NeurotechEU
The European University of Brain and Technology

Description of the Alliance: NeurotechEU is the European University of Brain and Technology (www.theneurotech.eu), founded in 2020 under the European Universities Initiative. NeurotechEU aims to establish a trans-European network of excellence in the field of brain and technology to increase Europe's competitiveness in education, research, and innovation. By bringing together leading European universities and associated partners, NeurotechEU creates a unique educational environment where the next generation of researchers, professionals, and citizens can cooperate and work across different European and global cultures.

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D2.12 Develop inclusive and flexible pedagogical methods for learners at all levels

Executive summary

The NeurotechEU Alliance is dedicated to advancing effective pedagogy by integrating innovative teaching strategies and digital technologies. To support this mission, the alliance released a pedagogy handbook in 2023, which is continuously updated to reflect ongoing educational innovations.

The current edition presents cutting-edge pedagogical approaches, with a particular emphasis on Constructive Alignment, distance learning, and the effective integration of artificial intelligence (AI) in teaching. A key element of this edition is the introduction of Campus+, the recently launched NeurotechEU digital learning platform designed to support adaptive and student-centered learning environments. Furthermore, the handbook is enriched by two illustrative courses that exemplify how innovative educational methods can be applied in real-world teaching contexts. Overall, by combining theoretical foundations with practical examples and digital innovations, the revised pedagogy handbook serves as a dynamic resource for educators seeking to improve teaching and learning.

Correspondence

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Annex: Pedagogy Handbook

The Pedagogy Handbook is presented on the following pages.

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INNOVATIVE PEDAGOGY HANDBOOK

Workpackage 2
Interdisciplinary Knowledge Creation

Task Force
INNOVATIVE PEDAGOGY HANDBOOK

This Innovative Pedagogy Handbook was developed by faculty and administrative staff from the founding universities of NeurotechEU - the European University of Brain and Technology, an initiative that aims to build a trans-European network of excellence in brain research and technologies to increase the competitiveness of European education, research, economy, and society. NeurotechEU Alliance partners are listed below in the order of their assignment to project work packages:

- Radboud Universiteit (The Netherlands)
- Universidad Miguel Hernández de Elche (Spain)
- Karolinska Institutet (Sweden)
- Rheinische Friedrich-Wilhelms-Universität Bonn (Germany)
- Boğaziçi Üniversitesi (Türkiye)
- University of Lille (France)
- Universitatea de Medicină și Farmacie din Cluj-Napoca (Romania)
- Reykjavik University (Iceland)

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Innovative Pedagogy Handbook

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1 Introduction

1.1 Purpose of this document

One goal of the NeurotechEU Alliance (NTEU) is to develop and establish suitable and innovative pedagogical practices. An important area of development is finding ways to increase the efficiency of learning on virtual platforms and paving the way for expanded virtual mobility. NTEU supports its partners to share and jointly optimize their teaching methods and to strengthen the links between teaching, research and innovation. By considering challenges, practices and required skills, we aim to show that digital approaches to teaching are both relevant to educators' everyday problems and easy to implement. We hope that these insights will encourage readers to adopt a more structured approach and facilitate trying out digital teaching.

This document is intended to be a continuously expanded source of innovative teaching methods that can be useful for NTEU members. It reflects our past and future activities in the NTEU Pedagogy field-lab (PFL), in which we develop and test suitable approaches for teaching within NTEU.

After a brief introduction, it will provide examples of teaching innovations by NTEU members, which are suitable for delivering NTEU content such as learning modules to NTEU students or other NTEU target groups. By clearly stating the purpose, advantages and limitations of tools and platforms the handbook will help the reader with selecting the most appropriate tool to achieve their goals. It will be continuously updated as new tools and approaches are being developed, tested, and rolled out.

1.2 Update of the pedagogy handbook

In light of the ongoing developments in innovative pedagogical methods, important updates have been made to the existing handbook since its first release in 2023. The handbook will be updated on a continuous basis to remain a relevant and practical resource for teachers.

In the current version, the constructive alignment of intended learning outcomes, teaching and learning activities, and assessment tasks is explained in detail (sub-chapter 2.1). In addition, key aspects of distance learning and teaching have been added (sub-chapter 3.1, sub-chapter 3.3). Following the development and launch of the Campus+ learning platform, the INCF platform is no longer the primary platform used within the alliance. Consequently, the description of INCF has been replaced with a comprehensive overview of Campus+ (sub-chapter 4.1). Given the growing importance of Artificial Intelligence (AI) in higher education, we also elaborate on how AI can be integrated into teaching (sub-chapter 4.2). Finally, to further illustrate the methods described in the pedagogy handbook, two examples from our partner universities have been added (sub-chapter 4.3, sub-chapter 4.4). These courses are excellent examples of innovative teaching methods in practice and therefore serve as models for course development.

1.3 Teaching in NeurotechEU

The field of higher education is crucial to the social and economic development of any country. Against the backdrop of rapidly changing socioeconomic conditions (e.g., the Covid-19 pandemic), the need to ensure access to education is critical for the continued pursuit of technological innovation and the prosperity of society at large.

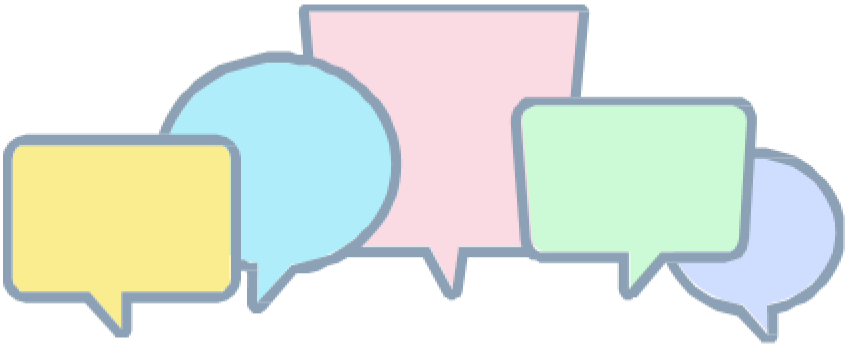
NTEU programs are being designed to bridge disciplinary boundaries and borders between participating universities, creating a unique organization that is not constrained by faculty, institutional and geographical limits. NTEU students will receive comprehensive multidisciplinary, international, and cross-sectoral training at all education levels (bachelor's, master's, and doctoral) to develop a common European identity with educational and research opportunities in a multicultural, multilingual environment across the continent. In addition, NTEU actively promotes lifelong learning via structured yet flexible, scalable, and personalized programs to remove obstacles to accessing education, bridge employment disparities, and maximize human potential in an atmosphere that promotes inclusion and diversity. The goal is also that the next generation of multidisciplinary scientists and engineers will have access to state-of-the-art infrastructure for basic, translational, and applied research across a wide range of disciplines to help them become the transformative future leaders of society, industry, and academia.

Beyond its educational mission, NTEU research also fosters technological and societal innovation by bringing together partner organizations to create an innovative ecosystem and help Europe become a global leader in brain research and technology. Outstanding universities of the future will be more than educational and research institutions. As the backbone of the Knowledge Triangle (education, research, and innovation), higher education, research, and business will join forces in the Universities of the Future to develop cutting-edge technology and push the frontiers of knowledge. In NTEU, students and staff work together to develop integrated and open curricula that combine study periods in different countries and settings across sectors. Mobility, physical and virtual, will be a key component in all programs shared. In this way, NTEU will contribute to the emergence of European university degrees. By pooling educational and training capabilities of the participating partner universities, leveraging next-generation virtual exchange and mobility platforms, and intensifying collaboration between students and researchers, the mobility rate is expected to increase substantially. Furthermore, information and communication technologies will enable a new interactive virtual mobility platform that increases accessibility and inclusivity while providing a scalable, economical and modular alternative to physical mobility.

To achieve its broad goals and to adapt to continuously changing requirements in teaching and learning, NTEU must develop and implement innovative teaching methods throughout. Traditional classroom or lecture hall instruction are still commonly used by teachers and lecturers to impart knowledge to their students. However, especially the Covid-19 pandemic has taught us that it is increasingly important to support and further develop asynchronous distance learning. It is essential that online learning materials take advantage of all the media formats available. These range from short video podcasts to longer recorded lectures and can be complemented by online toolboxes for self-study and materials and tools to promote interactive and group learning, as well as in-person events such as internships and summer schools to promote hands-on experiences. Finding ways for automatic recognition of learning periods, internships, and degrees between the partners is another practical necessity. Above all, NTEU aims to support active learning as this is considered most effective.

Currently, the handbook focuses on teaching methods. The material presented here is intended to first provide an overview of teaching practices in chapter 2 "Innovative teaching methods and practices". These are not meant to be comprehensive but to serve as an overview of concepts that will be useful for content creation and refinement in NTEU. This is followed by a short overview of distance learning concept in chapter 3 "Implementing distance teaching and learning", and innovative examples from NTEU partners in chapter 4 "Innovative implementations in NTEU". All the references used for the redaction of this handbook are listed in chapter 6

"References". For other aspects of learning such as assessment, we provide a glossary (chapter 7 "Appendix/Annex/Glossary").



2 Innovative teaching methods and practices

For discussing more recently developed teaching methods, it is helpful to keep in mind some of the basic terminology and concepts. An important step during the design of new content is choosing suitable formats. They define, for instance, the available types of interactions between students and teachers, the usable course material, the number of participants and they narrow down which media can be used and to what extent it can be performed online. An overview of typical formats can be found in sub-chapter 7.1 "teaching formats and course types". It is also essential to clearly define learning outcomes, pedagogical activities and assessment methods when designing courses and lessons. In creating programs these should transform into a set of concrete learning objectives. An assessment of learning outcomes is necessary in many cases. There, the goal is to set standards that allow you to measure as fairly and objectively as possible whether a student's or participant's work has met the declared learning outcomes of the course. Assessments also allow students to monitor their progress during the course; the latter can be incorporated as formative assessments. As the demand for online learning environments in higher education grows, so does the need for systematic application of learning and educational theories to the design, development, refinement, and implementation of assessment strategies. The main concepts and terminology are summarized in sub-chapter 7.2 "Assignments and assessments".

