training Platform helped develop an early prototype of training-event and training-material schemas, which have now been adopted by 9 content providers: specifically, by BITS VIB (ELIXIR-BE), BMTC, SIB (ELIXIR-CH), ELIXIR-PT, Edinburgh Genomics (ELIXIR-UK), EBI TrainOnline, IFB (ELIXIR-FR), BioComp and VSC.

Since then, further work was carried out by the LRMI (Learning Resource Metadata Initiative). Subsequently, members of TeSS co-organised a workshop to review and suggest improvements to the LRMI schemas at the GOBLET annual meeting in Oeiras (PT), in November 2017. A task-force, comprising ELIXIR and GOBLET members, was formed during the workshop to help drive this work forward, and to help provide input to a future paper about the Bioschemas initiative.

7.2.4. Conclusion and future plans

TeSS development is on-track, and the portal is growing steadily, both in terms of content and visibility. During the last year, this positive trajectory has been stimulated by a full schedule of workshops and conference presentations given by the TeSS Team and by TeSS collaborators and users (including posters, flash-talks, live demonstrations, and so on) at venues such as the annual ELIXIR All Hands meeting, the ISMB annual conference, the International Workshop on Data Science Training, CHARME COST Action workshops, GOBLET's AGM and satellite workshops, and so on. A flavour of some of the publicity given to TeSS in third-party posters, reports and videos is given in the list below). Although the visibility and use of TeSS is increasing, there is nevertheless more work to be done to ensure that the portal is better promoted, better used and championed by more ELIXIR Nodes; we will therefore be taking active steps in future to address this.

Looking ahead, the TeSS team will continue its work in collaboration with ELIXIR partner Nodes, especially via its current Implementation Studies, and with third-party organisations, such as Bioschemas, GOBLET, BD2K TCC, CHARME, *etc*. More specifically, in collaboration with the ELIXIR Hub, the TeSS Team plans to embark on a targeted communication plan, aiming to i) survey the ELIXIR Training Coordinators, to ensure that the portal remains useful and relevant for their needs; ii) consult more widely about the feasibility of running a usability study to optimise the portal design; iii) continue to reach out to ELIXIR Nodes to encourage those who have not yet provided information about ELIXIR training events to the portal to do so, and iv) to advocate Training Coordinators to promote TeSS within their Nodes. Furthermore, in order to make the metadata in TeSS richer, and make full use of our semi-automated metadata-suggestion framework, we plan to organise a hands-on, online training event - a 'curate-a-thon' - in which ELIXIR Training Coordinators, course organisers, other training experts and TeSS curators will have an opportunity to learn how to accept or reject suggestions generated by the framework. Up-skilling a future cadre of TeSS curators in this way, and the body of work they will achieve both during the 'curate-a-thon' and in the future, will significantly enhance the search efficacy in TeSS and hence improve the user experience.

Third-party posters, reports and videos recently promoting TeSS

- Batut B, Grüning B, Coppens F *et al*. Scaling bioinformatics training: an ELIXIR, GOBLET & Galaxy Training Network collaboration [version 1; not peer reviewed]. F1000Research 2017, 6(ISCB Comm J):1218 (poster) (doi: 10.7490/f1000research.1114489.1)

- Batut B, Galaxy Training Network, Clements D and Grüning B. Building an open, collaborative, online infrastructure for bioinformatics training [version 1; not peer reviewed]. *F1000Research* 2017, **6**:1694 (poster) (doi: 10.7490/f1000research.1114881.1)
- Goble C, Jimenez R, Gray A *et al.* Bioschemas.org [version 1; not peer reviewed]. *F1000Research* 2017, **6**:1226 (poster) (doi: 10.7490/f1000research.1114493.1)
- De Bo C. Building a bioinformatics training community within ELIXIR Belgium. [version 1; not peer reviewed]. *F1000Research* 2018, **7**(ELIXIR):184 (poster) (doi: 10.7490/f1000research.1115266.1)
- Larcombe L, Hendricusdottir R, Attwood TK *et al.* ELIXIR-UK role in bioinformatics training at the national level and across ELIXIR [version 1; referees: 4 approved, 1 approved with reservations]. *F1000Research* 2017, **6**:952 (doi: 10.12688/f1000research.11837.1)
- Ambite JL, Lerman K, Fierro L, Geigl F, Gordon J and Burns GA (2017) BD2K ERuDIte: the Educational Resource Discovery Index for Data Science. Proceedings of the 4th WWW Workshop on Big Scholarly Data: Towards the Web of Scholars, Perth, Australia.
- ELIXIR Training (2018) https://www.youtube.com/watch?v=oAD8FdGf8tI

