ENCCS Instructor Training

ENCCS

Nov 30, 2022

BEFORE THE WORKSHOP

This ENCCS instructor training material is focused on helping competent practitioners and experts teach their knowledge to others. It also serves a kickstart to teaching ENCCS lessons.

The material presented here is partly derived from two instructor training resources developed in the CodeRefinery project as well as the instructor training lesson from The Carpentries:

- CodeRefinery Community Teaching
- CodeRefinery Instructor Training
- Carpentries Instructor Training

Inspiration has also been drawn from the free online book Teaching Tech Together by Greg Wilson.

After attending a workshop covering this material, learners should:

- Have increased confidence in teaching interactive workshops in online and in-person settings.
- Be familiar with important pedagogical concepts and scientific findings about how people learn new skills.
- Appreciate the importance of frequent hands-on practice in building skill.
- Understand how learning can be improved by following certain best practices in interactive teaching.
- Know how to backwards-design training material based on intended learning outcomes.
- Know about important differences between online and in-person training and how inherent challenges in online training can be overcome.
- Be familiar with a technical approach to collaboratively developing open source lessons based on a template.

Prerequisites

This course has no strict prerequisites, but

- It is helpful if you have attended an ENCCS or CodeRefinery workshop, which are taught in an interactive and hands-on way.
- We assume you already have competence in the technical topics and tools you want to teach.
- While not a prerequisite for this course, version control (Git) is necessary to contribute to lesson development the way we show here (but the lesson design concepts are applicable to other styles, too).

Instructor note

- 30 min homework

Questions

- What should I do before the ENCCS instructor training workshop?

CHAPTER

ONE

PRE-WORKSHOP PREPARATION

These things will help you get the most out of this workshop, by giving you a broad overview at the beginning that you might only get later on during the workshop.

1.1 Read "How to help someone use a computer" (5 min)

How to help someone use a computer, by Phil Agre. Summary: Most of our teaching challenge is helping people to overcome bad user interface design.

1.2 Browse an ENCCS lesson (5 min)

Please take 5 minutes and go through an ENCCS lesson and understand the general layout. Don't go in-depth to any of the material (unless you want, obviously).

You can for example go through one of the following lessons:

- SYCL
- Julia for HPC
- CMake
- Python for HPDA
- Intermediate MPI
- CUDA

1.3 Read "The science of learning" (20 min)

Read this short paper The Science of Learning which provides a brief overview of some key evidence-based results in teaching. This paper is also used by The Carpentries for their Instructor Training workshops.

Remark

Don't worry if there are sections you do not understand. The main objective is to have a baseline for our discussions, not to check your ability to teach the lesson during the instructor training workshop.

Instructor note

- 10 min teaching
- 10 min exercise

CHAPTER

TWO

WELCOME AND INTRODUCTION

What do we want to get out of this workshop

- Introduction of instructors and helpers
- Each instructor can say what we want to get out of the instructor training
- But we want to know from everybody and collect these in the live notes

2.1 Goals for this workshop

- **Inspire teachers and staff who teach technical topics:** Use best practices, especially for online teaching.
- **Promote collaboration in teaching**.
- **Motivate new instructors** to take up our lessons, remix them, and to contribute.
- **Get feedback** to improve the material as well as our collaboration model.
- **Catalyze and form new networks** and collaborations of teachers and trainers of practical scientific computing.

2.1.1 Giving confidence

> *Goal number one should be that we give participants the confidence to independently apply the tools or knowledge learnt. This is more important that giving a "complete" overview.* [Lucy Whalley gave this great comment at a CodeRefinery workshop]

2.2 Tools for this workshop

We always start workshops with these:

- HackMD mechanics and controls
- Zoom mechanics and controls

2.3 Code of Conduct

We strive to follow the Contributor Covenant Code of Conduct to foster an inclusive and welcoming environment for everyone.

In short:

- Use welcoming and inclusive language
- Be respectful of different viewpoints and experiences
- Gracefully accept constructive criticism
- Focus on what is best for the community
- Show courtesy and respect towards other community members
- Contact details to report CoC violations can be found here.

Furthermore, as this is a hands-on, interactive workshop:

- Be kind to each other and help each other as best you can.
- If you can't help someone or there is some problem, let someone know.

Finally, if you notice something that prevents you from learning as well as you can, let us know and don't suffer silently, even the "little things":

- Volume too low?
- Font size too small?
- Generally confusing instructor?
- Not enough breaks?

Ice-breaker in groups (10 minutes)

- Share your approach to teaching and your teaching philosophy with your group.
- Please share your tricks and solutions in the live document for others.

Additional ice-breaker questions:

- What is your motivation for taking this training?
- How structured or informal are your own teaching needs?

Instructor note

- 10 min teaching
- 5 min discussion

CHAPTER

THREE

ENCCS TRAINING

ENCCS (EuroCC National Competence Center Sweden) is one of 33 nodes of the EuroCC project, which is funded by the European High-Performance Computing Joint Undertaking (EuroHPC-JU). As an NCC, we act as the central point of contact for HPC and related technologies in Sweden. Our mission is to empower Swedish industry, academia and the public sector to leverage HPC, AI, and HPDA efficiently and effectively.

Training is one of the main pillars of ENCCS' activities. We have developed a large amount of public and open source lesson material and have taught over 45 online workshops since September 2020. Our training philosophy and methods are to a large extent derived from two well established educational initiatives: CodeRefinery and The Carpentries. The material presented here covers both pedagogical ideas and practical aspects which underpin the development of lesson material, organisation of online or in-person workshops and the teaching itself.

3.1 The Carpentries

The Carpentries is an international project that comprises Software Carpentry and Data Carpentry, communities of instructors, trainers, maintainers, helpers, and supporters who share a mission to teach foundational computational and data science skills to researchers. The Carpentries teach foundational coding and data science skills to researchers worldwide.

3.1.1 Carpentry instructor training

ENCCS instructors are encouraced to complete the Carpentry instructor training workshop, which anyone can apply for.

This instructor training lesson presents several concepts and methods from the Carpentries approach to teaching and highlight parts that are most important for teaching ENCCS style lessons. We encourage you to further study the Carpentry lesson later and to sign up for a 2-day Carpentry intructor training workshop.

3.1.2 Carpentries audience

The Carpentries aims to teach computational **competence** to learners through an applied approach, avoiding the theoretical and general in favor of the practical and specific. **Learners do not need to have any prior experience in programming.** One major goal of a Carpentry workshop is to raise awareness on the tools researchers can learn/use to speed up their research.

By showing learners how to solve specific problems with specific tools and providing hands-on practice, learners develops confidence for future learning.

Novices

Carpentry learners can be qualified as **novices**: they do not know what they need to learn yet. A typical example is the usage of version control: the Carpentry `git` lesson aims to give a very high level conceptual overview of Git but it does not explain how it can be used in research projects.

3.2 CodeRefinery

CodeRefinery is a Nordic e-Infrastructure Collaboration (NeIC) project that started in October 2016. The main goals of CodeRefinery are:

- Develop and maintain training material on software best practices for researchers that already write code. The CodeRefinery lessons address all academic disciplines and try to be as programming language-independent as possible.
- Provide a code repository hosting service that is open and free for all researchers based in universities and research institutes from Nordic countries.
- Provide training opportunities in the Nordics using Carpentries and CodeRefinery training materials.
- Articulate and implement the CodeRefinery sustainability plan.

3.2.1 CodeRefinery audience

CodeRefinery workshops differ from Carpentry workshops as the audience is assumed to already write code and scripts and we aim at teaching them **best software practices**.

CodeRefinery learners usually do not have a good overview of **best software practices** but are aware of the need to learn them. Very often, they know the tools (Git, Jupyter, etc.) we are teaching but have difficulties to make the best use of them in their software development workflow.

Competent practitioners

CodeRefinery learners can be qualified as **competent practitioners** because they already have an understanding of their needs. *Novices* and *competent practitioners* will be more clearly defined in a *later section*.

3.2.2 ENCCS audience

Similarly to CodeRefinery, ENCCS targets **competent practitioners**: participants are assumed to know what their needs are. Typically, their needs are to learn a technique or method to adapt their code to HPC, to learn novel programming languages or frameworks, or to deepen their knowledge of machine learning methods.

3.3 Teaching philosophy

ENCCS, CodeRefinery and The Carpentries all teach computational competences to learners through an applied approach founded on research-based teaching principles. Usually, we avoid the theoretical and general in favor of the practical and specific. By showing learners how to solve specific problems with specific tools and providing hands-on practice, we develop learners' confidence and empower them to start applying new knowledge immediately.

- Learners need to practice what they are learning in real time and get **feedback** on what they are doing. That is why the teaching approach relies on **live coding**.
- Learners best learn in a respectful and motivating classroom environment, so it's important to use a **Code of Conduct** and avoid certain demotivating language.
- Learners are encouraged to **help each other and collaborate** during workshops as this improves their confidence and reinforces concepts taught.