When discussing innovative teaching methods, we should first clarify what we mean by 'innovative'. The basic idea behind the term is that it defines a new or novel way of doing things. In the pursuit of innovation in teaching, teaching strategies must be different from what has been common practice in the past, and teachers likely need to abandon traditional approaches to some extent to come up with truly innovative teaching methods. This is also captured by the term 'disruptive'. It, too, can refer to teachers breaking with traditional approaches, but it can also mean that new technologies have a disruptive effect on the way we teach and think about teaching. A very recent example is the impact of chatGPT on essay writing. Teaching methods are also called teaching strategies or instructional strategies. This term has been defined differently by several authors. Some state, for instance, that teaching methods are processes that are primarily descriptions of objective-orientated activities and of the flow of information between teachers and students (Kizlik 2016).

In the traditional 'chalk and talk' method or textbook method, the teacher is almost always the only active person in class. While some teachers still use a blackboard, whiteboards and markers, smart boards and, in blended-learning methods, lightboards are supplanting the earlier tools. Regardless of the tools used, the key characteristic of this approach is that the instructor lectures while simultaneously creating notes on a medium visible to the students. There is evidence suggesting that oral presentations to large groups of passive students contribute little to actual learning (Raupach et al., 2015). Therefore, it is important that students are actively involved in the learning process. Conversely, it should be noted that the format as such (e.g., 'chalk and talk') does not necessarily define the level of interaction, as those formats can also be designed to be highly interactive and collaborative. There are already many alternatives to traditional teaching methods. For instance, Experiential Learning (also called Learning-by-Doing) can be an important component of course design. The goal is for students to actively engage in carefully designed activities (opportunities for Learning-by-Doing), and then to reflect on those activities. It is believed that this will empower them to use their theoretical knowledge in practical or applied work. Another approach to education is Competency-Based Learning. Here, the focus is on the demonstration of desired learning outcomes by the student as a central element of the learning process. It typically begins by identifying specific competencies or skills. Students are then given the opportunity to acquire and master those skills or competencies at their own pace. Sometimes, when learners can demonstrate that they have already achieved a certain level through a test or assessment, they can then be allowed to progress to the next level of competency. This enables students to skip through content in which they already have expertise. In principle, this allows educators to break away from the model of regularly scheduled classes, in which students learn the same material at the same speed and time as their fellow students. The main value of the approach is the direct development of skills and competencies, but it is also used for abstract or academic skill development.

In the following, we explore the principles of constructive alignment and Bloom's taxonomy, in order to define accurate and practical learning objectives, and briefly highlight some pedagogical concepts and approaches that could be useful for content development in NTEU.

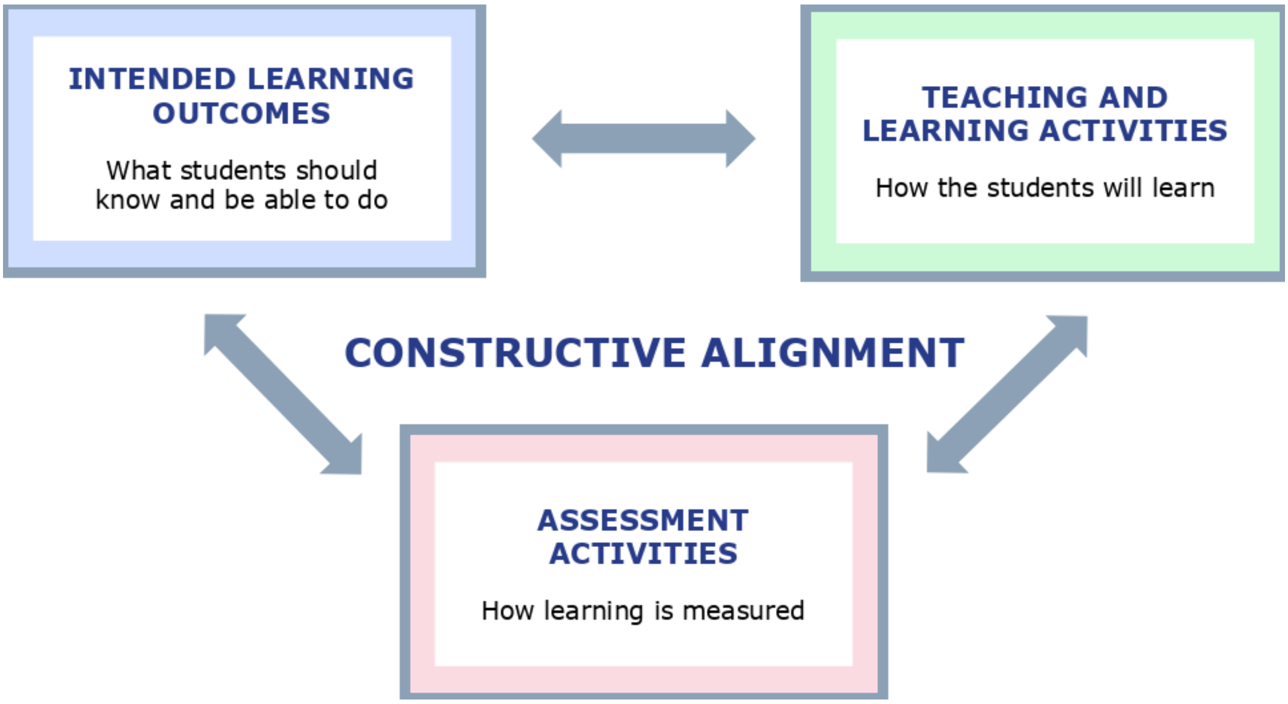
2.1 Leveraging Constructive Alignment to build effective teaching

2.1.1 Constructive alignment

This pedagogical approach, championed by John Biggs (1996), emphasizes the crucial alignment between three key components of the learning process:

- **Intended Learning Outcomes (ILOs)**: Clearly defined statements of what students should know, understand, or be able to do upon completion of a learning activity, module, or course. These should be articulated using action verbs that are observable and measurable.
- **Teaching and Learning Activities (TLAs)**: The tasks and experiences designed to engage students in learning and help them achieve the stated ILOs. These activities should actively involve students in constructing their own understanding.
- **Assessment Tasks (ATs)**: The methods used to evaluate student learning and determine the extent to which they have achieved the ILOs. Assessment should directly address the learning outcomes, using criteria aligned with the desired level of performance.

The following figure summarizes constructive alignment:

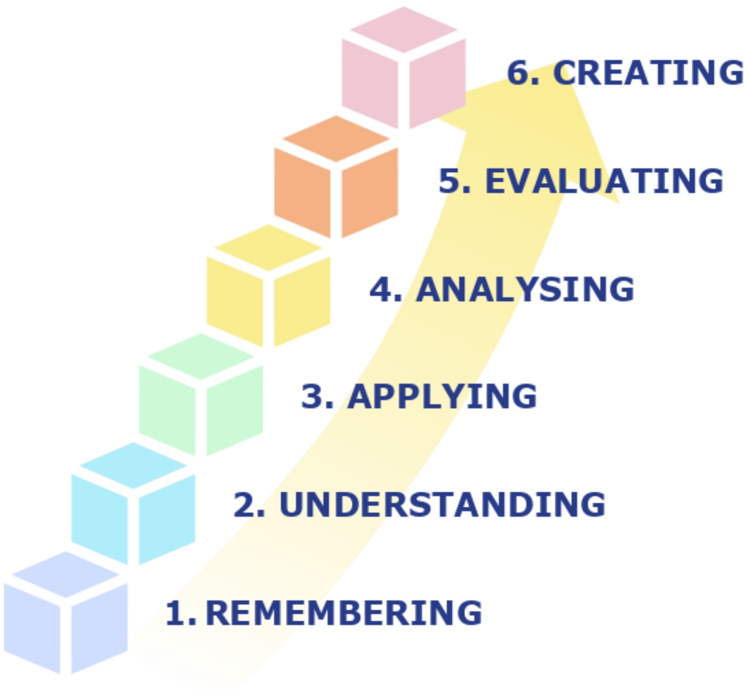


The term "**constructive**" highlights the constructivist view of learning, where students build meaning through their activities. "**Alignment**" signifies the deliberate connection between the ILOs, the activities designed to facilitate learning, and the methods used to assess student achievement. Effective implementation of constructive alignment leads to **deeper learning** and a more coherent educational experience for students.

2.1.2 Bloom's Taxonomy

Developed by Benjamin Bloom and his colleagues (1956), this is a hierarchical classification system that categorizes educational goals and cognitive skills into six levels of increasing complexity:

1. **Remembering**: Recalling or recognizing information.
2. **Understanding**: Comprehending the meaning of information.
3. **Applying**: Using learned material in new and concrete situations.
4. **Analysing**: Breaking down complex information into its component parts and understanding the relationships between them.
5. **Evaluating**: Making judgments based on criteria and standards.
6. **Creating**: Combining elements to form a new whole.



This taxonomy provides a framework for educators to design learning objectives and assessment tasks that target different levels of cognitive engagement, moving students from lower-order thinking skills to higher-order thinking skills. A revised version by Anderson and Krathwohl (2001) uses verbs for each category and rearranges the top two levels to Evaluating and Creating.

2.1.3 Writing coherent Intended Learning Outcomes

Well-crafted Intended Learning Outcomes are fundamental to constructive alignment. They provide a clear roadmap for both educators and students, outlining what students should be able to achieve by the end of a learning experience. Coherent ILOs are specific, measurable, achievable, relevant, and time-bound (SMART), although the time-bound aspect often applies to the overall course or module rather than individual ILOs.

