ARTICLE
Trainingspace: Neuroeducation Without Borders

Pradeep George\textsuperscript{1,2}, Malin Sandström\textsuperscript{1,2}, Mathew Birdsall Abrams\textsuperscript{1,2}
\textsuperscript{1}International Neuroinformatics Coordinating Facility (INCF), Stockholm, Sweden, 171 77; \textsuperscript{2}Department of Neuroscience, Karolinska Institutet, Stockholm, Sweden, 171 77.
https://doi.org/10.59390/BIWD8550

Advancements in the field of neuroinformatics have resulted in a massive explosion of raw data of many varieties, yet many traditional neuroscience training programs have not changed their curricula to reflect the urgent need for improved computational skills that would enable trainees to handle, organize, and interrogate such large, multimodal datasets. Thus, the objective of this project was to build an open access hub of neuroscience educational resources to fill the gap between current neuroscience curricula and the computationally focused skillset required to work with big data. To achieve this aim, we invited representatives from the world’s leading neuroscience societies and large-scale brain initiatives to form the INCF Training and Education Committee that would provide oversight over the content and capabilities of the online hub. As a result, we developed TrainingSpace (https://training.incf.org/), an open access hub of nearly 500 multimedia courses, lectures, and tool tutorials covering the

Materials and Methods
Content
The paradigm for Trainingspace topical content was devised by the INCF Training and Education Committee composed of representatives from INCF Network, Human Brain Project, Canadian Open Neuroscience Platform, International Brain Research Organization, Society for Neuroscience, Federation of European Neuroscience Societies, Organization for Human Brain Mapping, IEEE Brain, BD2K Training Coordinating Center, and the iNeuro Initiative. The paradigm was heavily influenced by the results of the NSF-funded iNeuro Workshop held in 2014. The Committee elected to have 2 content tracks, one catering to undergraduate trainees and the other for graduate trainees.

For undergraduates, the Committee desired content on: computing, theory, database design, web programming, data structures, statistics, research methodology and design, ethics, intellectual property, and neuroscience.

For graduate trainees, the Committee desired content on: neuroscience methodologies and techniques, data collection, analysis, information and data science, metadata, annotation, data lifecycle management, data formats and standards, data wrangling and integration, data and information bases, standard workflows and software applications, semantic web (vocabularies, lexicons, ontologies, semantics), interoperability, computer science, machine learning, data mining, coding, communication, data visualization, and ethics.

Courses, lectures, and tutorials that fit the content tracks were provided by members of the INCF Network, the organizations with representation on the Committee, or recommended by the community-at-large for inclusion. All materials were vetted by the INCF Training and Education Committee for subject matter quality and the Trainingspace development team for the quality of production before being posted to Trainingspace.
George et al.      An Engaging Neurophysiology Lab Exercise      A281

Neuroscience Neuroinformatics Computational Neuroscience

Computer Science Data Science/ Open Science Project Management

Genomics Clinical Neuroscience Ethics

Table 1. TrainingSpace Topics Categories.

Platform
The Drupal 8 open source content management system was selected as the platform for TrainingSpace due to its large suite of supporting tools, scalability, ease of implementation, ability to interact with different applications, and fewer backend restrictions while still maintaining suitable accessibility and security.

Content Management
TrainingSpace employs a controlled vocabulary and a metadata schema to manage all content using a tagging system. While content providers submit recommended tags for their resources, all tagging is performed centrally by INCF to ensure compliance. The tagging system used captures: title, provider, description, target audience, learning outcomes, required resources, keywords, structure and duration, additional information, and date of the last update.

RESULTS
TrainingSpace was developed as an open access hub of multimedia neuroscience educational content to serve both the neuroscience trainee looking to gain more knowledge about the subspecialisms of neuroinformatics and the computer scientists working in neuroscience looking to gain more knowledge about neuroscience.

Educational Content
To date, TrainingSpace currently contains nearly 500 courses, lectures, and tool tutorials covering the subspecialisms of neuroscience and neuroinformatics, as well as computer science, data science, and ethics—all collected from the world’s leading neuroscience institutes and societies (Table 1). The current catalog of training resources is appropriate for beginner to intermediate level trainees (undergraduate to early graduate), although efforts are underway to expand the catalog to include resources for established neuroscientists seeking to learn new, complementary skills and tools. All content in TrainingSpace is released under open access licenses, so content may be used freely by trainers to include in their training activities. Currently, all lectures/tutorials in TrainingSpace contain either videos or audio slide presentations. In addition to the audiovisual content, content providers may also link lecture slides, lecture notes, and suggested reading, as well as Jupyter Notebooks, laboratory exercises, and sample datasets to their lectures/tutorials. To ease a trainee’s journey towards becoming a scientist by actively performing science, we have integrated KnowledgeSpace (https://knowledge-space.org/), a data discoverability portal and neuroscience encyclopedia, developed by the INCF, Human Brain Project, and the Neuroscience Information Framework, that provides trainees with access to publicly available data files as well as links to literature references and scientific abstracts.