3.3.1 Specific aspects

- Teaching material (lessons) available in advance and not PDF slides.
- Lessons suitable also for self study.
- Interactive, hands-on teaching: presentations and type-alongs interleaved with exercises.
- Shared collaborative workshop document for questions, answers, information etc.
- Clearly defined teaching roles (instructor, host, answering questions in shared document, . . .)
- Recruiting volunteer helpers and instructors.
- Frequently asking for and encouraging feedback.
- Emphasis on code of conduct and inclusivity.
- Thoughtful screen sharing and shell sharing.
- Lessons developed from well defined learning objectives.
- Using a standard lesson template.
- Collaborative lesson development and peer review on GitHub.
- Lessons are open source instead of private.

How common are these practices?

How many of the teaching features above do you use in your own teaching?

The instructor can copy-paste the list below to the shared workshop document and conduct a poll.

Poll

```
Which of these practices do you use in your teaching? Vote by adding "o".

- Teaching material (lessons) available in advance and not PDF slides: o
- Lessons suitable also for self study: o
- Interactive, hands-on teaching: presentations and type-alongs interleaved with exercises: o
- Shared collaborative workshop document for questions, answers, information etc: o
- Clearly defined teaching roles (instructor, host, answering questions in shared document, ...): o
- Recruiting volunteer helpers and instructors: o
- Frequently asking for and encouraging feedback: o
- Emphasis on code of conduct and inclusivity: o
- Thoughtful screen sharing and shell sharing: o
- Lessons developed from well defined learning objectives: o
- Using a standard lesson template: o
- Collaborative lesson development and peer review on GitHub: o
- Lessons are open source instead of private: o
```

3.4 See also

- Active Learning Leads to Higher Grades and Fewer Failing Students in Science, Math, and Engineering

Instructor note

- 10 min teaching
- 5 min discussion

CHAPTER

FOUR

ENCCS LESSONS

Below is a list of current ENCCS lessons along with their intended learning outcomes. These lessons are at different maturity levels and have been developed by many different people, so they do not all conform equally well to the recommendations presented in this lesson!

4.1 GPU computing

OpenMP for GPU Offloading

- Get an overview of the architecture of GPU and how they differ from CPUs
- Understand how OpenMP fits into the landscape of GPU programming approaches
- Understand OpenMP's shared parallel model and program execution model
- Learn how to use basic OpenMP directives and clauses

OpenACC

- Get an overview of the architecture of GPU and how they differ from CPUs
- Understand how OpenACC fits into the landscape of GPU programming approaches
- Understand OpenACC's shared parallel model and program execution model
- Learn how to use basic OpenACC directives and clauses

Intermediate CUDA

- Get an overview of the architecture of GPU and how they differ from CPUs
- Understand GPU concepts like threads, blocks and streaming multiprocessors
- Learn to write simple CUDA kernels
- Learn to work with GPU memory
- Learn to optimize CUDA kernels
- Understand asynchronous execution

SYCL

- What is SYCL and why it is useful.
- Write hardware-agnostic code to express parallelism using the queue, command group, and kernel abstractions.
- Use buffer and accessors to handle memory across devices.
- Evaluate drawbacks and advantages of unified shared memory.

- Get acquainted with the SYCL profiling API.

4.2 HPC

Intermediate MPI

- Understand communicators, groups and derived datatypes
- Learn to use one-sided communication
- Understand and be able to use collective communication, blocking and non-blocking
- Understand how to work with MPI and threads

4.3 Programming languages

High-performance Data Analytics with Python

- Have a good overview of available tools and libraries for improving performance in Python
- Know what libraries are available for efficiently storing, reading and writing large data
- Be comfortable working with NumPy arrays and Pandas dataframes
- Be able to explain why Python code is often slow
- Understand the concept of vectorisation
- Understand the importance of measuring performance and profiling code before optimising
- Be able to describe the difference between "embarrassing", shared-memory and distributed-memory parallelism
- Know the basics of parallel workflows, multiprocessing, multithreading and MPI
- Understand pre-compilation and know basic usage of Numba and Cython
- Have a mental model of how Dask achieves parallelism
- Remember key hardware differences between CPUs and GPUs
- Be able to create simple GPU kernels with Numba

Julia for High Performance Scientific Computing

- Experienced practitioners in other languages understand what's different/special about Julia
- Become familiar with typical structure of a Julia package
- Set up efficient workflow for developing in Julia and using the package manager
- Learn to efficiently work with data
- Know what performance pitfalls exist and learn to benchmark and profile code
- Learn to use multithreading and distributed computing
- Understand what different approaches exist for porting code to GPUs

4.4 AI

Upscaling A.I. training

- Learn different strategies to perform distributed training in TensorFlow
- Learn how to use Horovod for distributed training
- Learn to containerise neural network training

A.I. as a Tool for Change

- Get an overview of possible use cases for artificial intelligence
- Understand how AI can effectively be put to use in different sectors and application domains

Graph Neural Networks and Transformer

- Learn to use graph neural networks
- Learn to use transformers

4.5 Applications

Gromacs GPU Performance

- Understand the difference between MPI ranks and OpenMP threads when running GROMACS
- Be able to name the most important parts of the molecular dynamics workflow
- Appreciate some of the internal architecture of mdrun
- Know how to assign the PME workload
- Know how to use several GPUs efficiently.
- Know common pitfalls to avoid

VeloxChem: Quantum chemistry from laptop to HPC

- Learn to perform quantum chemical simulations of ground- and excited-state properties of large systems using VeloxChem.
- Leverage the aggregate resources of modern HPC clusters to efficiently tackle large molecular systems.
- Use the Python application programming interface (API) to prototype new methods.
- Design interactive computational teaching materials in Python.

OpenFOAM

- Learn how to use OpenFOAM

4.6 Other

CMake

- Write a CMake build system for C, C++, and Fortran projects producing libraries and/or executables.
- Run tests for your code with CTest.
- Ensure your build system will work on different platforms.
- Detect and use external dependencies in your project.
- Safely and effectively build mixed-language projects (Python+C/C++, Python+Fortran, Fortran+C/C++)

Containers

- Learn to use Docker
- Learn to use Singularity

Introduction to Quantum Computing and hybrid HPC-QC systems

- Learn key concepts: quantum states, qubits, quantum algorithms
- Get an overview of QC programming in high-level languages for use cases in optimisation, finance and quantum chemistry
- Get an overview of the main QC hardware approaches
- Understand how QC can be integrated with classical computing through hybrid classical/quantum algorithms and HPC-QC systems.
- Learn to perform quantum software testing with the Quito tool

Discussion

- Are there any lessons in the list above that you would like to use in your own teaching?
- (After the instructor gives an overview of one of the lessons) What do you think about this lesson format? How does it compare to training material that you use?

4.7 Recommended external resources

The lessons above do not cover all relevant topics in HPC, HPDA and AI, but ENCCS also maintains a list of recommended public training material which you can find at https://enccs.se/external-training-resources/.

Contribute to the list of external training resources

For after this workshop:
If you know of other good public training material, or if you have developed own material that you would like to share with the world, please get in touch or open an issue on this repository!

Instructor note

- 20 min teaching
- 25 min exercises

CHAPTER

FIVE

ACQUISITION OF SKILL

Questions

- How do people learn?
- Does subject expertise make someone a great teacher?

Objectives

- Get an overview of cognitive development and how learners build mental models.
- Compare and contrast three stages of skill acquisition.
- Create a concept map to explore a simple mental model.

5.1 Know your learners

The first task in teaching is to figure out who your learners are. According to the Dreyfus model of skill acquisition learners acquire skills and advance through distinct stages through practice and formal instruction. In simplified form, the three stages of this model are:

5.1.1 Novices, competent practitioners and experts

- *Novice*: someone who doesn't know what they don't know, i.e., they don't yet know what the key ideas in the domain are or how they relate. One sign that someone is a novice is that their questions are "not even wrong".
- *Competent practitioner*: someone who has enough understanding for everyday purposes. They won't know all the details of how something works and their understanding may not be entirely accurate, but it is sufficient for completing normal tasks with normal effort under normal circumstances.
- *Expert*: someone who can easily handle situations that are out of the ordinary.

Participants in ENCCS workshops are usually *competent practitioners*. They already write code and know what additional tools or techniques they need to learn to accomplish their goals.