Here’s a guide to writing effective ILOs:

- **Start with action verbs**: ILOs should always begin with an action verb that is observable and measurable. These verbs should align with the cognitive level you want students to reach, based on Bloom's taxonomy. Avoid vague verbs like "understand" or "know" and opt for more active terms such as "describe", "analyse”, "design", or "evaluate".
- **Specify the learning outcome**: Clearly state what the student will be able to do. This should be concise and directly related to the content and skills covered in the learning activity.
- **Define the context (optional but recommended)**: Where relevant, specify the context in which the student will be expected to perform the action. This adds clarity and helps students understand the application of their learning.
- **Ensure alignment with assessment**: Each ILO should be directly assessable. Consider how you will know whether a student has achieved the outcome when you formulate it. The chosen action verb often hints at the appropriate assessment method.
- **Limit the scope**: Each ILO should focus on a **single, specific outcome**. Avoid combining multiple outcomes into one statement, as this can make assessment difficult, and the learning objectives unclear.

Here are some examples of coherent ILOs in the field of neurotechnology, aligned with different levels of Bloom's taxonomy:

Remembering	"**Identify** and **list** the main components of a typical electroencephalography (EEG) system." "**Define** key terms related to neural communication, such as action potential and synapse."
Understanding	"**Explain** the fundamental principles behind functional Magnetic Resonance Imaging (fMRI) in non-technical terms." "**Summarize** the findings of a seminal research article on brain-computer interfaces for motor rehabilitation."
Applying	"**Apply** the principles of signal filtering to remove noise from a simulated EEG dataset using appropriate software." "**Demonstrate** the correct placement of electrodes for a standard 10-20 EEG recording montage on a physical model."
Analysing	"**Analyse** the artifacts present in a given EEG recording and **propose** potential sources." "**Compare** and **contrast** the advantages and limitations of different neuroimaging techniques for studying cognitive function."
Evaluating	"**Evaluate** the ethical implications of using neurotechnology for cognitive enhancement." "**Critique** the methodology and conclusions of a research paper investigating the efficacy of a novel neuromodulation technique."
Creating	"**Design** a basic experimental protocol to investigate a specific research question using transcranial magnetic stimulation (TMS)." "**Develop** a user-friendly interface concept for a neurofeedback training application."

By following these guidelines and considering the specific context of neurotechnology, educators can create coherent ILOs that form the bedrock of constructively aligned and effective learning experiences.

2.2 Examples of innovative teaching and learning practices

2.2.1 Inquiry-based learning

Inquiry-based learning (IBL) describes pedagogical strategies such as problem-based learning and case-based learning that focus on students exploring, thinking, asking, and answering questions together with peers to acquire new knowledge through a carefully designed activity. These provide students with the opportunity to engage with and apply the scientific process as scientists, rather than following a predetermined protocol (Yew and Goh, 2016; Laforce et al., 2017).

Problem-based learning (PBL) uses specific problems (e.g., clinical cases) to stimulate inquiry, critical thinking and application of knowledge (Barrows and Mitchell, 1975). It can be applied to many fields but is often found in medicine. Defining the problem by the student is a part of the process. Research inside and outside of class and arriving at a final response in an iterative fashion are common features (Nilson, 2016). The goal is for students to gain a deeper understanding of the content taught and, more importantly, acquire the skills necessary for lifelong learning through this active and collaborative learning process using concrete cases. For further reading on inquiry/problem-based learning please see (Davis, 1999).

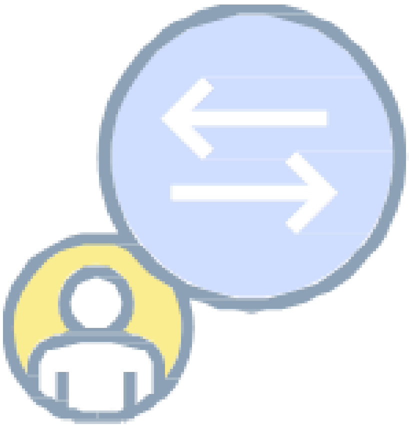
Case-based learning is similar to PBL, because students develop skills in analytical thinking and reflective judgment by reading and discussing complex, real-life scenarios. Like PBL, case-based learning uses a guided inquiry method, but it typically requires students to have substantial prior knowledge for analyzing the case. The case-based learning approach is particularly popular in business education, law schools and clinical education in medicine, but it can be used in many other disciplines as well. For examples and further reading see (Irby, 1994).

Project-based learning is again similar to case and problem-based learning but tends to come in no longer learning units, which are also broader and more varied in terms of learning content. It expects students to have even more autonomy and responsibility when choosing sub-topics, organizing their work, and choosing methods for conducting the project. Projects are usually based around real-world problems and give students a sense of responsibility and ownership. This method can be used to promote interdisciplinary conversations and group work. For examples and further reading see (Larmer and Mergendoller, 2010).

Challenge-based learning (CBL) is a pedagogical method that builds on PBL, in which students learn in real and relevant context. The aim is to identify and analyze a problem (e.g., sociotechnical) and to come up with a real-world solution that is socially, economically, and environmentally sustainable and therefore often interdisciplinary in nature. For further information see (Challenge based learning, 2021) and (Kohn Rådberg et al., 2020).

2.2.2 Flipped classroom

A flipped classroom is a teaching approach where students are first exposed to content before coming to a class. In class, they then spend time engaging more deeply with the ideas and concepts. This encourages the use of active learning to allow students to explore concepts, solve problems, and discuss ideas with each other and the teacher/instructor. The group sessions are usually done in a classroom or lab setting. However, students can also conduct research and information gathering by accessing resources online, by using online multimedia resources to create reports or presentations, and by collaborating online through group project work or through critique and evaluation of each other’s work. Therefore, the flipped classroom method can also be used in a blended learning setting.



Team-based learning (TBL) (Haidet et al., 2012) is one specific implementation of a flipped classroom. A potential implementation could look like this: Students are split into teams of 5-7 students who work together. Before each unit of a course, they prepare by reading material related to the course work (typically selected by the teacher). In the beginning of the class, students complete individually a short multiple-choice test based on the readings and then the same test is retaken by the entire team. Then the teacher/instructor encourages teams to identify questions where they have disagreed with the answer given by the teacher/instructor. They then review the material, evaluate their understanding, and defend the choice they made. The class is concluded by a mini lecture that focuses on the concepts that students struggled the most with. As such, TBL incorporates not only a flipped classroom, but also collaborative learning (2.2.4) and peer teaching (2.2.5).

2.2.3 Simulation-based learning

In simulation-based learning (SBL), simulation(s) are used for learning purposes. This training is done in a realistic environment utilizing simulation equipment. To create a realistic environment, the setting must include faculty members who have been formally trained in simulation pedagogy. In medical education, SBL is used to recreate clinical scenarios for developing knowledge, skills, and attitudes of healthcare professionals while protecting patients from unnecessary risks. In biology, chemistry and physics education, SBL is used to recreate scenarios of complex machine operation, or requiring for example, animal testing.

2.2.4 Learning through collaborative argumentation

Argumentation in science (i.e., the interactive coordination of evidence and theory to support or refute an explanatory conclusion, model, or prediction) helps to absorb and construct scientific knowledge. Argumentative learning practices are defined as activities in which participants cooperate to solve/explore a particular problem, for which a set of hypotheses or solutions are proposed, by engaging in argument (Muller Mirza, 2012). Both consensus and challenge contribute to learning.

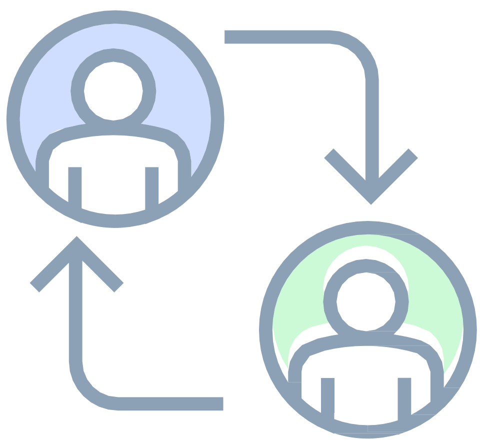
Students can deepen their understanding of contested topics in science, history or arts by arguing in ways similar to professional scientists and academics. Argumentation also helps students to appreciate the value of opposing ideas and evidence. Together they refine ideas with others, so they learn how scientists work together to establish or refute claims. In this way, argumentation pedagogy prepares students for a world where the consequences of science, technology and public policy affect many and are publicly debated (Sharples, 2019), and it also prepares them for peer teaching (2.2.5. "Peer teaching (learners become teachers)").

2.2.5 Peer teaching (learners become teachers)

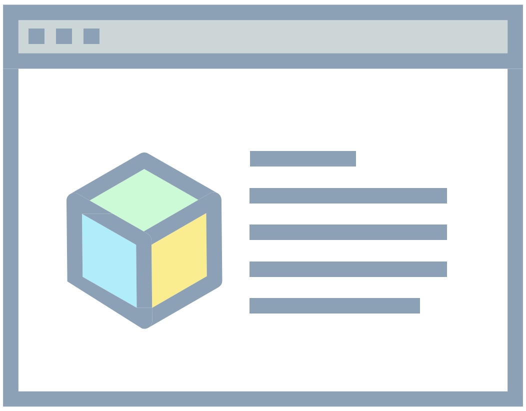
In peer teaching, students act as teachers. It is widely used in primary and secondary education, universities, and increasingly in medical schools. Peer teachers can give lectures on assigned topics, lead problem-based learning, or act as tutors for their classmates (Benè and Bergus, 2014). The model can also be attractive to study programmes because it enables students to act as teachers elsewhere (e.g., in tutorials, see 7.1.4 "Tutorials"). When working with well-defined rubrics, peer teaching can also incorporate peer assessment where students assess the product of other students. Examples of such products are reports, essays, poster presentations and oral presentations. Peer assessment helps students to actively think about assessment criteria, thereby improving the quality of their own product.

2.2.6 Space-oriented learning

Another active learning approach pursues the unifying hypothesis that physical space can play a critical role in human memory and experience, or space as a frame for memory formation and a source of authentication (i.e., space-oriented learning). An example is the Future Memory Project, which applies this method to Historical and Cultural Learning (HCL). Future Memory is based on this unifying hypothesis and has implemented it for authentication and education of singular historical events in a concrete HCL paradigm using mobile and mixed reality technologies. In a recent study, these technologies have been used to facilitate understanding in the form of individualized mixed reality audiovisual narratives through the active and embodied exploration of digitally enhanced physical sites implicated in the Holocaust and Nazi crimes (Verschure and Wierenga, 2022).