7.3. Appendix 3: eLearning

7.3.1. Introduction

Distance learning has become essential to reach large audiences spread over many countries, as it is the case of the ELIXIR community. In 2016, we surveyed the technological and pedagogical options, as well as the e-learning expertise and technology available across the Nodes and globally. The analysis and recommendations that resulted from the survey were published in the white paper "Defining a lingua franca for the ELIXIR/GOBLET e-learning ecosystem". In the light of these recommendations, and within the constraints of the funding available, some of the e-learning principles have been introduced in ELIXIR training and community events by testing the ELIXIR-SI eLearning Platform (EeLP, https://elixir.mf.uni-lj.si) and virtual conference (VC) system. EeLP is being developed and maintained by the ELIXIR-SI node with the feedback from and in collaboration with other Nodes.

Since the beginning of ELIXIR-EXCELERATE, 4 workshops have been run to gather the ELIXIR training community to discuss e-learning developments, 16 e-learning courses have been run using EeLP and the VC system, and 1 set of self-standing materials has been developed and made available in EeLP (see Table 1). The "Guidelines for courses trainers and organisers using EeLP" for synchronous e-learning events are also available and are continuously updated.

Table 1. ELIXIR e-learning events (w = workshop, c = course, m = materials)

Title	Date	Location	Particip. nodes	Type	Access	# particip ants
WP11 eLearning workshop	15.-17.9.2015	Ljubljana, SI	WP11	w	participants	21
RNA Seq & Chipster course	18. 9. 2015	Ljubljana, SI	SI, FI	c	registered	10
RNA Seq & Chipster course	16. 2. 2016	Prague, CZ	SI, FI, CZ	c	registered	18
1st Genome assembly and	12.-14.10.2016	Prague, CZ	WP10	c	registered	22

Annotation Course						
Unix/Linux Tutorial for Beginners 1	17.-19.10.2016	Linkoping, Umea, SE	SE, SI	c	registered	24
1st conference of EASyM - 2nd SysBioMed Tutorial: Modelling and bioinformatics for personalised medicine	26.-28.10.2016	Berlin, DE	SI	c	participants	17
ELIXIR eLearning definitions and glossary	31. 10. 2016	web	WP11.1.3	m	open	N/A
Linux command line course as a use case for the 4th TtT workshop	28.-30.11.2016	Ljubljana, SI	WP11	c	participants	10
RNA Seq & Chipster course	31. 1. 2017	Prague CZ, Ljubljana SI	SI, FI, CZ	c	registered	36
Webinar uArray	14. 2. 2017	web/remote	SI, SE	c	open	60
eLearning Tutorial - ELIXIR All hands meeting 2017	20.-23.3.2017	Rome, IT	SE, PT, FI, SI	w	registered	24
Unix/Linux Tutorial for Beginners 2	27.-29.3.2017	SE and SI	SI, SE	c	registered	56
The 3rd SysBioMed hands-on tutorial: Systems Medicine Approaches in Personalized Medicine - CASyM/EASyM	29.3.-1.4.2017	Ljubljana, SI	SI, DE	c	participants	26
ELIXIR-EXCELERATE HPC Train-the-Researcher Course	6.-7.4.2017	Malaga, ES	ES, PT, SI	c	participants	25
ERACoSysMed & CFGBC simpozij	8.-9.6.2017	Ljubljana, SI	SI	c	participants	30
2nd Genome Assembly and Annotation Course	19.-23.6.2017	Ljubljana, SI	WP10	c	registered	19
3rd Genome Assembly and Annotation Course	23.-27.10.2017	Oeiras, PT	WP10	c	registered	20
eLearning f2f subtask meeting	20. 11. 2017	Oeiras, PT	WP11	w	participants	10
eLearning workshop - GOBLET AGM 2017	21. 11. 2017	Oeiras, PT	WP11	w	participants	15
CHARME Think Tank Big Data Analysis	6.-7.2.2018	Ljubljana, SI	SI	c	participants	11
Introductory Linux Tutorial for Life Science (AKA Unix/Linux Tutorial for Beginners 3)	13.-15.2.2018	SE, SI and web/remote	WP11	c	registered	64
Total						518