Self-Guided Learning and Content Integration
The INCF Training and Education Committee curated five introductory study tracks in neuroinformatics, neurobiology, computational neuroscience, brain medicine, and ethics in order to facilitate self-guided study. The study tracks combine lectures and courses from multiple content providers and are arranged in a logical order for training with lectures providing a general overview of the subject area and courses providing more in-depth learning of the subject. The related content feature at the bottom of each lecture page provides recommendations for other content that serves as: prerequisite, related, or more advanced content related to the content currently being viewed. To further facilitate self-guided study, all TrainingSpace content is described and annotated with a controlled vocabulary of relevant keywords and a metadata schema that provides trainees with information ranging from title to target audience and learning objectives to required resources (Table 2).

<table>
<thead>
<tr>
<th>Type of metadata</th>
<th>What is included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Title of the training material</td>
</tr>
<tr>
<td>Author</td>
<td>Speakers name and institution/organization/project arranging the course</td>
</tr>
<tr>
<td>Description</td>
<td>Overview of the subject matter and aims of the training</td>
</tr>
<tr>
<td>Learning Outcomes</td>
<td>Statement on what the trainee should know upon successful completion</td>
</tr>
<tr>
<td>Target Audience</td>
<td>Intended audience and prerequisite knowledge</td>
</tr>
<tr>
<td>Required Resources</td>
<td>Links to software, datasets, infrastructure</td>
</tr>
<tr>
<td>Keyword</td>
<td>Keywords and tags identifying the topic of the material</td>
</tr>
<tr>
<td>Structure And Duration</td>
<td>Description of the structure of the materials and time allocated</td>
</tr>
<tr>
<td>Additional Information</td>
<td>Links to the provider</td>
</tr>
<tr>
<td>Date Of Last Revision</td>
<td>Date of last update of the materials and version</td>
</tr>
</tbody>
</table>

Table 2. TrainingSpace metadata.
Having a controlled vocabulary enables TrainingSpace to integrate content from multiple providers into a coherent whole. For example, provider A provides a course and indicates the Python programming language as a prerequisite for the course; the course bundle provided by provider A does not contain an introduction to the Python programming language, but a course provided by provider B contains an introduction to the Python Programming language. TrainingSpace offers 2 options for including provider B’s content into provider A’s course either as a prerequisite or related lecture.

To facilitate reuse of TrainingSpace content, all lectures within a course are uploaded and indexed individually. This enables the INCF Training and Education Committee to create study tracks and courses by reusing existing content, as well as to supplement one provider’s content with that of another.

Navigating TrainingSpace
At the TrainingSpace landing page, users have several options for navigating the platform (Figure 1). From the upper banner on the landing page, users can perform quick searches by: i. topic, ii. courses, iii. tutorials, iv. study tracks, or v. keyword search. There is a where to start button in the body of the landing page that takes users to TrainingSpace’s user guide; and from there, users are able to navigate to the different search options. In addition, there are also buttons that enable users to search by full courses and resources/tools.

When searching by topic, users can further refine their searches using the faceted search feature which allows them to limit the search to: i. topic, ii. difficulty level, and iii. the type of content included in course, lecture, or tutorial, such as videos and slides (Figure 2). Individual content pages provide users with a general description of the content, the topics covered, video, and difficulty level, as well as links to any prerequisite content or required technology. When available, links to slides, tutorials,
Figure 3. Example of a TrainingSpace content page. The same format is used regardless of whether the content is a lecture, course, or tutorial.

Figure 4. Community adoption of TrainingSpace. Geographic distribution of countries with TrainingSpace users from March 2019 to December 2021.

content instead of developing new course materials for their workshops, e-learning platforms, or webinars. Also, organizers can deposit their modifications and supplements to TrainingSpace content for future reuse. Another benefit of TrainingSpace is that it provides users with community through Neurostars which is often lacking from many e-learning platforms and webinars.

REFERENCES


Received March 31, 2021; revised September 24, 2021; accepted September 27, 2021.

We thank the members of the INCF Training and Education Committee past and present for their tireless dedication to developing TrainingSpace. Special thanks to the developers of Neurostars.org and KnowledgeSpace for allowing us to integrate these platforms into TrainingSpace. MBA received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under the Specific Grant Agreement No. 945539 (Human Brain Project SGA3).

Address correspondence to: Mathew Abrams, INCF, Karolinska Institutet, Nobels väg 15A, Stockholm, Sweden, 171 77. Email: mathew@incf.org

Copyright © 2022 Faculty for Undergraduate Neuroscience www.funjournal.org