The open access co-creation platform Gala (see section The NTEU Case Library on the Gala Platform for further explanation) has implemented space-oriented learning in one of its course modules by recreating a digital map of a natural reserve with focus points, or site visits, the students can visit. By cycling through the different site visits in subsequent sessions, or walks, students approach the learning objectives in an innovative and active manner to learn more about the natural reserve while memorizing the map, hereby forming memory in a context, space-driven orientation. This approach was taken further in the NTEU 'How to... fMRI' course presented in Gala, where students navigate a digital twin to learn the practical and theoretical aspects of MRI research (see Innovative Implementations in NTEU below, 4.6).



3 Implementing distance teaching and learning

Distance education has gained immense popularity in a short span of time as it allows individuals to pursue their studies despite potential obstacles (e.g., long/expensive commuting, access restrictions to the university during a pandemic). In this context, however, it should not go unmentioned that limited access to the internet remains a challenge in implementing distance teaching and learning. Furthermore, the Covid-19 pandemic has taught us that social, in-person, interactions between students, and students and teachers are important for the social and emotional well-being of students. The field of distance education is very broad and therefore only some implementations of distance/online learning will be briefly presented below.

Blended learning combines tools of distance learning, e.g., the examples given below and other online technology-mediated types of content presentation with physical classroom-based methods. A common example is the flipped classroom concept (see sub-chapter 2.2.2 "Flipped classroom"), in which a lecture or other material is made available before an in-class session, which is then held as a seminar that the participants physically attend. Similar separation of content is a practical form of training, where the theoretical concepts can be obtained by online content or via distance learning whereas the hands-on practical work is in separate sessions in person in a lab. Effective use of a learning management system (LMS, see below) can make this type of education a rich experience for students, and many universities have explored this method during the recent pandemic.

After quickly reviewing the main obstacles and opportunities brought by distance education, we take a look at the most common technical infrastructures used in online teaching and learning, then give examples of pedagogical activities that respect constructive alignment in a distance scenario.

3.1 The challenge of distance teaching and learning

Distance teaching and learning in neurotechnology present unique challenges and opportunities compared to traditional face-to-face university education:

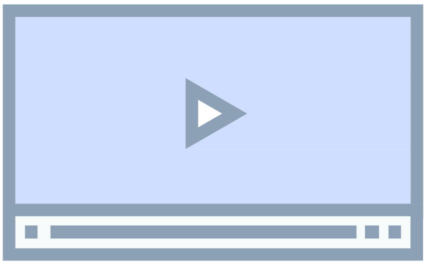
- **Shift in interaction**: The direct, physical interaction characteristic of lectures, tutorials, and practical labs is significantly altered or absent in online environments. This necessitates a conscious effort to design activities that foster engagement and a sense of community among learners and with instructors.
- **Technological infrastructure and skills**: Students and educators may have varying levels of access to reliable internet, suitable devices, and the necessary digital literacy skills. Course design must account for this diversity and potentially offer flexible, asynchronous options alongside synchronous activities.

- **Maintaining engagement and motivation**: The lack of a physical classroom environment can make it more challenging to keep students engaged and motivated. Constructively aligned courses, with clear goals and relevant activities, can help boost student motivation. Frequent, low-stakes formative assessments can also increase engagement.
- **Assessment integrity**: Ensuring the integrity of online assessments, particularly high-stakes summative evaluations, requires careful consideration of strategies to prevent cheating.
- **Opportunities for innovation**: Distance learning offers opportunities to leverage a wide range of digital tools and pedagogical approaches, such as multimedia resources, interactive simulations, collaborative platforms, and personalized learning pathways. This allows for the design of diverse and engaging learning experiences tailored to the specific needs of neurotechnology education.

3.2 Infrastructures for distance education

3.2.1 Live streamed video

This is basically a face-to-face lecture or seminar delivered live to students attending remotely. It usually takes the form of a webinar (two-way communication between instructor and students) or, more rarely, a webcast (one-way communication by the instructor only). Distance learning students may be watching the live stream on their own at home, work or in transit, or in small groups at another campus or local learning center. In a hybrid format, there may be students in the lecture hall too. Typically, there is no change in the design of the lecture, but the instructor must be careful not to ignore the remotely participating students (e.g., questions or contributions to discussions), especially in a hybrid format. Open-source platforms like Jitsi can be used for larger groups of students, and there are also many commercial video-conferencing platforms such as MS Teams, Zoom, Meet and Cisco Webex, which are free to use to some extent and often have university/educational licenses/ discounts. Most platforms are relatively easy to use and to set up and include various features that teachers might find helpful during a lesson, such as a virtual whiteboard and tools for sharing and annotating a wide range of contents (e.g., documents, pictures, videos, websites, programs etc.) on screen. Moreover, break-out sessions, in which a group can be divided into smaller units, enable group work. Beyond the video-conferencing platforms themselves, additional online tools offer a variety of features, such as computerized surveys and quizzes (e.g., Mentimeter, Vevox) or interactive brainstorming (e.g., Miro, Padlet), which can increase student motivation and support learning processes. Of course, a stable IT infrastructure is critical.



3.2.2 Classes using lecture capture

This format was originally developed to make lectures available for repeated viewing by students at any time (e.g., for homework or reviewing). There are numerous programmes for recording video lectures on the market (e.g. Panopto, Opencast, etc.). There are many advantages of capturing lectures, both for the tutor as well as for students. Students have the comfort of knowing that they can revisit lectures whenever they like, which can help to close knowledge gaps. Typically, students are also eager to review course content later to clarify especially difficult concepts and in preparation for exams (Davis et al., 2009). Recorded lectures also help to implement flipped classroom approaches (see sub-chapter 2.2.2 "Flipped classroom"), because the information (e.g., the lecture) is already recorded and can be viewed online by the students before the class. Last but not least, lecture capture can relieve the pressure of note-taking, since the lecture can be viewed later again. This allows the students to devote their undivided attention to the lecture content. However, pre-recorded lectures on their own could promote student passivity if not combined with motivating features (e.g., flipped classroom).

3.2.3 Support through learning management systems

Learning management systems (LMSs) enable instructors and students to log in and work within an online learning environment with personalized and password-protected accounts for both students and teachers. Traditionally LMSs are used to distribute course content, assignments, additional reading, et cetera.

Most online learning management systems, such as Moodle, Blackboard and Ilias are in fact used to replicate a classroom-like design model. They consist of weekly units or modules. The instructor selects and presents the material to all students in the class at the same time. A large class can be divided into smaller groups with their own instructors. There are opportunities for (online) discussion. Students work through the materials at roughly the same pace, and assessment is done through end-of-course tests or essays. Through incorporation of video-centric tools like Kaltura, LMSs can be used for online lecturing, especially for smaller groups, or when students are also expected to create video content. For teachers, these video tools also enable them to create short knowledge clips to accompany their lecture materials. In fact, using green screen recordings or lightboards, these knowledge clips (typically short videos of max. five minutes) can become a highly dynamic content resource that teachers can also adapt to further explain content that is difficult for students during classes. This content can be easily reused in the following years.

The main differences to courses exclusively taught in a classroom are that (1) the content is a mix of text, video and audio, often with the possibility of integrating or linking to video-conferencing sessions, (2) online discussions are often asynchronous rather than synchronous, and (3) course content can be accessed online anytime from anywhere. Despite these important differences from a physical classroom, the basic organizational framework of the LMS remains like an actual classroom, and experienced teachers and instructors can modify or adapt LMSs to meet different teaching or learning needs (also similar to a physical classroom). The platform Gala (see The NTEU Case Library on the Gala Platform) can also be described as an LMS even though there are a few differences to ‘classic’ implementations.

Alongside the rise of LMSs, Massive Open Online Courses (MOOCs) have made their appearance. They represent a newer strategy for information delivery and education. Courses consist of online videos and short lectures that can be combined with automated computer tests or peer assessments. They can be offered by cloud-based software platforms such as Coursera, edX and FutureLearn, which are in fact specialized LMSs.

3.3 Aligning distance teachings constructively

Applying constructive alignment and Bloom's taxonomy in neurotechnology distance learning involves designing specific online activities and assessments for each cognitive level, in accordance with the technologies at hand. The table below, although non-exhaustive, gives examples of online activities and assessment tasks to design well-aligned courses and lessons:

Level	Online Activities	Assessment Tasks
Remembering	Digital flashcards with key neuroanatomical structures and terminology, online glossaries within the LMS, short recall quizzes using the LMS testing tools, labelling diagrams of neural circuits using annotation tools.	Multiple-choice quizzes defining key concepts, fill-in-the-blank exercises on brain regions and functions, matching exercises linking terms to their definitions.
Understanding	Summarizing research abstracts related to neurotechnology breakthroughs in online forums, paraphrasing explanations of complex neural mechanisms in collaborative documents, explaining the principles behind different neuroimaging techniques through short video presentations, participating in asynchronous discussions interpreting experimental results.	Short answer questions explaining concepts, concept mapping exercises illustrating relationships between different neurotechnologies, interpreting graphs and data related to neural activity.
Applying	Solving simulated problems related to signal processing in neurotechnology using online tools, designing a basic experimental protocol for a specific neuroscience question in a shared document, using online simulation software to model neuronal behaviour, applying ethical guidelines to hypothetical neurotechnology scenarios in a forum debate.	Case studies requiring the application of neurotechnology principles to solve a given problem, practical assignments using virtual lab environments to operate simulated neurotechnology equipment.
Analysing	Comparing and contrasting different brain-computer interface designs in a wiki, analysing the methodology of a published neurotechnology study in a discussion board, deconstructing the components of a neural network algorithm in a collaborative document, identifying potential limitations of a specific neurotechnology application.	Written analyses of research papers, comparative essays on different neurotechnology approaches, identifying flaws in experimental designs presented as case studies.
Evaluating	Critiquing the ethical implications of a novel neurotechnology in a moderated online debate, evaluating the feasibility and potential impact of a proposed neurotechnology solution in a peer-assessment activity, justifying the choice of a particular neurotechnology for a specific clinical application in a written report, reviewing and providing constructive feedback on a classmate's experimental design.	Essay-based critiques of existing neurotechnologies, developing evidence-based arguments for or against a particular neurotechnology policy, peer review of project proposals based on predefined criteria.
Creating	Designing a novel neurotechnology solution for a specific challenge and presenting it through a multimedia presentation, developing a prototype of a user interface for a neurotechnology application using online tools, creating a podcast or video blog explaining a complex neurotechnology concept to a non-expert audience, building a 3D model of a neural circuit using online modeling software.	Project-based assignments requiring the design and development of a neurotechnology solution, creating a research proposal for a novel neurotechnology investigation, developing an educational resource (e.g., a video tutorial or interactive simulation) explaining a neurotechnology principle.