7.3.2. Achievements

Synchronous[4] e-learning principles together with tools and services were used to facilitate the delivering of ELIXIR training courses. In many cases, the courses were broadcasted

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[4] For definitions, refer to the white paper Defining a lingua franca for the ELIXIR/GOBLET e-learning ecosystem, or the online e-learning glossary.

via a VC system to allow for attendance of numerous and geographically distributed users. Bioinformatic tools and services were also embedded into the EeLP (ELIXIR-SI eLearning Platform) easing the access of course participants to HPC, cloud-based resources and in particular containers, overcoming the usual problems of technical installations.

For the courses where containers were not available, we provided the course participants with instructions for installation of necessary tools on their computers. To facilitate different parts of training courses or events, we used the EeLP alone, or the EeLP in combination with the VC system (see further below) for distributed remote rooms. Based on the recommendations given in the white paper[2] , several courses have been designed following the defined essential and desirable attributes. In particular, the following essential attributes:

- "Measurable learning outcomes" which are well-defined before the courses and can be measured with assessment tests after the courses.
- "Easy-to-use": the design and user interface modules of courses were optimised based on users' - teachers and students - feedback.
- "Sustainable": course teachers have committed to maintain long term the course contents.
- "Open access": a step has been taken in this direction, however, due to courses' IPR (intellectual property rights) issues, the course materials are mostly accessible as "registered open". One full open access course is the "[How to get the most out of your microarray experiment](#)".

Other essential attributes (Online, Interactive, Prerequisites, Maintainable) are embedded in EeLP. In the reporting period, we started to implement the following desirable attributes: Scalable, Interoperable, Quality control, and at least a partial Support with a forum). In the future, the following desirable attributes will be implemented: Self-paced, Available on demand, and Contextual. Presently we are finalising the connectivity between TeSS and EeLP, which will make the interoperable part effective.

7.3.3. Functionalities of the developed Infrastructure

Since the start of EXCELERATE, the following technical functionalities have been tested in ELIXIR courses and some have been added to EeLP.

7.3.3.1. EeLP developments

EeLP has been used to store and give online access to Open Educational Resources (OERs) following the SCORM standard recommendations (one of the recommendations in the white paper). SCORM allows high level interoperability among Learning Management Systems, and EeLP allows to easily export and import courses (or parts of courses) in SCORM format.

User management is a very important administration task in a training course. It enables easy grouping of participants, using different roles and authorisation levels (e.g. course developers and students) and authentication methods. EeLP is AAI compatible with eduGain, and will be connected to the ELIXIR AAI system in the future.

Community tools are important in allowing better communication between teacher and students, or between students themselves, and largely enabling faster learning curves for all participants. To ease the communication, the following Moodle tools and features have been enabled in EeLP:

- a forum for announcements (teachers publish new topics that reach all participants via email, the topic is stored permanently within forum)
- a forum for students (anyone can start a topic discussion)
- a chat as an online messaging tool. Several chat channels can be open available at the same time for different groups of participants, and the history of chats is automatically saved.
- self-enrollment into groups. Participants can enrol into different groups that can give access to different exercises. The GUI for this feature is very intuitive.
- different types of educational materials can be linked
  - slide files, videos, datasets, exercises, …
- assessment tools
  - assessments of knowledge acquisition
    - with single- and multiple-choice questions, essays, questions with selection lists, questions with image drag-and-drop answering, matching questions, closed questions ...
    - with OpenBadges certification (ongoing development)
  - feedback surveys
    - short and long term feedback forms following the ELIXIR Quality and Impact metrics subtask recommendations, facilitating the tailoring to specific course/event
    - automatic survey analysis & report generation