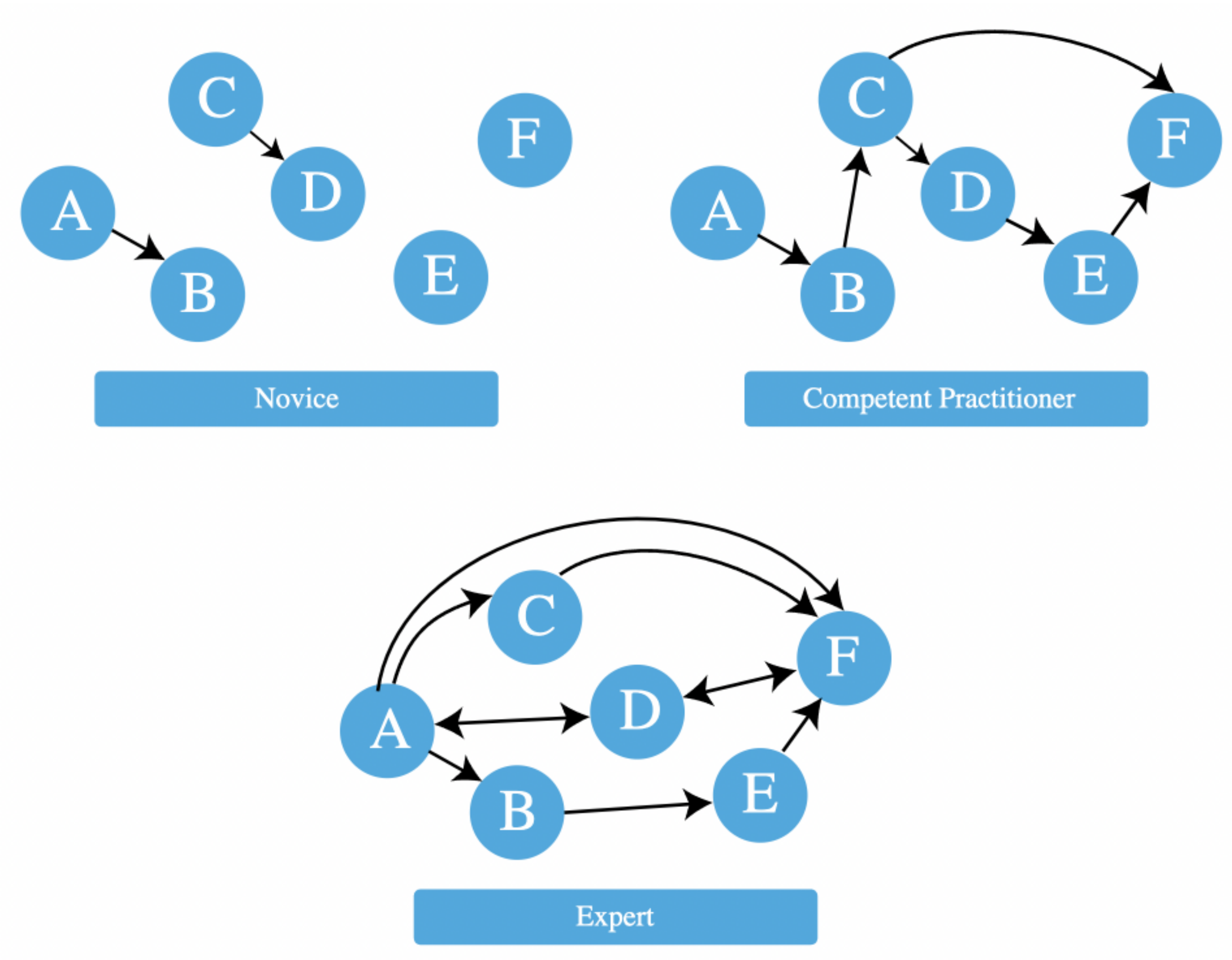
As will be further discussed in the episode on *Lesson design*, it is important to clearly define the target audience of workshops, including their background knowledge and training needs.

5.2 Cognitive development and mental models

Effective learning is facilitated by the creation of a well-founded *mental model*. **A mental model may be represented as a collection of concepts and facts, connected by relationships.** The mental model of an expert in any given subject will be far larger and more complex than that of a novice, including both more concepts and more detailed and numerous relationships. However, both may be perfectly useful in certain contexts.

Example mental model

A long-time European resident may have an advanced understanding of the location of European countries, major cities and landmarks, weather patterns, regional economies and demographic patterns, as well as the relationships among these, compared with their understanding of these relationships for other countries. In other words, their mental model of Europe is more complex compared with their mental model of other countries.



We can distinguish between a *novice* and a *competent practitioner* for a given domain based on the complexity of their mental models.

- **A *novice*** has a minimal mental model of surface features of the domain. Inaccuracies based on limited prior knowledge may interfere with adding new information. Predictions are likely to borrow heavily from mental models of other domains which seem superficially similar.
- **A *competent*** practitioner has a mental model that is useful for everyday purposes. Most new information they are likely to encounter will fit well with their existing model. Even though many potential elements of their mental model may still be missing or wrong, predictions about their area of work are usually accurate.
- **An *expert*** has a densely populated and connected mental model that is especially good for problem solving. They quickly connect concepts that others may not see as being related. They may have difficulty explaining how they are thinking in ways that do not rely on other features unique to their own mental model.

5.2.1 Concept maps

Most people do not naturally visualize a mental model as a diagram of concepts and relationships. Mental models are complicated! Yet, visual representation of concepts and relationships can be a useful way to explore and understand hidden features of a mental model.

A useful tool for exploring any network of concepts and relationships is a **concept map**. A concept map asks you to identify which concepts are most relevant to a topic at hand and to identify how they are connected.

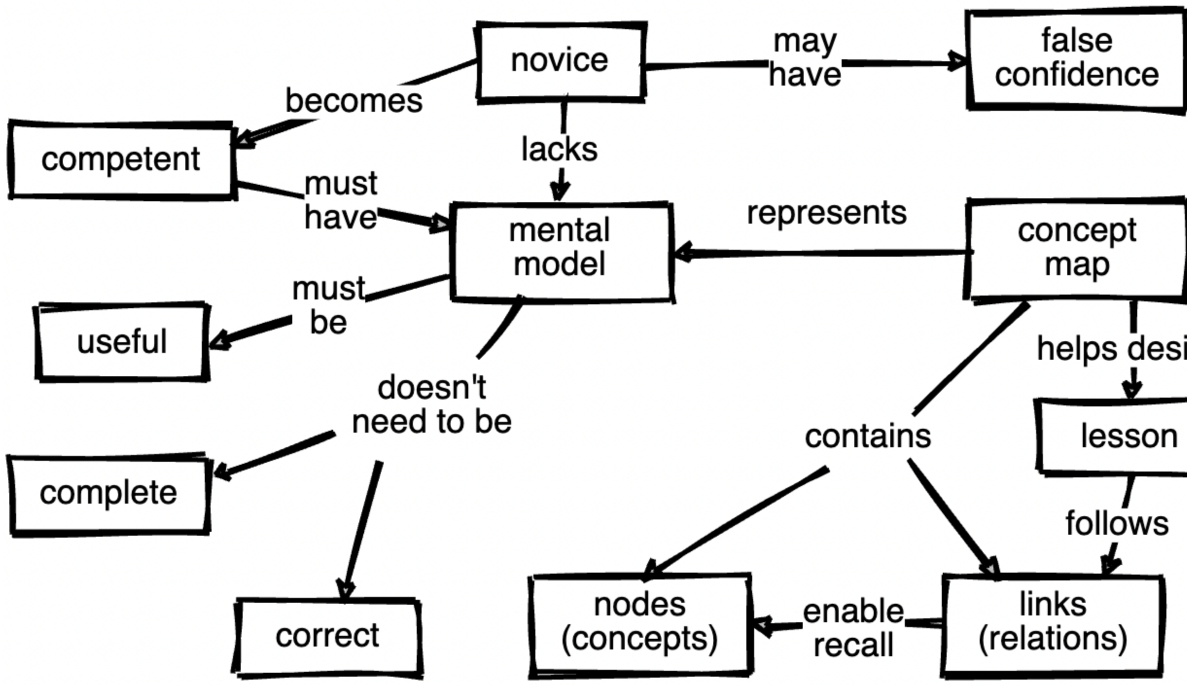


Fig. 1: Adapted from Teaching Tech Together, licensed under CC-BY-NC-4.0

Mapping a mental model (20 min)

On a piece of paper, draw a simplified concept map of a topic that you are already teaching or that you want to teach in the future.

- What are 3-4 core concepts involved?
- How are those concepts related?
- If you would like to try out an online tool for this exercise, visit https://excalidraw.com

5.2.2 Integrating new knowledge

According to the constructivism theory in education, learners do not acquire knowledge and understanding by passively perceiving it but rather by constructing new understanding and knowledge through experience and social discourse, **integrating new information with what they already know**.

We can understand this as adding new nodes and their connections to existing nodes to their mental models. We should thus try to connect new concepts with existing knowledge that we can assume the learners to have.

5.2.3 Meaning

Memory retention is also improved when learners are required to **attach meaning to new information and reflect on why it is important**. Instructors can assign tasks which require explanation (e.g. why something happened) to promote learners to meaningfully organise new information.

5.2.4 The power of analogies

Good analogies can be extraordinarily useful when teaching, because they draw upon an existing mental model to fill in another, speeding learning and making a memorable connection. However, all analogies have limitations! If you choose to use an analogy, be sure its usefulness outweighs its potential to generate misconceptions that may interfere with learning.

5.2.5 How "knowledge" gets in the way

Mental models are hardly ever built from scratch. Every learner comes to a topic with some amount of information, ideas and opinions about the topic. This is true even in the case where a learner can't articulate their prior knowledge and beliefs.

In many cases, this prior knowledge is incomplete or inaccurate. Inaccurate beliefs ("misconceptions") can impede learning by making it more difficult for learners to incorporate new, correct information into their mental models. Correcting learners' misconceptions is at least as important as presenting them with correct information. Broadly speaking, misconceptions fall into three categories:

- **Simple factual errors**. These are the easiest to correct.
- **Broken models**. We can address these by having learners reason through examples to see contradictions.
- **Fundamental beliefs**. These beliefs are deeply connected to the learner's social identity and are the hardest to change.

Describe a misconception (5 min)

Describe a misconception you have encountered as a teacher or as a learner.