By thoughtfully integrating **constructive alignment** and the principles of **Bloom's taxonomy** into the design of neurotechnology distance learning experiences, educators can create engaging, effective, and rigorous online environments that foster deep learning and enable students to achieve the desired competencies.

4 Innovative implementations in NTEU

Innovative educational practices are important to NTEU from several perspectives. On the one hand, we want content produced or available at one NTEU partner to be available to a maximum of students across the alliance. As already pointed out, this inevitably implies that a considerable amount of content should be available online and accessible by digital tools. On the other hand, we want content newly produced by NTEU to take advantage of innovative teaching concepts. Given the diversity of teaching concepts and educational content, no single (technical) solution will cover all our needs. Instead, we aim to create a growing portfolio of innovative and feasible teaching solutions with known advantages and clearly stated limitations. This will enable our teachers to select the most appropriate tool for providing a specific piece of educational content. We expect the following section to evolve as we develop, grow, and optimize the NTEU education and teaching infrastructure.

In the following section, we describe the three platforms that are currently in use by NTEU and its partners and describe further developments of a platform where needed. They represent our past work in the Pedagogy field-lab (PFL). In addition to a brief explanation of the goals, content and implementation, the following sections highlight the specific advantages of a particular tool or platform and its challenges.

4.1 The NTEU Campus + Platform

Campus+ is the digital learning platform of NeurotechEU. It consists of (1) the main platform, (2) based onthe INCF TrainingSpace platform as a repository of open access courses and lectures, and built and hosted by INCF, and (32) the Gala platform for case studies, built at the University of Michigan. The objectives of the Campus+ platform that are currently implemented are:

A course catalogue of online courses and case studies that are non-credited but demonstrate the application of engaging and effective pedagogical tools. This catalogue currently comprises 10 courses, and 123 case studies. All these courses and case studies have been specially created for NeurotechEU learners.

A course catalogue of credited courses that are mainly taught on campus at different partners to stimulate physical mobility of students between partners. The catalogue currently comprises 101 courses from three partners: University of Bonn, Karolinska Institute and Radboud University.

A collection of courses that align the online content with the eight content dimensions of NeurotechEU sourced from the INCF TrainingSpace and partner institutions, totaling 30 courses from Campus+ and TrainingSpace.

A searchable directory of staff and students involved in NeurotechEU. In this 'Faces of NeurotechEU' there are currently 27 members. In total, there are 75 registered users on the Campus+ platform.

A NeurotechEU Community Forum in which members can ask questions, discuss and exchange ideas and files. There are currently 187 registered users in the Community Forum.

Campus+'s design and suite of features were developed over several years in response to feedback from users and an expanding sense of the platform's potential. The design team of Campus+ looks closely at the interoperability framework that is created by the European Digital Education Hub (EDEH), in order to streamline future development.

Campus+ is accessible through any standard web browser and requires no further software installation. For the creation andTo create and editing of casescourses, course materials, or adding 'Faces of NeurotechEU", a user profile needs to be generated. This is for free and only requires a name and an email institutional email need to be givenaddress. A full documentation of the Gala platforms is are available at:

www.nteucampus.org and www.nteuforum.org. To add training materials to the INCF TrainingSpace, users currently have to submit the content to the TrainingSpace development team who curates the content before publishing on the platform.

We keep on expanding the implementation of new features in Campus+. A new option to import course catalogues via .csv has been implemented and is currently undergoing testing. In the long term, we aim to enable acquisition of this data through APIs from partner institutions. Our next step is to leverage the user identity among all partners to facilitate information exchange for our joint master's programme that is currently under development.

4.1.1 Current implementation

As stated in the previous section, we have implemented two course catalogues, one for non-credited online courses and one for credited on campus courses, collections of courses that align with the eight dimensions of NeurotechEU, and a searchable directory for staff and members and a forum. Whereas the directory of users is relatively underused, that forum is widely adopted for communication and file exchange within the consortium. File storage and exchange is facilitated by the SharePoint server from Radboud University.

4.1.2 Advantages and Challenges

The open availability of Campus+ facilitates that teachers and students can work together on online courses. Teachers can choose to reuse course materials from assignments in courses in following years, thus providing a continuous developing course; a. And institutions can offer on- campus courses to students from other partners in the alliance. A limitation for on-campus courses is that we do not yet offer a borderless registration process, thereby making the process less user-friendly for the learners.

The main practical advantage of Campus+ is the low threshold for its use. No software installation is required, and a user profile is quickly generated. Sufficient online documentation is provided, and courses, cases and profiles can be created and edited in a user-friendly way directly through in the web browser. Very little training is required to get the first results. In addition, the individual courses and cases can also be reached directly via their URLs, which can be embedded where desirable.

Staff have 2 options to support online discussion groups: (1) The NeurotechEU Community Forum or (2) Neurostars (neurostars.org), a Question and Answer Forum developed and maintained by INCF. Both forums support flexible access-controlled and open, which can be changed depending on the needs of the staff. For example, an instructor could set up a discussion group for a specific course with controlled access during the study period, then make the content of the discussion group open after the course and link it to course content made available via Campus+ to support self-guided and lifelong learning. At present, non-credit, online courses made available through Campus+ lack a mechanism for assessments which Students and staff can comment online in discussion groups of the forum. There is currently no infrastructure for monitoring and controlling access to content, for moderating the discussion. The lack of assessment complicates the accreditation of participation for the online courses and case studies. Private communication between members is possible in the forum, but setting up smaller discussion groups is not straightforward and user-friendly. Learning performance assessments and real-time teaching cannot be offered.

For ease-of-use and to ensure consistency across all content of the Campus+ platform, there are some restrictions regarding the design and organization of course design and structure. (1) It is not possible to control the layout or the fonts of a base page. For example, the image size and positions of text and images cannot be modified. (2) Cases, courses, and lectures from the LearnGala and the INCF TrainingSpace platforms can cannot be easily grouped into study tracks or themed-based libraries, called collections, on the INCF TrainingSpace according to content within a library (e.g. folders and subfoldersthen posted as a content type on Campus+). Currently, a case library is a list of cases sorted by date of creation (date of publication). This can become confusing as the amount of content in a case library is increasing. (3) It should also be noted that while it is possible to store materials on the Campus+ server the majority of material such as videos need to be stored on a separate platform and embedded by linking to it. With the current debate on the use of big tech and Europe's dependence on it, this is a weak point that needs to be addressed in a European unified way.

4.1.3 Conclusion

Campus+ is an easy-to-use platform for bringing relatively compact pieces of information online in very little time. The correct set of features finds use within staff and students of NeurotechEU, and we continue to build upon its features as the need arises. There are limitations regarding the organization of content, controlling access and registration to on campus courses.

4.2 Use of Generative Artificial Intelligence in Educational Work

4.2.1 Context

The field of Generative Artificial Intelligence (AI) has experienced rapid developments since 2022. Artificial Intelligence tools, which simulate certain aspects of human intelligence, have been made accessible to a wide audience. Generative artificial intelligence tools allow for the generation of content in various forms: text, code, images, videos, and audio, or a combination of these formats, with highly realistic results.

As a network of universities, we are committed to the ethical, responsible, and pedagogical use of IAGs, based on principles of support for specific uses. The use of AI tools should be approached with a critical mind, while recognizing the weaknesses, limitations, and biases inherent in these tools. One has to frame the uses of IAGs in a spirit of responsibility, transparency, and respect for university values, while encouraging enriched and innovative learning. Every user of IAGs remains solely responsible for the accuracy of the content and for ensuring conduct that respects the principles of academic integrity.
The principles and recommendations regarding the use of IAGs may be revised at regular intervals, in order to be adjusted and enriched through the contributions of all.

4.2.2 Fundamental Principles

- **Integrity**: Submit authentic and original work, correctly citing all sources and acknowledging any assistance received, including that of AI tools, provided that this practice is permitted within the relevant framework.
- **Respect**: Recognize the ideas and work of others, respect their intellectual property, and do not engage in plagiarism.
- **Equity**: Ensure equal opportunities for all members of the community and evaluate them fairly, without resorting to unfair means.
- **Responsibility**: Take responsibility for one's actions and their impact on the university community.

4.2.3 Recommended Practices for the Use of IAGs

- **Sobriety**: Any use of IAG tools must be carried out sparingly, in accordance with needs. The user must also be aware of environmental issues.
- **Reflexivity and Critical Thinking**: Productions generated by IAGs must be reread, analysed, and verified in order to avoid errors, hallucinations, and biases. The user is encouraged to develop their own thinking and reasoning.
- **Transparency**: Any use of IAG tools in the production of academic work must be clearly indicated. Users must specify how and to what extent the IAG was used and for what purposes. The teacher must be able to identify the contributions of the student, who must be able to report them transparently. Correctly cite IAG sources (software, algorithms, platforms) as well as human sources (bibliographic references).
- **Originality**: Using IAGs can support personal reflection and creativity. However, the work submitted must reflect the mobilization of critical thinking and individual understanding. It is expected that student work will be distinguished by the quality of their argumentation, justification, and critical analysis.
- **Data Protection**: Do not transmit sensitive documents or personal data to IAG tools hosted externally. Ensure the confidentiality policies of the tools used before integrating them into a university project. Ensure compliance with the General Data Protection Regulation (GDPR).