Embedded connection to HPC and cloud tools

A module and Docker container was developed to embed a web terminal in EeLP. This module enables easy access to cloud or HPC tools to any courses. The course participants don't need any installation on their computers to be able to test and learn bioinformatics tools, making their usage independent of any operating system. The participants only need Internet access and a reasonably recent HTML5 web browser such as Mozilla Firefox or Google Chrome. An example of this module is shown in Figure 1.

Open versus closed access

For the courses were the EeLP was tested, not all could be run completely under open access because of technical reasons: the majority of the courses were synchronous and thus the presence of the teacher was needed or the necessary tools were not be available indefinitely. Sometimes for IPR (intellectual property rights) reasons, the course contents could not be released open access either. However, some of the course materials developed are accessible using the registered access principles or in TeSS (e.g. microarray experiment).
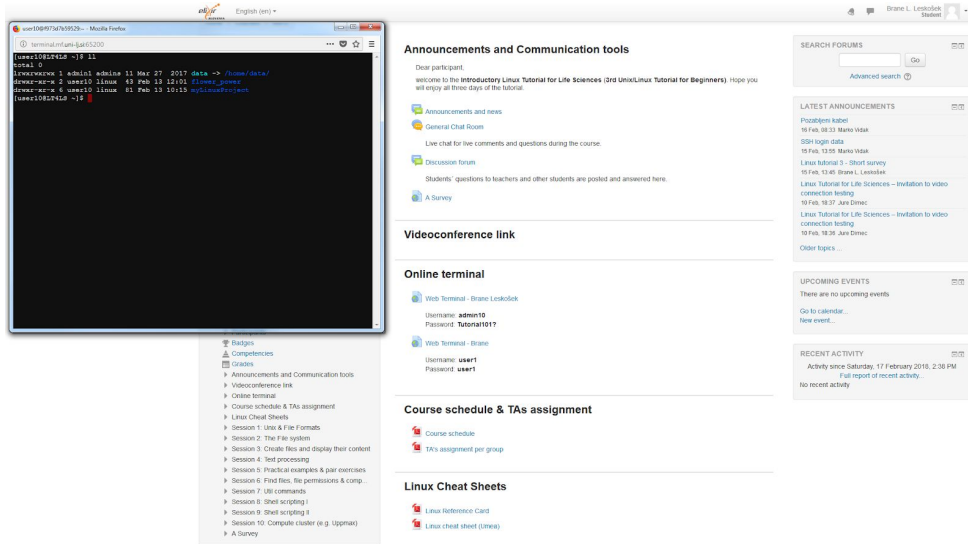

Figure 1: EeLP and the embedded online terminal connected to the cloud backend.

7.3.3.2. Video conference (VC)

To reach numerous and geographically distributed course participants, the courses were broadcasted via the ELIXIR-SI video conference (VC) system. The most modern variant uses Pexip servers and allows more than 100 concurrent full HD connection points, that stream video and content channels with constant full HD bandwidth. The minimal requirements of compatible equipment are included in the "Guidelines for courses trainers and organisers using EeLP". Additionally, we tested different versions of Adobe Connect installations from the ELIXIR-FI and ELIXIR-SI nodes and other publicly or ELIXIR available VC systems like Big Blue Button, Zoom, appear.in, WebEx.