5.3 Expertise and teaching

Expertise is more than just knowing more facts - an expert's mental models are also much more densely connected as we saw above. Having a greater connectivity of a mental model allows experts to:

- See connections between two topics or ideas that no one else can see.
- See a single problem in several different ways.
- Know intuitively how to solve a problem, or "what questions to ask".
- Jump directly from a problem to its solution because there is a direct link between the two in their mind. Where a competent practitioner would have to reason "A therefore B therefore C therefore … therefore F", the expert can go from A to F in a single step ("A therefore F").

However, experts are often so familiar with their subject that they can no longer imagine what it's like to not see the world that way. They can thus be less able to teach the subject than people with less expertise who still remember learning it themselves. This phenomenon is known as the "expert blind spot" or the "expert awareness gap".

The good news is that this impediment can be overcome by training! Experts can be highly effective as long as they **learn to identify and correct for their own expert awareness gaps**.

Keypoints

- People at different skill level have different connectivities of their mental models.
- Teachers can help learners integrate new knowledge by connecting it to previous knowledge, by attaching meaning to the new information, and by powerful analogies.
- Experts can face challenges when teaching novices due to expert awareness gaps.

Instructor note

- 20 min teaching
- 20 min exercises
- 45 min practice (optional)

CHAPTER

SIX

LESSON DESIGN

Questions

- How can we design lessons to work with, rather than against, memory constraints?

Objectives

- Understand the principles behind backwards lesson design.
- Remember a few tricks for facilitating memory retention.

6.1 Backwards lesson design

When writing an ENCCS lesson, we take a "reverse" approach to instruction, as described in Wiggins and McTighe's Understanding by Design, that keeps the focus firmly on learning outcomes. The order of preparation in this case becomes

- Determine your learning objectives
- Decide what constitutes evidence that objectives have been met, and design assessments to target that evidence
- Design instruction: Sort assessments in order of increasing complexity, and write content that connects everything together

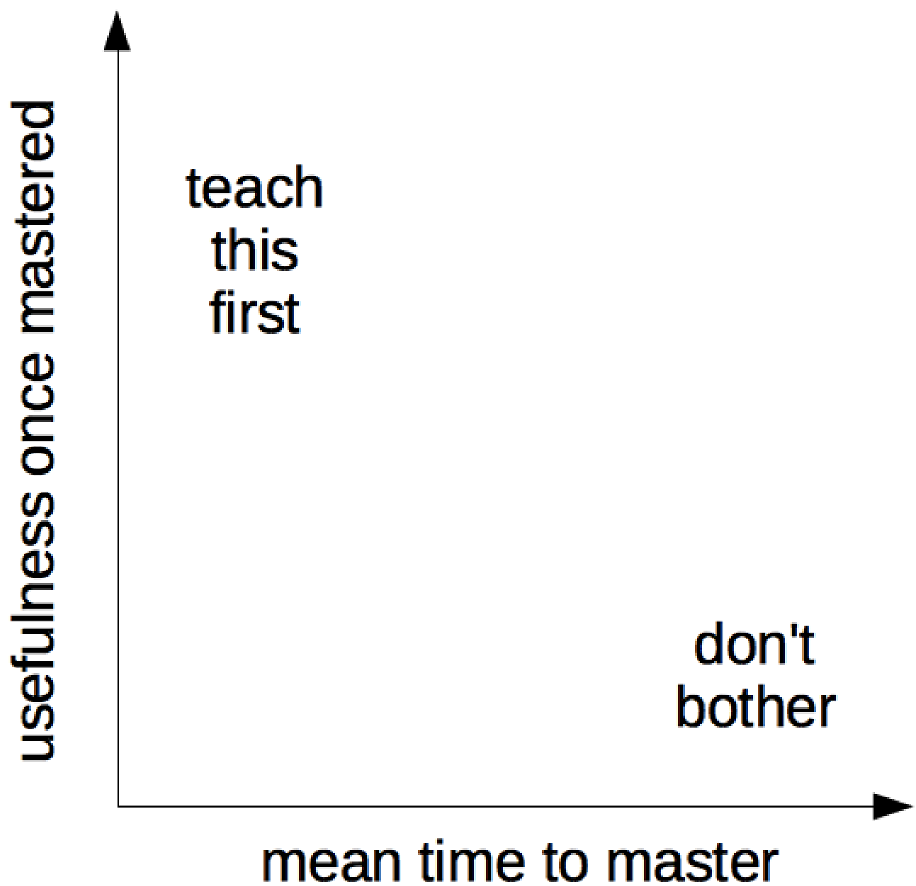
6.1.1 Deciding what to teach

6.1.2 Working with learning objectives

ENCCS lessons usually have a *learning objectives* section. Good learning objectives are quite specific about the intended effect of a lesson on its learners. We aim to create learning objectives that are specific, accurate, and informative for both learners and instructors.

In practice, it's best to start defining your target audience by answering to questions such as:

- **What is the expected educational or skill level of my audience?**
- **Have they been already exposed to the technologies I am planning to teach?**
- **What tools do they already use?**
- **What are the main issues they are currently experiencing?**


usefulness once mastered
teach this first
don't bother
mean time to master

Once you clarified your target audience, it is useful to create **learner personas**. This will help you during the development process by providing concrete examples of potential learners showing up at your workshops.

- For each **learner persona**, try to think of what is **useful to them**.
- What do they **need** to remember/understand/apply/analyze/evaluate/create (see Bloom's taxonomy below).
- Then, you create a sequence of exercises which test incrementally progressing tasks and acquisition of the new skills.
- Finally, you write material to teach the gap between exercises.

6.1.3 Using Bloom's Taxonomy to write effective learning objectives

Bloom's Taxonomy is a framework for thinking about learning that breaks progress down into discrete, hierarchical steps. While many ideas have come and gone in education, Bloom's has remained a useful tool for educators, in particular because the hierarchy seems to be reasonably valid: outcomes at the top of the hierarchy cannot be achieved without mastery of outcomes at the bottom.

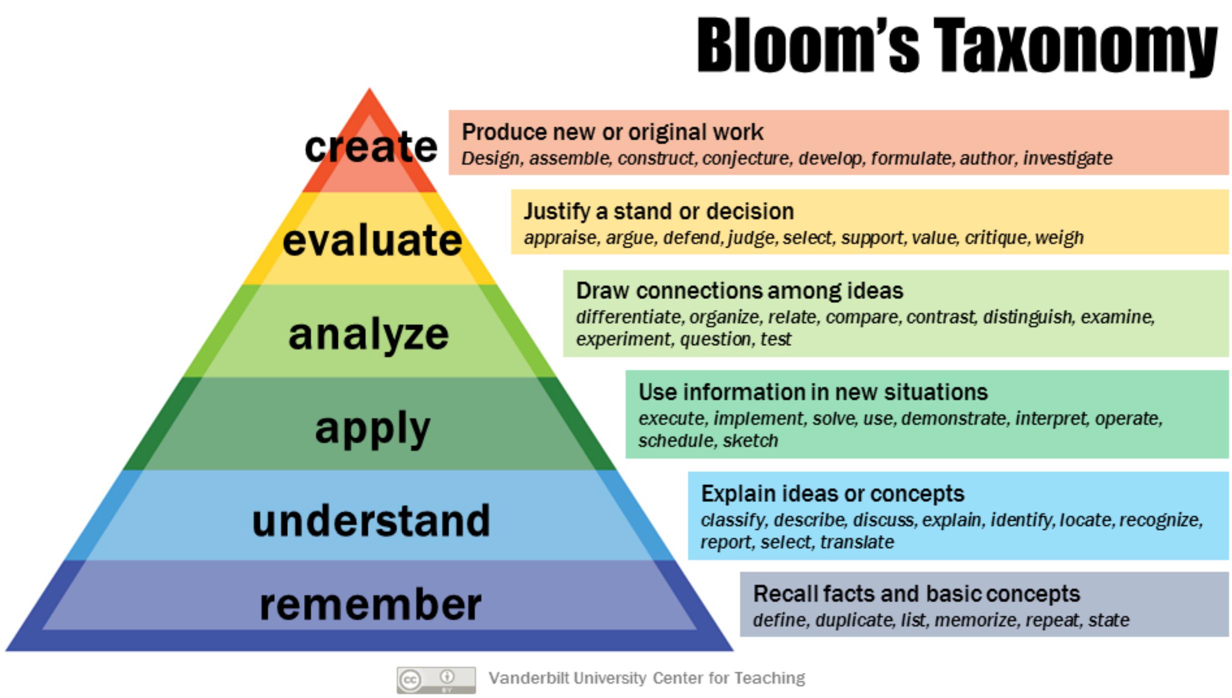


Fig. 1: Image credit: Vanderbilt University Center for Teaching

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How do you design? (10 min)

Discuss either in groups or via collaborative document:

- How do you start when you design a new lesson/presentation?
- Has your approach changed over the years? If yes, how?

6.2 Memory management

Learning involves memory. For our purposes, human memory can be divided into two different layers, **long-term** and **short-term**. Long-term memory, which we use to store persistent information, is essentially unbounded but is slow to access. Short-term memory (also called working memory), which we use to actively think about things is much faster but also much smaller. It has been estimated that the average adult's short-term memory can hold 7±2 items for a few seconds before things started to drop out.