4.2.4 Prohibited Uses

- **Fraud and Plagiarism**: Presenting content generated by IAG as one's own production is prohibited. The use of AI to paraphrase content from others is considered a form of plagiarism, insofar as it makes it difficult to identify any original production and represents a form of concealment.
- **Substitution of Skills**: The student must be able to justify all intellectual and practical steps required in the production of content. IAGs, as an aid to production, must not substitute for the development of skills.

4.2.5 Integration of IAGs into Teaching

The integration of IAGs into teaching must respect the preceding principles. It must take into account the principles of equity in the work requested from students and consider a potential inequality of

access to tools. In addition, teaching staff cannot oblige students to use IAG tools requiring personal data to connect or register or entailing costs as part of their training.
Teachers must specify the instructions for using IAGs in their courses. Teachers undertake to inform students how the use of IAGs is integrated, or not, into simulations and/or assessment methods.
IAGs can potentially be integrated into training programs to support learning objectives, encourage the development of critical thinking and analytical skills, as well as creativity. Pedagogical alignment is a priority: the use of IAGs must be consistent with the content, practices and pedagogical methods as well as the assessments, which are designed and implemented to enable students to develop and have certified the skills targeted by the training. The skills-based approach can be used in this context to promote simulations, interactivity and monitoring of skills development.
The integration of the uses of IAGs into a course will respect the conditions set by the study regulations of the university concerned.

4.3 A project course on replication as an example for inquiry-based learning

As outlined in section 2.1, inquiry-based learning describes learning strategies that focus on students exploring, thinking, asking, and answering questions together with peers to acquire new knowledge and skills. One type of inquiry-based learning is project-based learning, where students have a high level of autonomy to conduct a comprehensive project. During a project, students can acquire both content knowledge and competencies to apply their knowledge, as well as soft skills.

Here, we will provide an example of a project course taught in the M.Sc. of Psychology at the University of Bonn (UBO). As an overview, we will provide some general information:

- **Aims**: The course aims to sensitise students to conscientious scientific work and provide helpful and application-oriented preparation for further studies, especially the master's thesis. Students usually conduct a complete study.
- **Format**: In the past, the project course has both been conducted online (during the Covid-19 pandemic) and in presence. In both settings, diverse innovative teaching methods from chapter 2 can be implemented.
- **Organisational information**: The course covers two semesters (October – March; April – September), so the project has a duration of nearly a year (though we note that project courses similar to this one can also be conducted with a shorter schedule). The project course module is mandatory for all students, but students may choose between a high number of courses (e.g., 8 courses) dealing with different topics within psychology at the start of the first semester (i.e., October), so that overall course sizes are limited (e.g., to 15 students).

This section will primarily deal with one specific project course focusing on a replication project, which has evolved as a response to recent discussions on the reproducibility of findings in psychology and beyond (Open Science Collaboration, 2015). Assignments in this course include an individual report in semester 1 and a group poster in semester 2.

4.3.1 Current implementation

At the start of the first semester, all students of the M.Sc. cohort gathered in a kick-off event, where the different projects were introduced by instructors. All students were provided with organisational information and got to know the topics of all projects. They had the option to change courses if they were not satisfied with the project they had chosen or been assigned to. After kick-off, work started within the individual courses.

In the individual course (replication project), the first weekly seminars were used to familiarize students with the general framework of replication and the replication crisis (definition, causes, steps to be taken). Therefore, a mixture of pedagogical methods was used, ranging from standard interactive seminars to flipped classroom approaches and peer teaching. For instance, while a general introduction on replication was interactively introduced by the instructor (week 1), small groups of students prepared a selection of papers on (failed) replication attempts for the next seminar (week 2), in which they presented and discussed these papers using guiding questions (see 2.2.2 flipped classroom). Similarly, for the third seminar (week 3), they used provided and self-researched materials on specific causes of the replication crisis (see 2.2.2 flipped classroom). During the seminar, they had time to finalize a short presentation, which they used to teach their peers (see 2.2.5 peer teaching), with a follow-up discussion regarding the interplay of causes. Then, in the fourth and fifth seminar, students discussed measures to take against the replication crisis (e.g., Open Science) (week 4) and received an introduction on the topic of a replication study previously chosen by the instructor (week 5).

After these weeks of learning about contents, students entered into a more autonomous stage. They read the previously chosen replication study and discussed study procedures and results carefully (if required, under guidance of the instructor) (week 6). Then, in smaller groups (3–4 persons), they met and brainstormed on how to replicate the study, either directly or conceptually (Schmidt, 2009) and discussed whether and how they wanted to extend the original study (e.g., research questions, considerations about sampling / study procedures / measurements). The group results were collected and discussed in plenary (week 7). Depending on the compatibility of group results, the different study ideas were then either reconciled (conduction of a single study) or remained separate (conduction of several smaller studies). During the final weeks of the semester (weeks 8–11), students prepared a preregistration of their study part according to the As Predicted template (https://aspredicted.org/). They received feedback from the instructor and could adapt their preregistration accordingly. Moreover, depending on the students' coding knowledge, they also prepared (parts of) study programming in this time period. Once programming was done (by the students and/or the instructor), all students piloted the study/studies. At the end of the lecture period of the semester (week 12), the complete course met once again in plenary, where final issues regarding preregistrations, programming and recruitment were clarified. Moreover, students received information on end-of-semester assignments, which consisted of individual registered reports of the respective studies. During the lecture-free period, students collected study data and prepared their assignments.

The first seminar in the second semester consisted of a discussion of experiences made during the data collection phase and an outlook on data analyses, which students had already planned in their preregistration (week 1). In the following weeks, students analysed data autonomously in their groups (weeks 2–3). Afterward, they presented them to their peers in plenary, where they were discussed. Moreover, with the next end-of-semester assignment in mind (group poster), students were instructed to collaboratively argue how scientific posters should look like, with a summarizing overview presented by the instructor (week 4). In the following weeks, student groups finalized their data analysis and prepared a poster to present their study (weeks 5–8). If wished, they received feedback from the instructor within this period. Afterward, the poster drafts were presented in plenary, where student groups gave each other feedback (week 9). Student groups then had a final opportunity to optimize their posters. In the final week of all project courses (week 10), a common session was organized in which students presented their posters to the members of all project courses, similar to a scientific conference. Students also evaluated the posters from other project groups regarding content and design, and, as an incentive, the three winning posters won small prizes. Grading of posters was up to the instructors. The final grading of the module was computed as the mean of individual report grade and group poster grade.

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4.3.2 Advantages and Challenges

As outlined in Section 2.1., project-based learning offers students the possibility to apply the scientific process as scientists rather than simply following protocols (Yew and Goh, 2016; Laforce et al., 2017). The presented project course is an example for this: All steps of the scientific process (i.e., development of research questions, study design, data collection, data analysis and study presentation) are done by the students in group work under careful guidance by an instructor. Thereby, the project course sensitizes students to conscientious scientific work, in particular Open Science practices, and provides a useful preparation for further studies. A huge advantage of the project course is that different innovative teaching methods can easily be combined. As outlined before, project-based learning is the dominating method (especially in semester 2), but methods such as flipped classroom (2.2.2), collaborative argumentation (2.2.4) or peer teaching (2.2.5) can easily be implemented to enhance knowledge of relevant topics. Moreover, as the past years have shown, the general approach can be transferred to an online setting as well. Of course, several aspects such as online teaching methods (see sub-chapter 3.1 “the challenge of distance teaching and learning”), study design aspects and poster session setting need to be adapted individually, but in our experience, a transfer to an online setting is generally possible without major influences on assignment outcomes.

There are several points to consider when planning a project course, however. First, it is a crucial and time-intensive challenge to find a suitable study to replicate. While it might be tempting to leave this choice to the students, we made the experience that they usually do not have sufficient research experience to select a suitable study. Therefore, instructors need to carefully screen the literature for a study that is worth replicating and that, in terms of methods, is replicable as part of a project course (e.g., the experimental methods should not be too complicated, it should be possible to collect data within approx. 2 months, different research questions for different groups are conceivable, etc.). Second, an important point to consider is the student group size. In our experience, groups of 3–4 people work best because smaller groups have a high workload, whereas with larger groups there is a higher risk of responsibility diffusion. Third, the instructor needs to be careful to give not too much nor too little guidance for students. This is a balancing act to ensure that students work responsibly and autonomously on the one hand, but do not get lost within the project on the other. It is important therefore that the instructor is open to questions at any point of the project.

4.3.3 Conclusion

The project course presented in this section can be used as a guidance for structuring future project courses in NTEU aiming to teach scientific methods as well as open science practices in an applied way. It is possible to flexibly adapt it regarding contents, teaching methods and teaching setting.

4.4 Space-oriented learning with the 'How to... fMRI' digital twin course on Gala

4.4.1 Introduction

The original goal for this project was to produce a tour of the Donders Institute MRI laboratory that enabled students to explore the facilities without interrupting ongoing research. A 3D digital representation (digital twin) of the MRI facilities was created using a Matterport Pro 3D camera. It soon became clear that the digital twin was an ideal platform to create online course content for NTEU, and so we made the 'How to... fMRI' course. To our knowledge, this is the first course to utilize this technology, and it provides a blueprint for future online content that uses this space-oriented learning approach.

Once a space has been mapped with the 3D camera, the model is stitched together and hosted on Matterport's servers. The user-friendly software allows you to place icons at any location inside the twin and attach videos, images, simple text, documents, and hyperlinks **(Figure 1).** This allows you to create a journey through your digital twin that could serve a range of purposes, including educational content, safety training, equipment demos, and public outreach.

Duplicates of a digital twin can also be created to serve different purposes. For example, you could use one twin for students to learn a laboratory process, and a duplicate twin to test their knowledge by getting them to repeat the process from memory (see Implementation below).