The VC system was used for instance during the recent course "Introductory Linux Tutorial for Life Science 3", which counted 34 concurrent connections from all around the globe (but most from Sweden and Slovenia) and more than 60 course participants. Connections are presented in Figure 2.
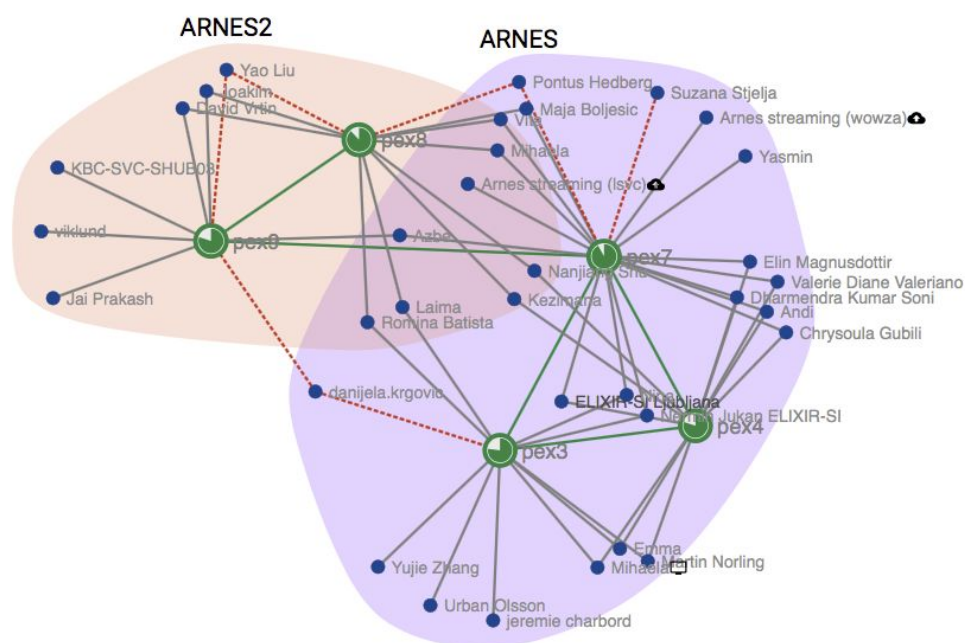
Figure 2: Virtual servers and connections used for VC during the course "Introductory Linux Tutorial for Life Science 3".

7.3.4. Evaluation of courses run using EeLP

The previous section highlighted the infrastructural elements developed in EeLP during the reporting period and the usage of the ELIXIR-SI VC system in courses run with the help of eLearning subtask group. This section focuses on the evaluation of the courses summarised in Table 1. Several of these courses have already been reported in the MTR review report, in Deliverable D11.2. and a final list will be reported in the deliverable D11.3.

The strategy adopted to choose the courses to be run within this sub-task were: courses that are at the heart of the **Subtask 11.2.2: Train the Researcher**, courses that would gather as many Nodes as possible, courses with different settings and different pedagogical approaches. Several of these courses were evaluated using the basic set of questions defined in the **Subtask 11.1.1: Assessing training quality, good practice and impact**, to which specific questions regarding the use of EeLP and VC have been added. Table 2 summarises the results for some of the survey questions. Furthermore, we report the following highlights for some selected courses:

7.3.4.1. Unix/Linux command line

This course, targeted life scientists (ELIXIR users) providing them with basics of Unix/Linux file system, command line instructions and bash scripts, which is very useful when accessing ELIXIR resources. This three days course reaches somewhat beyond the

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basic knowledge. It is planned to transform this course (or parts of it) into a self-contained and asynchronous course, with a final assessment and certificate. The certificate would then serve as prerequisite for other advanced courses that require basic Unix/Linux command line skills. Discussions are ongoing to test these principles with Genome Assembly and Annotation courses (in collaboration with sub-task 10.3 – Capacity Building in Genome Assembly and Annotation), with HPC/Cloud/Grid for life scientists courses (in collaboration with ELIXIR-SI, ELIXIR-ES, ELIXIR-PT and ELIXIR-NL), and with Python for life scientists courses (in collaboration with ELIXIR-IT, ELIXIR-SI, ELIXIR-PT, ELIXIR-UK, GOBLET and H3ABioNet). This Unix/Linux course was so far repeated three times, and have constantly received very positive feedback with excellent scores. All participants would recommend the Unix/Linux courses to their colleagues (see Table 2).