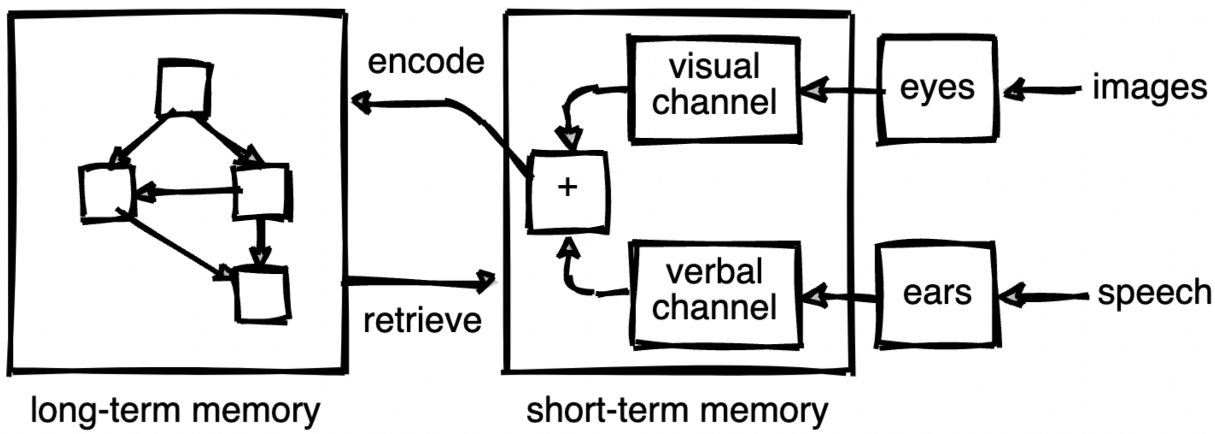


Fig. 2: Figure adapted from Teaching Tech Together, licensed under CC-BY-NC-4.0

If we present our learners with large amounts of information, without giving them the opportunity to practice using it (and thereby transfer it into long-term memory), they will not retain the material as well as if we present small amounts of information interspersed with practice opportunities.

When designing lessons we can try to maximise memory retention through a number of strategies:

- **Chunking**: Our minds can store larger numbers of facts in short-term memory by creating chunks, or relationships among separate items, allowing them to be remembered as a single item. Connecting information makes it easier to remember.
- **Formative assessment to support memory consolidation**: Formative assessment helps learners solidify their understanding and begin transferring ideas into long-term memory. Limitations of short-term memory are one reason why assessments should be frequent: short-term memory is limited not only in space, but also in time.
- **Group work**: Elaboration (explaining your work) supports transfer to long-term memory. This is one reason why teaching is one of the most effective ways to learn! Group work can feel uncomfortable at first and consumes time in a workshop, but learners often rate group work as a high point for both enjoyment and learning in a workshop.
- **Opportunities for reflection**: Reflection is another tool that can help learners review things they have learned, strengthen connections between them, and consolidate long-term memories. Asking learners for feedback can be an effective consolidating prompt as providing feedback demands some reflection on what has been learned.
- **Limit concepts**: It is important to limit the number of concepts introduced in a lesson, but this can be hard! Planning your lesson with a concept map can help you not only identify key concepts and relationships, but also to notice when you are trying to teach too many things at once.

Formative and summative assessment

Formative assessment takes place during teaching and learning. It sounds like a fancy term, but it can be used to describe any interaction or activity that provides **feedback to both instructors and learners about learners' level of**

understanding of the material. For learners, this feedback can help focus their study efforts. For instructors, it allows them to refocus their instruction to respond to challenges that learners are facing. Used continuously.

Summative assessment is used to judge whether a learner has reached an acceptable level of competence. Usually at the end of a course Learners either "pass" or "fail" a summative assessment.

6.3 Designing formative assessment

Well designed formative assessment tasks - i.e. quick questions and exercises - can go a long way towards correcting misconceptions and expanding the mental models of learners.

Here are some suggestions to keep in mind when designing exercises:

- Not every exercise has to be an amazing hand-on example. Mixing with smaller, more conceptual things can reduce cognitive load.
- Try to make your exercises relevant, meaningful and connected to previous knowledge. Connect the exercises to the real world. When learners understand the meaning of new concepts it will be easier for them to remember.
- Create also more advanced exercises which can be optional for more advanced learners. This can go a long way to meet the needs of participants with a wide range of background knowledge.

Good exercises are the most important factor in a good lesson. Even if you are preparing the rest of the lesson mostly alone, consider a good long brainstorming session to go from "list of topics to cover" to "sequence of exercises".

When you are stuck thinking "how can I make an exercise that covers X", think of the lists below inspiration. Not every exercise has to be an sophisticated hands-on thing, so don't be afraid to use different types:

Types of exercises:

- Multiple choice (easy to get feedback via a classroom tool - try to design each wrong answer so that it identifies a specific misconception).
- Code yourself (traditional programming)
- Code yourself + multiple choice to see what the answer is (allows you to get feedback)
- Minimal fix (given broken code, make it work)
- Parsons problems (working solution but lines in random order, learner must only put in proper order)
- Fill in the blank, faded problems
- Tracing execution
- Tracing values through code flow
- Reverse execution (find input that gives an output)
- Theme and variations (working code, adapt to other type of situation/problem)
- Refactoring
- Draw a diagram
- Label diagram
- Matching problem: two sets of Q/A, match them.

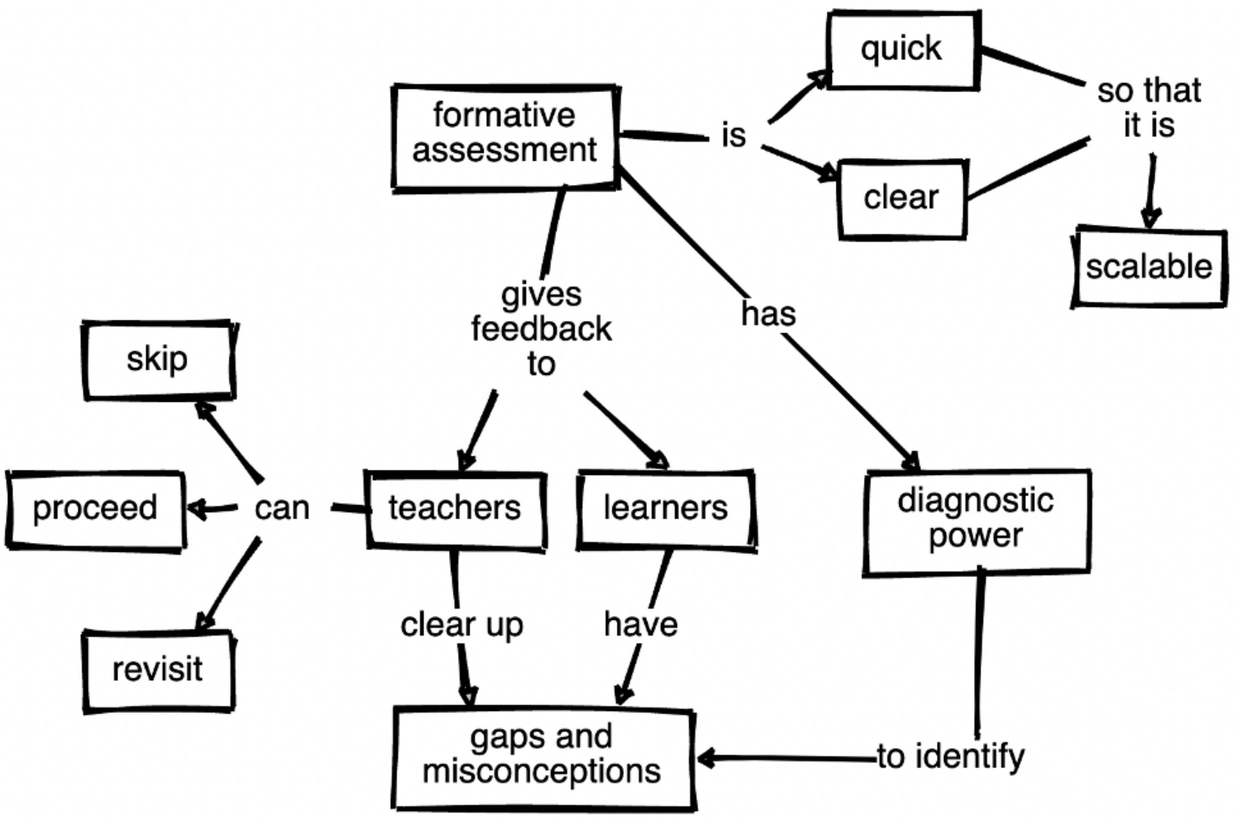


Fig. 3: Adapted from Teaching Tech Together, licensed under CC-BY-NC-4.0

Using formative assessment to identify misconceptions

Formative assessment can be used to tease out misconceptions using for example multiple choice questions (MCQ). When designed carefully, MCQs can target anticipated misconceptions with surgical precision.

For example, suppose we are teaching children multi-digit addition. A well-designed MCQ could be:

Q: what is 27 + 15 ?

- a) 42
- b) 32
- c) 312
- d) 33

What misconceptions do the wrong answers reveal?