Figure 1. The digital twin environment. Users can navigate to any location inside the 3D model (shown bottom right), such as the presented location inside the scanner room. Icons can be attached to any location, creating a journey for the user. The icons display information when selected, including image slides (shown here), videos, file attachments, and imbedded links to additional content (e.g., google forms). Icons are colour coded for the 'How to...fMRI' course: red for steps in phase 1 of the experiment, blue for phase 2, green for phase 3, and grey for additional information (e.g., equipment descriptions).

4.4.2 Current implementation

The "How to... fMRI" course takes place inside a digital twin of the MRI laboratory at the Donders Centre for Cognitive Neuroscience and can be accessed through the Gala online learning platform (https://www.learngala.com/magic_link?key=V020s8HeBX4-261J2Gj1-Q). This innovative approach allows students to experience the process of conducting an fMRI experiment in a safe and accessible environment on their own computers.

The course is structured in three phases, mirroring the typical research process: preparing the participant, running the experiment, and analysing the data. Each phase consists of nine practical steps that the student follows by navigating freely around the lab and locating coloured icons **(Figure 1).** An icon at the beginning of each phase provides an overview of all the steps the student needs to follow.

Each step contains either a video (~5-20 minutes) or slides of information that provide practical instructions and theoretical explanations. For example, when the student carries out the step of removing metallic items from their participant, they learn the MR physics theory that explains why they must do that. Citations are also provided at each step in an attached PDF for students that want to delve deeper into the covered topics.

After completing each phase, students are tested on their practical and theoretical knowledge by entering three duplicate digital twins in turn: the beginner test, amateur test, and pro test. The tests gradually remove information from the digital twin, challenging students to carry out the practical steps from memory, while also requiring them to answer questions of increasing difficulty inside each step. This reinforces learned concepts and ties them to the practicalities involved in research, while allowing students to acquire detailed practical knowledge of labs that are very difficult to access in a real-world setting. While this particular course is carried out entirely online, we can also envisage a similar course being used in a blended learning framework, where students acquire knowledge inside a digital twin that then allows them to more efficiently learn skills when they enter the same lab in the real world.

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4.4.3 Advantages and Challenges

There are numerous practical and theoretical benefits to using this method. From a practical perspective, a laboratory digital twin can be created in a single day and hosted online at a relatively low cost (approximately €2.50 per month). Moreover, the creators of this course are available to visit partner institutions to create digital twins of laboratory spaces and support the creation of educational content. The accessibility threshold is also quite low, as the user-friendly, web-based software does not require downloads, and the twins can be easily embedded in Gala. The method is highly flexible, making it suitable for standalone online courses, blended learning, and laboratory tours, among other applications. It also addresses safety concerns, allowing students to interact with hazardous equipment without risk to themselves or interference with ongoing research. Digital twins also have the potential to enhance the efficiency of time spent in real-world laboratories. Students can familiarize themselves with the lab remotely and use the digital twin within the physical lab to locate resources or access equipment demonstrations.

Student engagement has also been notably positive, with students appreciating how the combination of spatial exploration, videos, and slide content helped sustain their interest and deepen their understanding, particularly given their limited access to the real-world MRI laboratory. Moreover, the capacity to visit partner facilities via digital twins offers one solution to student mobility. This could serve as a unique selling point for NTEU courses, as graduates would gain exposure to multiple lab environments across all eight dimensions of neurotechnology. We are also working on making our digital twins accessible in virtual reality, which has the potential to further promote student mobility and lifelong learning.

A practical disadvantage is that the digital twins themselves cannot be used for assessment, necessitating careful integration with other evaluation tools. Additionally, while the creation of a digital twin is relatively quick, designing an educational journey within it—along with scripting, filming, and editing content—is time-consuming. To address this, we have developed a User Guide to facilitate the process.

From a theoretical standpoint, spatial learning methods have a well-established history in psychology. The method of loci, or Memory Palace technique, has been famously used by memory champions to rapidly learn vast amounts of information. This mnemonic technique overlaps considerably with the 'How to…fMRI' course. The spatial element most likely leverages the human brain's natural capacity to learn and retain critical information from the environment. The course also incorporates several additional mnemonic strategies to enhance learning. First, information is chunked into separate phases and steps, aiding recall. Second, the process of students answering questions while they retrace their steps from memory in the beginner, amateur, and pro tests helps to create enduring long-term memories (the ‘testing effect’). Additionally, embedding both practical and theoretical information within the same spatial locations is not only a great way to understand abstract concepts, but these different aspects will also support one another. For example, practical tasks will trigger memory of the associated theoretical concepts and vice versa and visiting real-world laboratories should trigger relevant memories to further reinforce both types of knowledge.

The disadvantages of digital twins are that they cannot replace some critical real-world experiences. For example, many neuroscience techniques require the practice of manual skills, therefore digital twins should be used carefully to complement the acquisition of such skills rather than replacing them. Learning through digital twins also lacks the collaborative and communicative aspects of other educational methods, therefore study programs should seek to encourage interaction between students and educators beyond these online environments.

4.4.4 Conclusion

The "How to... fMRI" course offers an innovative approach to teaching complex procedures and concepts within a virtual environment, allowing students to safely explore a laboratory they cannot access in the real world. Students are able to learn the practical steps involved in conducting research and link them to the related theoretical explanations in an engaging and memorable way. While digital twins cannot replace many forms of hands-on experience, they can enhance those experiences via blended learning and could play an important role in supporting student mobility within NTEU.

5 Conclusion

This Innovative Pedagogy Handbook aims at presenting a comprehensive overview of current and emerging teaching methods, with a particular focus on the integration of digital and blended learning approaches within the NeurotechEU Alliance. The current version details the constructive alignment of learning outcomes, activities, and assessments, and introduces key aspects of distance learning. With the launch of the Campus+ platform, it now replaces INCF as the main alliance platform, and guidance on integrating artificial intelligence into teaching has been added. Two exemplary courses from partner universities have also been included to showcase practical applications of these innovative pedagogical approaches. Therefore, the implementation of platforms such as Campus+ and the adoption of generative artificial intelligence tools have further expanded the capacity for virtual mobility, collaborative learning, and personalized educational experiences.

The outcomes of this work demonstrate the Alliance’s commitment to fostering multidisciplinary, cross-border, and inclusive education by leveraging a diverse set of pedagogical strategies-ranging from inquiry-based and flipped classroom models to simulation-based and space-oriented learning.

The results outlined herein highlight several key achievements: the development of a continuously updated repository of innovative teaching practices, that facilitate both online and hybrid learning, and the effective adaptation of pedagogical models to support mobility, inclusivity, and lifelong learning across partner universities. This handbook, through its diffusion, will contribute to increase engagement among students and staff, improve access to multidisciplinary content, and the creation of scalable models for future educational initiatives. The contributors intend to share this material beyond the manual itself, through the establishment of workshops, panel discussions, and communities of practice.

Moving forward, these results will serve as the foundation for further refinement and expansion of pedagogical innovations within NeurotechEU. The handbook will continue to evolve as a living document, incorporating new tools, case studies, and best practices as they are developed and tested within the Alliance. By maintaining a collaborative approach, new contributions and examples of pedagogical practices are expected to be included in the near future. In addition, insights gained from the implementation of these methods will support the development of joint programs and master's degrees.

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8 Appendix / Annex / Glossary

8.1 Teaching formats and course types

8.1.1 Lectures

Lectures are teacher-centred instructions often, but not exclusively, directed at large groups of students. Depending on the topic, several hundred people may be attending a lecture. Topics can range from a basic introduction to the subject ("textbook knowledge") to a presentation of the latest research and technologies. A lecture is usually one to two hours long. They can be 'stand-alone' if they deal with a narrow subject or combined into a series to cover broader topics.

As a rule, lectures are usually not very interactive although follow-up questions from the audience are encouraged. In addition, lecturers may address students directly and actively involve them in the lecture by asking questions. However, this does not lead to a classic classroom discussion.

Students are often provided with scripts to accompany the lectures. The scope of these scripts varies widely, ranging from sparse lecture notes – for example, a collection of the diagrams presented, for which students must write down the actual knowledge themselves – to complete lecture notes that virtually eliminate the need to purchase a textbook (or to attend the lecture in the first place).

Overall, lectures are highly suitable for digital teaching, and especially so if complemented by scripts (or the possibility to attend a lecture or specific parts of a lectures multiple times) and an option for follow-up questions (live, chat, learning platform). Also see chapter 3 "Implementing distance teaching and learning" and sub-chapter 7.1.3 "webinar".

8.1.2 Seminars

A seminar is a small group session (up to 30 students) offering the opportunity to discuss teaching content (discussing papers, working on an assignment, group work, etc.). Seminars typically serve to deepen scientific knowledge and can be offered on any topic of the subject area. In contrast to the lecture, they are characterized by greater interactivity of the lecturer and seminar participants. The online version is called a Webinar (see below).

8.1.3 Webinars

Webinars are now used to describe events of various kinds that take place in a virtual classroom (e.g., seminars, offers on learning platforms, coaching, and mentoring meetings, courses and exams). Webinars make seminars accessible from anywhere in the world. In contrast to an on-demand webcast, where the information is only transmitted in one direction, a webinar is designed to be interactive and enable two-way communication between speaker and participants. Other typical interaction options include downloading files, asking questions via chat or taking part in surveys.

8.1.4 Tutorials

Tutorials are usually held in smaller groups (up to 20 students) by a lecturer or a graduate student (or teams of graduate students), Tutorials often accompany a seminar as a supplementary exercise. Students can review and deepen the material of a course together with a tutor.

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8.1.5 Practical classes

Practical classes are more complex training units. They are often designed to deepen knowledge about a particular concept and to simultaneously obtain practical skills related to that area of science. The number of participants is typically small (< 20). Participants learn and practice skills and further increase their understanding of a subject through experimentation, observation, and interpretation. The goal is to improve skills regarding the design of experiments, the safe use of equipment and the recording, analysis, and interpretation of experimental data. In NTEU, and especially in its life science related disciplines, practical classes are usually the most difficult to hold online.