On the technical aspects, we can highlight the availability of:
- a Docker container with all necessary tools accessible via the terminal embedded in EeLP. The container can be run on any cloud compatible with Docker and Singularity container platforms.
- an embedded terminal connection with separate account for every participant.
- the community tools - chat and forums as described above.
- the VC with high performance, full HD (1080p30) web interface that enables more than 100 concurrent VC rooms with distributed participants. VC and content channels can be recorded.

7.3.4.2. Genome Assembly and Annotation

The Genome Assembly and Annotation (GAA) course is also intended for life scientists interested in one or both topics. The prerequisite to attend this course is an intermediate level of Linux command line skills (that can be acquired or tested using the previously described "Unix/Linux command line" course). This course was organised under the auspice of the sub-task 10.3 – Capacity Building in Genome Assembly and Annotation in collaboration with ELIXIR-BE, ELIXIR-CZ, ELIXIR-FR, ELIXIR-NO, ELIXIR-PT, ELIXIR-SE and ELIXIR-SI.

On the technical aspects, we can highlight that course participants received access to:
- EeLP which contained all materials, assessments, community tools, tools and services needed to successfully follow the course.
- Three VMs (containerised) on the first course and later to two different VMs via embedded terminal in EeLP. Users didn't need to install software locally; the access to different VMs was seamless for them (the course manager only needed to change the links in EeLP).
- All necessary instructions in EeLP for the X11 connection.

7.3.4.3. RNA-Seq data analysis using Chipster

This RNA-Seq course was run as a synchronous e-learning course in collaboration with ELIXIR-FI. An important goal was to help reach out and spread the knowledge about RNA-Seq data analysis using Chipster to a larger community without the need for the trainer to travel. The course was repeated three times with different audiences.

During the last course, the presentation was recorded as a video, which was published in the [youtube channel](). Distributed course participants had remote access to Chipster, and all materials including presentations, exercises and quizzes were stored in EeLP.

7.3.4.4. HPC Train-the-Researcher

Life science research laboratories produce fast growing biological datasets that require high demand in computing power and storage, namely High Performance Computing (HPC) resources. HPC resources require substantial starting investments as well as high maintenance costs. Training in HPC is of utmost importance in order to ensure the optimal use of HPC resources. An ELIXIR HPC course was prepared, organized and executed in Malaga, in collaboration with ELIXIR-ES, ELIXIR-PT, ELIXIR-SI and international participants.

The participants used EeLP and the embedded web terminal to connect during the course. HPC and grid resources remained active for 6 months after the course, so that participants could test and improve their knowledge for a longer period after the course ended. EeLP and the embedded web terminal proved to be a reliable way of providing access to remote tools and services from many different types of computers and operating systems. HPC/Grid remote cloud resources covered all course needs. An article was submitted to PLoS Education presenting our training experiences with this HPC course as well as the outcomes and impact on the user community.

7.3.4.5. Highlights from feedback from course participants

In the feedback surveys, the course participants were asked to provide general comments. Some highlights are:
- Introductory Linux Tutorial for Life Sciences 3:
  - *"An excellent and very ambitious course, well organized and taught."*
  - *"It was very good course but quite dense, lot of new commands and concepts to assimilate in 3 days. I will need more time after the course to finish the exercises and to re-read the course."*
  - *"As I am a visiting researcher in Umea I will finish my one year visiting time soon. I think the course is very useful to me, and I want to know how could I continue to take part in similar useful courses when I go back to China."*
- Genome assembly and annotation course 3:

- ○ *"I enjoyed the most the availability of the instructors to discuss science, the will to try different approaches to solve the problems faced by the trainees."*
  - ○ *"The workshop was very well organized, and the balance between the theoretical and practical content allowed me to understand and successfully apply most concepts. Also, the number of experts present was incredibly useful to answer the questions at all times."*
  - ○ *"I just want to say thank you for the opportunity to be part of this course, and congratulate you for the good job!"*
- RNA-seq data analysis using Chipster:
  - ○ *"The coherent and comprehensive narrative of the subject worked well with the practical exercises. This allowed great understanding of the otherwise somewhat complex bioinformatic process."*
  - ○ *"The course was very informative and nicely prepared. Also hands-on part was very well organised. Also chipster platform seems to be easy to use."*
  - ○ *"Good pace (you don't get bored in the meantime and you're also not left behind if you run into any problems)."*
- HPC Train-the-Researcher course:
  - ○ *"Course nicely described the challenges in bioinformatics and needs for parallelisation. The examples were easy enough also for us who have lack of knowledge on bioinformatics field."*
  - ○ *"I think the course materials are very well organised inside the EeLP. Also the web terminal is a nice feature."*
  - ○ *"Absolutely recommend for all students in bioinformatics."*

7.3.4.6. Highlights from feedback from course organisers and trainers

We have received very positive results from the students, but we didn't collect explicit feedback from trainers. However, we believe that trainers have similar positive attitude to the organisation of our courses. Our belief is grounded on the fact that
all courses in EeLP, which were popular, were repeated several times and they used the same "EeLP and e-learning like" organisational approach indicating that EeLP also contributed to their success. Also, we show here some highlights from the mail correspondence with the trainers:

- ● Introductory Linux Tutorial for Life Sciences:
  - ○ *"very positive, easy to understand and follow the course"*
  - ○ *"EeLP worked fine and well"*
- ● Genome assembly and annotation course
  - ○ *"We are doing great, the participants are generally quite knowledgeable. No technical problems either, machines are running very smoothly."*

After every course, we have organized a Skype conference with trainers to discuss the experiences from the course, the tools and services used and possible improvements. There were a lot of positive feedback regarding EeLP received.

Table 2. Results for general feedback survey questions. Values range from 1 (the lowest) to 5 (the highest).

Title	How would you rate the event in general?	Did the event meet your expectations?	Would you recommend it?	How would you rate the local organisation of event	How would you rate ELIXIR-SI eLearning Platform (EeLP)?	How would you rate using ELIXIR-SI video conf. system?	How would you rate the embedded tools?
1st Genome assembly and Annotation Course	4,68	4,42	5,00	N/A	N/A	N/A	N/A
Unix/Linux Tutorial for Beginners 1	4,67	4,50	5,00	N/A	4,17	N/A	4,83
Linux command line course as a use case for the 4th TtT workshop	4,20	4,53	5,00	4,20	4,00	N/A	N/A
RNA Seq & Chipster course	4,36	4,36	5,00	4,27	4,45	N/A	N/A
Webinar uArray	3,50	3,75	4,33	3,50	3,17	N/A	N/A
Unix/Linux Tutorial for Beginners 2	4,21	4,41	5,00	4,56	4,67	4,41	4,38
The 3rd SysBioMed hands-on tutorial: Systems Medicine Approaches in Personalized Medicine - CASyM/EASyM	3,64	3,82	5,00	N/A	3,86	N/A	N/A
ELIXIR-EXCELERATE HPC Train-the-Researcher Course	4,40	4,40	5,00	4,73	4,57	N/A	4,43
2nd Genome Assembly and Annotation Course	4,61	4,44	5,00	4,39	4,50	N/A	3,78
3rd Genome Assembly and Annotation Course	4,36	4,50	4,86	4,71	4,86	N/A	4,75

eLearning workshop - GOBLET AGM 2017	4,17	4,17	4,50	4,25	4,17	N/A	N/A
Introductory Linux Tutorial for Life Science (AKA Unix/Linux Tutorial for Beginners 3)	4,36	4,28	5,00	4,74	4,61	4,39	4,29
Average	4,26	4,30	4,89	4,37	4,28	4,40	4,41