Solution

- If the child answers 32, they are throwing away the carry completely.
- If they answer 312, they know that they cannot just discard the carried '1', but do not understand that it is actually a ten and needs to be added into the next column. In other words, they are treating each column of numbers as unconnected to its neighbors.
- If they answer 33 then they know they have to carry the 1, but are carrying it back into the same column it came from.

Design formative assessment to identify misconceptions (10 min)

Individually or in groups, choose a topic that you have taught in the past or that you want to teach later.

- What relevant misconceptions might a novice learner bring to the classroom?
- Create your question. How many choices can you think of that will diagnose a specific misconception?

Type your question into the shared document and explain the diagnostic power of each choice. Discuss the question in the classroom.

Design a faded example (10 min)

This exercises assumes that you are teaching a technical topic like programming or similar.

- Try to design a faded example, i.e. an example code where learners should fill in the blanks.
- Think of the level of your learners. How much would you fade out for a novice? How about a competent practitioner?
- How did you decide what to fade out?
- Present your example in a small group and let others in your team guess which level you intended the example for!

When designing exercises, consider that some participants will get stuck and may want to re-join at a later exercise. In other words it is nice if exercises build up on each other but not at the cost that if participants get stuck at exercise 2, they will not be able to do exercises 3 to N.

6.4 Practice backwards design

Discuss the backwards-design of a lesson

Let's take as an example the *HPC Carpentry lesson*

Target audience

- What is the expected educational level of my audience?
  - A PhD student, postdoc or young researcher.
- Have they been already exposed to the technologies I am planning to teach?
  - The word **HPC** is not new to them and they may have already used an HPC but are still not capable of giving a proper definition of HPC. In addition, we do not expect them to know much about parallelism and they cannot make any distinction between various available parallelism paradigms.
- What tools do they already use?
  - serial codes, multi-threaded codes, data parallelism; usually out-of-the-box tools.
  - they may have tried to "scale" their code (multiprocessing, threading, GPUs) with more or less success.
- What are the main issues they are currently experiencing?
  - they cannot solve their problems either because they would like to run the same code but with many different datasets or because their problem is larger (more computations/memory).
  - most of the time they know their codes can run on HPC (from the documentation) but never really had the opportunity to try it out.
  - Very few will have their own codes where they may have tried different things to speed it up (threading, task parallelism) but have no clear strategy.

Learner persona

- Sonya is a 1st year PhD student: she recently moved to Oslo and joined the Computational and Systems Neuroscience group. She will be using the NEST, a simulator for spiking neural network model. She used NEST during her master thesis but on her small cluster: **she never used an HPC resource** and is really excited about it.
- Robert is a field ecologist who obtained his PhD 6 months ago. He is now working on a new project with Climate scientists and as a consequence will need to run global climate models. He is **not very familiar with command line** even though he attended a Software Carpentry workshop and the idea to use HPC is a bit terrifying. He knows that he will get support from his team who has extensive experience with HPC but would like to become more independent and be able to **run his own simulations** (rather than copying existing cases).
- Jessica is a postdoc working on a project that investigates numerically the complex dynamics arising at the tip of a fluid-driven rupture. Fluid dynamics will be computed by a finite element method solving the compressible Navier-Stokes equations on a moving mesh. She **uses a code she has developed** during her PhD and that is based on existing libraries. She has mostly ran it on a local desktop; her work during her PhD was very limited due to the lack of computing resources and she is now very keen is **moving to HPC**; she knows that it will requires some work, in particular to parallelize her code. This HPC training will be her first experience with HPC.

Learning outcomes

- Understand the difference between HPCs and other local/remote machines

- Understand the notion of core, nodes, cluster, shared/distributed memory, etc.
- Understand the notion of login nodes.
- Understand the need for a scheduler and how to use it appropriately
- Understand why optimising I/O is important on HPC and how to best use HPC filesystems
- Understand the need to parallelize (or use existing parallel) codes and in which cases HPCs is a must (when communications is required)
- Understand how to get your code ready to use on HPC (access to libraries, installation of your own libraries/software, etc.)
- Understand that an HPC is an operational machine and is not meant for developing codes.

Exercises

- Get basic information such the number of CPUs, memory from your laptop and try to do the same on a HPC. Discuss outcomes.
- Try to create files on the different filesystems on your HPC resource and access them.
- Create different types of job scripts, submit and check outputs.
- Make a concrete example to run a specific software on your HPC (something like GROMACS).

Backwards-design a lesson (45 min)

Choose a simple lesson topic and apply backwards lesson design. You won't get all the way through, but come up with a logical progression of exercises.

The section you pick should require **screen sharing** and be of some **follow-along task** (preferably using a shell).

Some suggestions:

- Regular expressions
- Making papers in LaTeX
- Making figures in your favorite programming language
- Linux shell basics
- Something non-technical, such as painting a room
- Some aspect from an already existing lesson
- An ENCCS lesson (or an episode therein)
- Unix shell in a HPC context (or an episode therein)
- A lesson you always wanted to teach

Exercise (30 minutes):

- Collect notes in a shared document.
- Start with learner personas and learning outcomes.
- Come up with a logical progression of exercises.

Discussion (15 minutes):

- How does this approach compare to other lessons or courses you have designed?
- We read, compare, and discuss our notes.

6.5 See also

- CodeRefinery lesson-design manual
- The Carpentries Curriculum Development Handbook
- Teaching Tech Together
- A short summary of "Teaching Tech Together"
- Ten quick tips for creating an effective lesson

Keypoints

- Having a semi-rigid lesson design process can **save time** to start drafting and will probably **increase quality and relevance** of the lessons

Instructor note

- 20 min teaching
- 30 min exercises

CHAPTER

SEVEN

GOOD INTERACTIVE TEACHING PRACTICES

Questions

- What is cognitive load and how does it affect learning?
- Why is motivation important?

Objectives

- Distinguish desirable from undesirable cognitive load.

7.1 Cognitive load

Memory is not the only cognitive resource that is limited. Attention is constrained as well, which can limit the information that enters short term memory in the first place as well as interfere with consolidating into long-term memory. While many people believe that they can "multi-task", the reality is that attention can only focus on one thing at a time. Adding items that demand attention adds more things to alternate between, which can reduce efficiency and performance on all of them.

There are different theories of cognitive load. In one of these, Sweller posits that people have to attend to three types of things when they are learning:

- Things they have to think about in order to **perform a task** ("intrinsic").
- Mental effort required to **connect the task** to new and old information ("germane").
- **Distractions** and other mental effort not directly related to performing or learning from the task ("extraneous").

Cognitive load is not always a bad thing! There is plenty of evidence that some difficulty is desirable and can increase learning. However, there are limits. Managing all forms of cognitive load, with particular attention to extraneous load, can help prevent **cognitive overload** from impeding learning altogether.

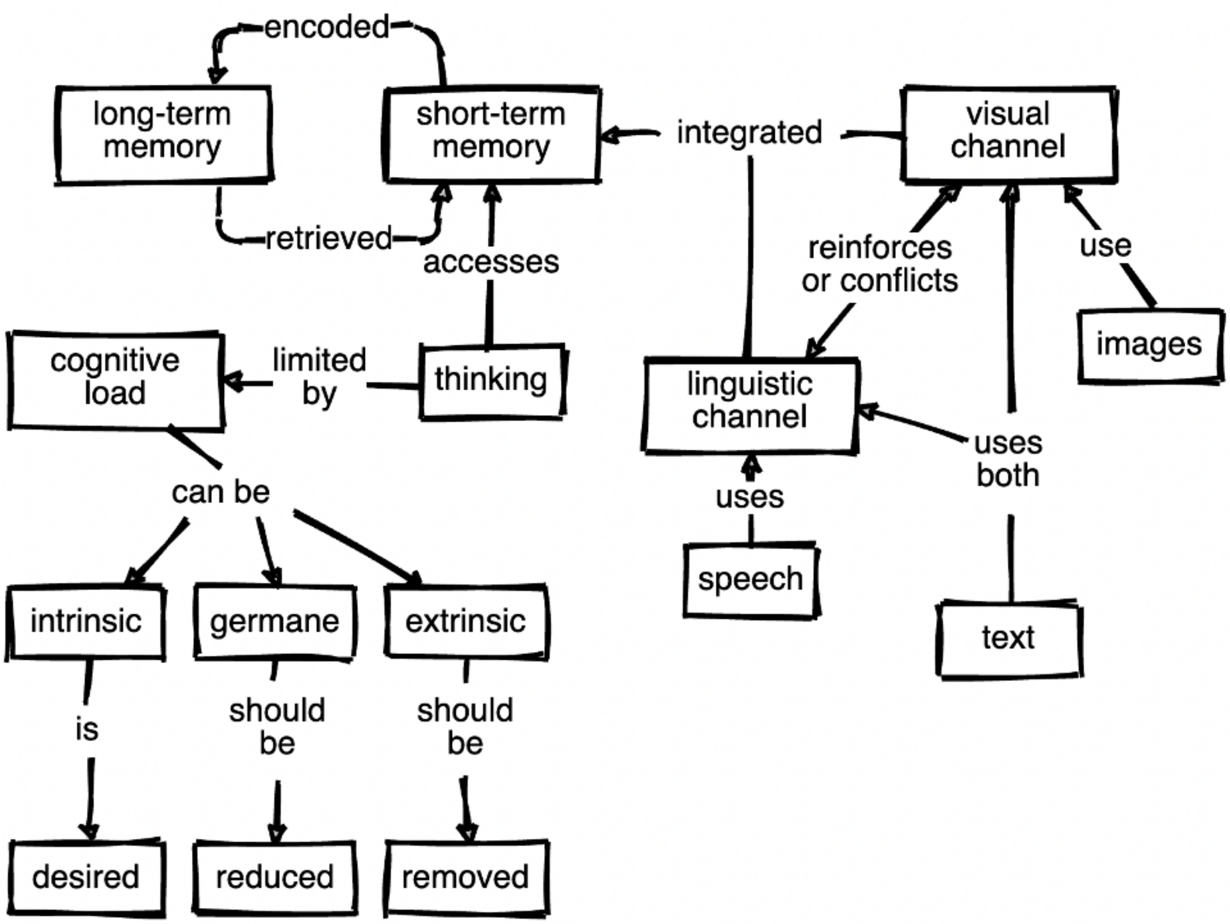


Fig. 1: Adapted from Teaching Tech Together, licensed under CC-BY-NC-4.0

7.2 Live demos and type-along sessions

One way to manage cognitive load as tasks become more complex is by using guided practice: creating a structure that narrowly guides focus on specific skills and knowledge in a stepped fashion, with feedback at each step before transferring attention to a new feature.