8.1.6 Courses and modules

A course or module usually consists of a sequence of teaching units. The unit formats within it can vary widely. They typically consist of lectures to provide basic knowledge, seminars and tutorials to deepen the understanding, to discuss the material and apply the newly gained knowledge. A module description should clearly outline the requirements, learning goals and what the path from the starting point to the learning objectives is. A course is usually designed for a specific number of participants. Outlined below are examples of formats with a very specific purpose.

Method Course/Practical Course: A methods course should enable students to deepen their understanding of the strengths and challenges of their chosen approach at a general level. Methods courses focus primarily on teaching practical skills. Practical work is usually accompanied by lectures, seminars, and tutorials.

Language course: A language course in NTEU is intended for promoting exchange and for enabling learners to move between NTEU partners by acquiring specific local language skills (university administration, shopping, work, local geography). They also support multicultural and multilingual cooperation and awareness thereby strengthening community spirit.

Soft skill course: For a successful career, it is essential that learners and students continuously upgrade their academic and non-academic skills through soft skills courses (e.g. academic writing, publishing, scientific presentation, independent research, learning to teach, leadership, data management and career management). The courses, taught by professionals in the respective fields, facilitate the strengthening of leadership, management and networking skills. In NTEU, such content is offered for example by the NTEU Lifelong Learning Centre and the NTEU graduate school.

Good Scientific Practice Course: Safeguarding good scientific practice is essential in all scientific work. The essential principles are typically taught in short courses to researchers and students at all levels.

Workshop: Workshops focus on specific concepts or techniques by a highly qualified instructor and have a smaller number of participants (5- 20). They tend to last for several hours up to days. They emphasize close interaction and are therefore often held in person, especially if they have a practical component.

Summer School and Winter School: They provide a systematic and comprehensive introduction to a key topic. The aim is typically twofold: 1) to expose students to current research topics and methods at an early stage in their careers and 2) to bring students together to create professional networks. These schools are typically very interactive and structured around a series of lectures or seminars. They can also contain practical components or practical courses and can be combined with visits to research laboratories.

8.2 Assignments and assessments

8.2.1 Objective tests

Objective tests are types of exams that typically have multiple-choice questions, questions with short answers and/or questions where the answer is true or false. They can also include problems or mathematical proofs. In addition, they can involve drawing schematics or charts (Hadwin, 1999). Because of their relatively simple design these tests are often straight-forward to do online.

Multiple-choice tests: A multiple-choice exam is a type of test that can be used to measure the knowledge of facts, concepts, rules, and quantitative techniques across disciplines. Its typical duration ranges between few minutes to several hours. It is often easy to score automatically (also see below). However, developing this type of test can be challenging, because it requires particularly well-formulated multiple-choice questions (Davis, 1993). Also, this type of assessment can be less helpful for assessing higher level skills and intellectual abilities because it is typically limited in its ability to evaluate for example sophisticated problem-solving, creativity, and evaluation (Bates, 2019).

True-false tests: True-false tests are less reliable than other types of exams because random guessing generates the correct answer half of the time. These items, however, are suitable for occasional use. When using true-false questions, some include a "explain" column in which students write one or two comments to support their choice (Davis, 1993).

Matching tests: In matching tests, students are presented at least two lists of options, which they have to correctly match to each other. The matching format is efficient for examining students' knowledge of the relationships between terms and definitions, events and dates, categories and examples, and other links (Davis, 1993).

Computer-based objective tests: Because of their relatively simple structure and their pre-defined sets of answers, the three tests mentioned above can be easily performed on a computer or online. Scoring the exams of large number of students is very fast and easily automated. In addition, analysis of results is fast and adjustment of evaluation/scoring criteria can be easily adjusted (e.g., to obtain a certain distribution of scores

8.2.2 Essay tests

These exams typically require students to respond to specific questions in an understandable and readable manner. Because the questions are focused, the student is usually expected to include some basic points in their essay. As a result, before marking these tests, the teacher should write down the key points so he can prepare model answers ahead of time (Hadwin, 1999). This method is effective for evaluating understanding and more sophisticated intellectual abilities, such as critical thinking, but it is time-consuming, prone to subjectivity, and ineffective for evaluating practical skills. Scoring such tests is usually more time-intensive compared to objective tests and automated scoring is typically not possible although experiments are being conducted taking advantage of advances in artificial intelligence. However, automated essay marking has difficulties in identifying the true semantic meaning of an answer and comparing it to a model answer so far, particularly at a higher education level (Bates, 2019).

8.2.3 Oral tests

In oral tests, students are required to present a work or to respond to questions posed by the examiner(s) in spoken form (between 10 and 90 minutes; online or in presence). The formats of oral tests vary widely (Joughin, 1998). For instance, one possibility is that students prepare a presentation of their work, with critical questions posed by the examiners afterwards (e.g., as often done in a Master's / PhD defense). Another possibility is to ask similar questions as in written tests such as objective tests and essay tests, but to dedicate more time to general conceptual rather than specific questions while having the possibility to test students in a more flexible way. That is, it is possible to use fewer questions and to probe responses, allowing a better understanding of the student's knowledge and conceptual reasoning (Theobold, 2021). Additionally, in times of text-producing AI models such as large-language models, oral tests provide a possibility to prevent plagiarism compared to lengthy written works (Newell, 2023). While the higher flexibility and plagiarism control are advantages of oral tests, potential disadvantages such as higher time effort for examiners (i.e., the need to test students one-by-one or in small groups and to prepare different questions for them), test fairness / equity (i.e., evaluations can be more subjectively biased than in objective written tests) and student anxiety should be considered (Theobold, 2021).

8.2.4 Performance tests

Students are required to perform tasks under timed conditions (e.g., follow directions, draw pictures, work with materials or equipment, conduct experiments, and respond to actual or simulated events in performance exams). Performance evaluations can be given to individuals or groups. Because they are logistically challenging to set up, difficult to grade, and the material of most courses does not always lend themselves to this sort of examination, they are rarely employed in colleges and universities. Performance examinations, however, can be helpful in courses where students must demonstrate their abilities (e.g., medicine, education) (Davis, 1993).

8.2.5 Formative assessment

The term describes methods that are used during a class or course to discover misconceptions, difficulties, and learning gaps while evaluating strategies for closing such gaps. The underlying idea is that when students comprehend that the purpose of the formative assessment is to improve learning rather than to increase final grades, they are more likely to take ownership of their learning. There are several strategies such as the use of open questions and the integration of extracurricular activities into the curriculum (e.g. idea mapping) (Wyse et al., 2015).

8.2.6 Summative assessment

At the end of a unit, course, or program, the learning, knowledge, proficiency, or success of the students is examined. Summative tests are virtually always officially graded and frequently given a lot of weight. Summative evaluation can be utilized effectively in conjunction with formative assessment and in accordance with it. Such assessments are also known as 'assessments of learning' since they aim to summarize and report on what has been learnt at a specific point in time. Although it may not have the same direct impact on learning as formative assessment, it can still be used to enhance learning in a less direct way when results are used to inform decisions about courses or teaching. Summative assessment is significant for several reasons according to (Wyse et al., 2015):

1) Provides accurate reports on the accomplishments and academic development of specific students.
2) Enables tracking of the academic progress of particular groups (e.g., top and bottom achievers, surface vs. deep type of learning, students' prior knowledge) and educational opportunity equity.
3) Can identify expectations and standards for students, teachers, and other users. 4) Improves learning in the long and medium terms.

8.2.7 Open book examination

An "open book test" allows students to access their class notes, textbooks, and other authorized materials while answering questions. This is not unusual in legal exams, but it is almost unheard of in other subjects. Although the concept may appear radical and perplexing to people accustomed to traditional tests, it is perfectly suited to teaching programs that specifically aim to improve critical and creative thinking skills (Vishavpreet, 2016).

8.2.8 Take-home-exams

Take-home exams (also homework assignments) enable students to work at their own pace while still having access to books and tools. They allow for lengthier and more complicated questions. Appropriate types of take-home tests include problem sets, short answers, and essays. Excessively demanding questions or not including time or word constraints should be avoided. Also, students require precise instructions on what they can and cannot do (e.g., discussing responses with colleagues). Another type of homework assignment is to announce some time before an exam that from a set of questions, some will be selected for the exam. This allows students to better focus on relevant topics while learning. (Davis, 1993).

8.2.9 Project work

Project work promotes the growth of real-world abilities that call for content comprehension, knowledge management, problem-solving, group collaboration, evaluation, creativity, and useful results. Project work is one of the greatest ways to evaluate the high-level skills, but it necessitates a considerable amount of expertise and inventiveness from the instructor, and the assessment procedure can be labor-intensive (Bates, 2019).

8.2.10 Peer assessment

In this type of exam, participants rate each other's work. This is considered as an effective technique to build deep comprehension and knowledge. Guidance and well-formulated model answers or outcomes are particularly important. Self-assessment and e-Portfolios Self-assessment through reflection, knowledge management, recording and evaluation of learning activities is another form of assessment even though it typically does not results in scores or grades. E-Portfolios are online tools, which are self-managed by the learner but can be made available or modified for formal assessment purposes or job interviews (Bates, 2019).

8.2.11 Self assessment and e-Portfolios

Self-assessment through reflection, knowledge management, recording and evaluation of learning activities is another form of assessment even though it typically does not results in scores or grades. E-Portfolios are online tools, which are self-managed by the learner but can be made available or modified for formal assessment purposes or job interviews (Bates, 2019).

8.2.12 Progress Report

Training measures can be complemented by mentoring and reporting programmes. These are typically found during work on complex projects (e.g., BSc, MSc or PhD thesis). Progress reports help students reflect on their progress and better plan their future milestones. It also allows the supervisor and advisory board to evaluate the students' work and the direction they have taken with their research. It is in both the student's and advisor's best interest to ensure that the research moves forward in a timely and well-thought-out manner. A standardized form/document can be used to document the progress of the learning. Such a form provides an opportunity to provide an overview of the student's achievements to date and recommendations for future development.