7.3.5. Conclusion and future plans

E-learning can cover all areas of training and capacity building and with a reliable internet infrastructure is becoming increasingly popular. E-learning courses are considered easy to use, but end-users and trainers usually don't anticipate all the complexity of asynchronous course preparation to function properly, especially if the course depends on bioinformatics tools, services and data resources provided by others. One of the strategies of the eLearning subtask adopted so far was to test EeLP with least complex synchronous courses that follow well-established ways of teaching, and adding online tools for easier access to the materials, tools and services (without necessary local installations as much as possible), and simplified user management and communication tools. Synchronous courses were tested as geographically distributed courses with several of different locations. All courses have been recorded and we plan to use these recordings during the development of asynchronous variants, again in a stepwise way regarding the course complexity. We plan to start by converting parts of courses into asynchronous formats, then whole courses, together with final exams, certificates with the ECTS credit points, and in the end the whole set of courses that can be part of a curriculum. In parallel, ELIXIR-SI eLearning Platform - EeLP will be improved and made accessible to the ELIXIR community. Technical aspects are being developed based on the requirements defined by the TrCG, TeCG, ELIXIR platforms (mostly Compute and Interoperability) and related Use Cases/Communities (Capacity Building, Rare Diseases, Human Data and Metagenomics). The most high-profile examples of improvements for EeLP, already available or planned, are:

- Create EeLP templates with the embedded terminal that allows access to variety of tools and services, mostly as containers, with forum and chat, VC, self grouping of participants for specific tasks, exercises or assessments, tools for the e-learning courses feedback surveys, etc.
- Make EeLP connections to Galaxy and other workflows using Common Workflow Language (CWL) for analysis execution. In this way, EeLP will be used for safe and secure data storage/archive and connection to analysis tools.

- Provide certifications to course participants using different types of badges, e.g. OpenBadges.
- Upgrade the VC modules, e.g. with open tools such as Big Blue Button for a small number of connections or ELIXIR-SI VC based on Pexip, which can manage more than 100 connection points in full HD with equal bandwidth.
- Establish a repository of well tested e-learning courses (synchronous and asynchronous);
- Define and implement ELIXIR principles of building new e-learning courses (e.g. updates of guidelines and e-learning guides);
- Provide a sustainable framework for storing and running e-learning courses with all necessary backend infrastructure (cloud, HPC, grid based on containers).
- Finalise the metadata exchange API between EeLP and TeSS using REST.
- Introduce additional SCORM compatible OERs authoring tools, such as Adapt, for specific activities e.g. dynamic course materials.

ELIXIR-SI has EXCELERATE funds to develop the EeLP platform until 2019 and local funds for basic maintenance of the EeLP until 2023. With the eLearning subtask team and the participating nodes, we are currently capable of providing approximately one new event per month, and executing other sessions of the previously run courses. The number of courses run depends also on the availability of teaching assistants in interested Nodes.

A few basic courses (Unix, Python) will be used as prerequisites for more advanced courses. These courses will be equipped with intermediate and end of the course assessments and certification. Use of certificates will be explored probably based on standard OpenBadges.

We have also planned to transform some of the most successful courses, and potential new ones, into asynchronous and synchronous e-learning formats and test them with the ELIXIR community. Some examples are the:
- HPC bioinformatics workshop for Life Scientist (May 2018)
- Genome Assembly and Annotation (WP10 - Sep 2018, FR, 1st Q 2019, IT)
- Linux Tutorial for Life Science (asynchronous, 2nd half of 2018)
- Python for Life Scientist (asynchronous course, 4th Q 2018)
- How to make a pathway? (asynchronous course, ELIXIR-NL, 4th Q 2018 - Q1 2019)

To reveal the quantifiable impact of e-learning courses and tools, we are preparing an e-learning meta-analysis paper. For this purpose, we have selected approximately 200 suitable research articles from Medline, Cochrane, MBase, WoS and CINAHL that reported measurable results of e-learning interventions. We have already extracted the dataset with the use of text mining tools, we have normalised this dataset and we are currently transforming this dataset into a more structured form of e-learning impact data, which will then be used to quantify the impact results.

7.3.6. References and produced documents

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