Worked examples, i.e. step-by-step demonstrations of how to perform particular tasks,
can reduce cognitive load as they provide the scaffolding needed for learners to transfer knowledge from working memory to long-term memory. Type-along sessions are particularly useful as learners get to develop their "muscle memory" while the instructor slowly walks through and explains each step. Splitting the task into well defined steps also helps learners see the underlying structure of a problem and how it can be transferred to other types of problems.

Exercises which learners should solve by themselves can build on the type-along sessions but with some of the scaffolding removed so that they need to complete some problem steps (faded examples).

7.2.1 Stick to the script

Learning can be enhanced by combining multiple information sources, for example by showing a piece of code (or a graphic or list of bullet points) while explaining it aloud. But make sure to stick to the script! Conflicting information splits the attention and leads to unnecessary cognitive load.

7.2.2 Copy-pasting vs manual typing

Manually typing out code into a programming environment takes significantly longer time than copy-pasting it from lesson material, but learners usually strongly prefer it. Typing out every single code covered in a workshop might be too much, but instructors should try to manually write out as much as is reasonable to do.

7.2.3 Good software practices

We shouldn't assume that all learners are aware of best software development practices. It is therefore a good idea to adhere to good practices in demos and type-along sessions (e.g. by following style conventions or using version control and testing in code examples), so that participants become acquainted with them as a side benefit of attending a workshop.

7.3 The importance of going slow

It takes work to actively assess mental models throughout a workshop; this also takes time. This can make Instructors feel conflicted about using formative assessment routinely. However, the need to conduct routine assessment is not the only reason why a workshop should proceed more slowly than you think.

7.3.1 Expert awareness gap

Because your learners' mental models will likely be less densely connected than your own, a conclusion that seems obvious to you will not seem that way to your learners. It is important to explain what you are doing step-by-step, and how each step leads to the next one.

Note that the expert awareness gap is also referred to as "expert blind spot".

7.3.2 Taking advantage of errors

Experts can quickly diagnose errors which may seem cryptic to novices or competent practitioners. If faced with an error message while teaching, an expert will often automatically diagnose and solve a problem before a novice has even finished reading the error message. Because of this, it is very important while teaching to be explicit about the process you are using to engage with errors, even if they seem trivial to you, as they often will.

When faced with an error message, take the time to explain what happened and how the error message can be understood. This will not only teach learners to understand and read stack traces, but also give them confidence from seeing that even an expert makes mistakes!

7.3.3 Meta-talk

Don't just teach, also make sure you guide the learners through the course.

- You know what you just discussed, and what is coming next, but learners are often stuck thinking about what is happening right now.
- Give a lot of "meta-talk" that is not just about the topic you are teaching, but how you are teaching it.
- Examples
  - **Why** you are doing each episode
  - What is the purpose of each exercise
  - Clearly state what someone should accomplish in each exercise and how long it will take - don't assume this is obvious.
  - What is the point of each lesson. How much should people expect to get from it? Should you follow everything, or are some things advanced and optional? Make that clear.

What are the top issues new instructors face? (10 minutes)

Brainstorm about what issues new teachers/instructors might face in interactive workshops. Write down your thoughts in the shared document.

Some suggestions

Addressing participant issues:

- Get the speed correct: not too fast and not (far) too slow.
- Don't make exercise sessions too short to "save time". Better to have them as long as possible.
- Don't expect too much of learners during exercises - just reading and understanding the task takes time.
- Cater to participants with different backgrounds and at different levels of experience.

- Learners may not have software prerequisites installed correctly and thus not able to follow along. Instructor mistakes:
- Trying to accomplish too much or go through everything - it's OK to cut out and adapt to the audience.
- Explaining *how*, but not *why*.
- Not using good screen sharing practices (font size, terminal history, portion of screen)
- Assuming learners remember everything you've covered earlier in a workshop.
- Forgetting to take sufficiently many breaks (minimum 10 minutes per hour)

7.4 Keeping learners motivated

People learn best when they care about a topic and believe they can master it with a reasonable investment of time and effort. A distinction is often made between **extrinsic motivation**, which we feel when we do something to avoid punishment or earn a reward, and **intrinsic motivation**, which is what we feel when we find something personally fulfilling.

According to self-determination theory, the three drivers of intrinsic motivation are:

- **Competence**: the feeling that you know what you're doing.
- **Autonomy**: the feeling of being in control of your own destiny.
- **Relatedness**: the feeling of being connected to others.

Well-designed lessons and teaching encourage all three.

Belonging

- It's been estimated that nearly 70% of individuals will experience signs and symptoms of impostor syndrome at least once in their life! Research shows that this phenomenon is not uncommon for students who enter a new academic environment.
- If learners feel that they belong and are accepted in a learning environment they will be more motivated to learn.
- Having, discussing, and enforcing a Code of Conduct provides a framework for positive communication to occur.

Invite Participation

- Encourage learners to learn from each other. Working in pairs or in groups encourages learners to talk through their learning process, reinforcing memory and making it more likely that confusion will be expressed and resolved. This can also address challenges of varying background experience: asking more advanced learners to help beginners can maximize learning for both. In these cases, make sure the beginner is doing the typing!
- Acknowledging when learners are confused. Acknowledging and exploring confusion with kindness rewards learners for sharing vulnerable information. Formative assessments can pinpoint misunderstandings. When learners see that others are confused, they are more likely to share their own uncertainties.

Any questions?

Instructor may accidentally dismiss learner confusion by asking for questions in a way that reveals that they do not actually expect that anyone will have them. Instead of asking "Does anyone have any questions?" and then quickly moving on, consider asking instead "What questions do you have?" and leaving a good pause for consideration. This establishes an expectation that people will, indeed, have questions, and should challenge themselves to formulate them.

Do no harm!

Here are a few things you should not do in your workshop:

- Talk contemptuously or with scorn about any tool or practice, or the people who use them. Regardless of its shortcomings, many of your learners may be using that tool, and may have invested many years in learning to do so.
- Dive into complex or detailed technical discussion with the one or two people in the audience who clearly don't actually need to be there. Reserve those conversations for breaks or follow-up emails.
- Pretend to know more than you do. People will actually trust you more if you are frank about the limitations of your knowledge, and will be more likely to ask questions and seek help.
- Use the J word ("just") or other demotivating words. Experts sometimes want to convey that a task is as easy as they think it is, but these signal to the learner that the instructor thinks their problem is trivial
- Take over the learner's keyboard. It is rarely a good idea to type anything for your learners. Doing so can be demotivating for the learner (as it implies you don't think they can do it themselves or that you don't want to wait for them). It also wastes a valuable opportunity for your learner to develop muscle memory and other skills that are essential for independent work.
- Express surprise at unawareness. Saying things like "I can't believe you don't know X" or "You've never heard of Y?" signals to the learner that they do not have some required pre-knowledge of the material you are teaching, that they don't belong at the workshop, and it may prevent them from asking questions in the future.

Does your motivation matter?

- Learners respond to an instructor's enthusiasm. The more motivated you are, the more motivated they will be!
- Instructors are learning to teach. This also takes motivation. Deliberative practice, seeking feedback, and reflecting on mistakes in the context of your own busy work life is a challenge. What will keep you energised to stay engaged with your learning process?

7.5 Giving feedback for live coding examples

Teaching by live coding is a performance art which requires practice. These exercises aim at learning to give feedback. We will watch videos of (pretend) teaching and give feedback on two axes: positive vs. negative and content vs. presentation. We will use a rubric (used during The Carpentries teaching demos) to help take notes.

Each person in the class adds one point to a 2x2 grid on a whiteboard or in the shared notes without duplicating any points. For online instructor training event, use breakout room (4-5 persons per group) to facilitate discussion. Then each group reports to the shared notes.

Live coding example 1 (20 min)

This exercise highlights some typical pitfalls that most instructors fall into sooner or later, and also shows how to avoid them. Watch closely since we will be giving feedback!

- Watch these two videos: video 1 and video 2
- What was better in video 1 and what was better in video 2?
- Please give feedback in the shared workshop document in the 2x2 rubric.

Template for feedback rubric

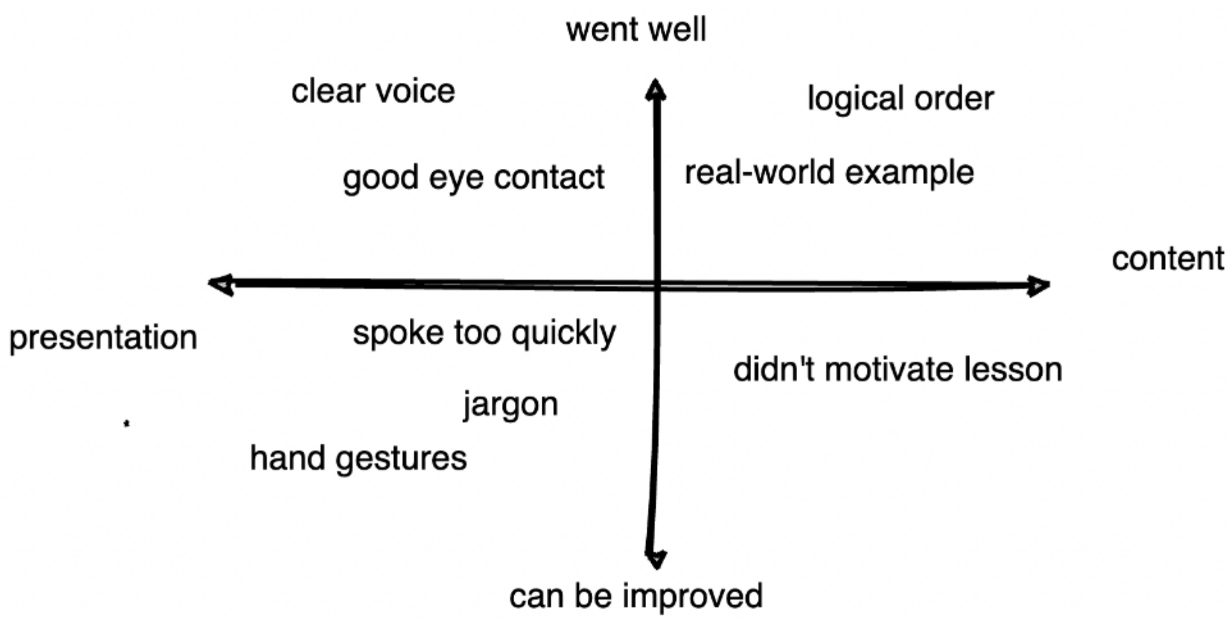


Fig. 2: Adapted from Teaching Tech Together, licensed under CC-BY-NC-4.0

```
Positive Content:
-
-
-

Content Opportunities for Growth:
-
-
-

Positive Delivery:
-
-
-

Delivery Opportunities for Growth
-
-
-
```

(Optional) Live coding example 2

As a group, we will watch this video of teaching. The instructor is making several mistakes, but can you also observe anything positive?

As before, give feedback on two axes: positive vs. negative and content vs. presentation. What did other people see that you missed? What did they think that you strongly agree or disagree with?

Instructor note

- 10 min teaching
- 10 min exercises

CHAPTER

EIGHT

TEACHING MECHANICS

Objectives

- Understand the pros and cons of online teaching compared to in-person
- Discuss practical aspects of teaching

8.1 Online vs in-person workshops

Challenges:

- More difficult for learners to stay focused during for a full day - "Zoom fatigue".
- More confusion and cognitive overload from watching and listening to instructor while typing along or solving exercises.
- Networking and socialisation is much more difficult.
- Group work takes more effort to prepare to encourage interaction between learners
- Learners more often stay quiet.
- Signaling problems or asking questions is more difficult.
- Awkwardness during silences or when multiple people start talking at the same time.
- Lack of non-verbal cues.

Benefits:

- More geographically inclusive.
- No travel costs.
- Possible for learners and teachers to participate in larger number of events.
- More natural format for collaborative teaching.
- Easier to scale up.

Addressing the challenges

- Have you encountered any of the challenges listed above?
- Do you have any ideas for how to solve them or reduce their effects?

Write down your suggestions in the shared workshop document.

A few ideas

- Only teach half days.
- Avoid cognitive overload by slowing down and including more “meta talk”.
- Use icebreaker questions for general introductions and to encourage active participation.
- Learners introduce themselves in groups using breakout rooms.
- Use shared workshop document for questions and answers and to signal problems.
- Strongly recommend screen sharing and colloboration in breakout room exercises.

But **what do learners actually think of online workshops compared to in-person workshops**? Here’s how learners in ENCCS workshops replied to a post-workshop survey question about the online format:

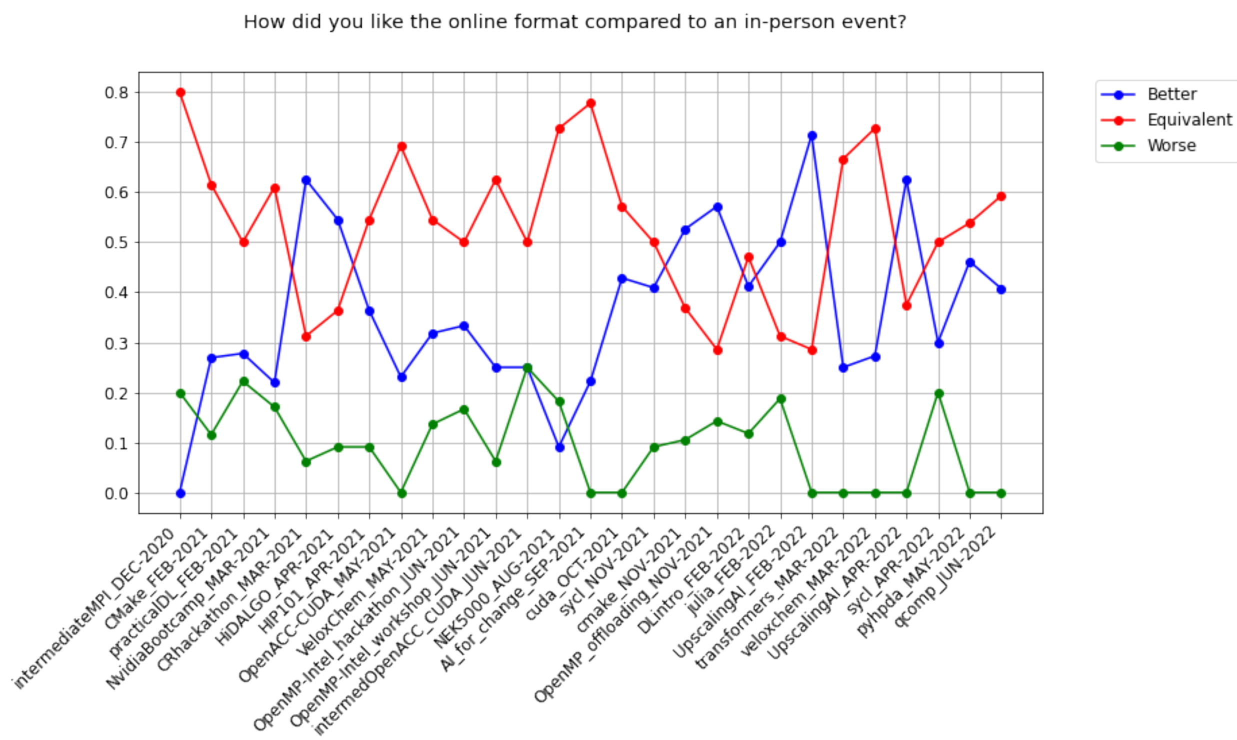


Fig. 1: ENCCS post-workshop survey results.

However, the survey question is simple and the answers do not reveal any details about the pros and cons of online workshops perceived by the workshop participants.

8.2 Tooling

The mechanics of online (or in-person) teaching is all about the tools and visual aspects of teaching. It is important to plan and prepare these technical aspects before a workshop.

- The learner has a *lot* more to think about than the instructor, so you need to minimize the possible distractions and unnecessary weirdness.
- A learner will often use only one small screen, limiting the number of things that they can focus on.
- You are much faster than learners. You have to do things to slow yourself down.

8.2.1 Shell sharing

When doing any demonstration, there are difficulties:

- If one misses something, you can't rewind to see it - is there any way to catch up?
- The learner must get oriented with the whole picture, while instructor knows precisely where to focus.

A good **shell share** has some of the following properties:

- Large font
- Shell history, available separately from the main shell window
- Closely matches the type-along instructions

A collection of good practices for screen sharing your shell environment can be found here.

Simple examples:

Bash

Set up simple prompt:

```
$ export PS1='\n\w\$ '
```

Define a command to be executed before new prompt:

```
$ PROMPT_COMMAND="history -a"
```

In new terminal, print updates to history file:

```
$ tail -f -n0 ~/.bash_history
```

Zsh

Set up simple prompt:

```
$ export PROMPT='%~ $ '
```

Define command to be executed just after a command has been read and is about to be executed:

```
$ preexec() { echo $1 >> ~/demos.out }
```

In new terminal, print updates to demos.out file:

```
$ tail -f ~/demos.out
```

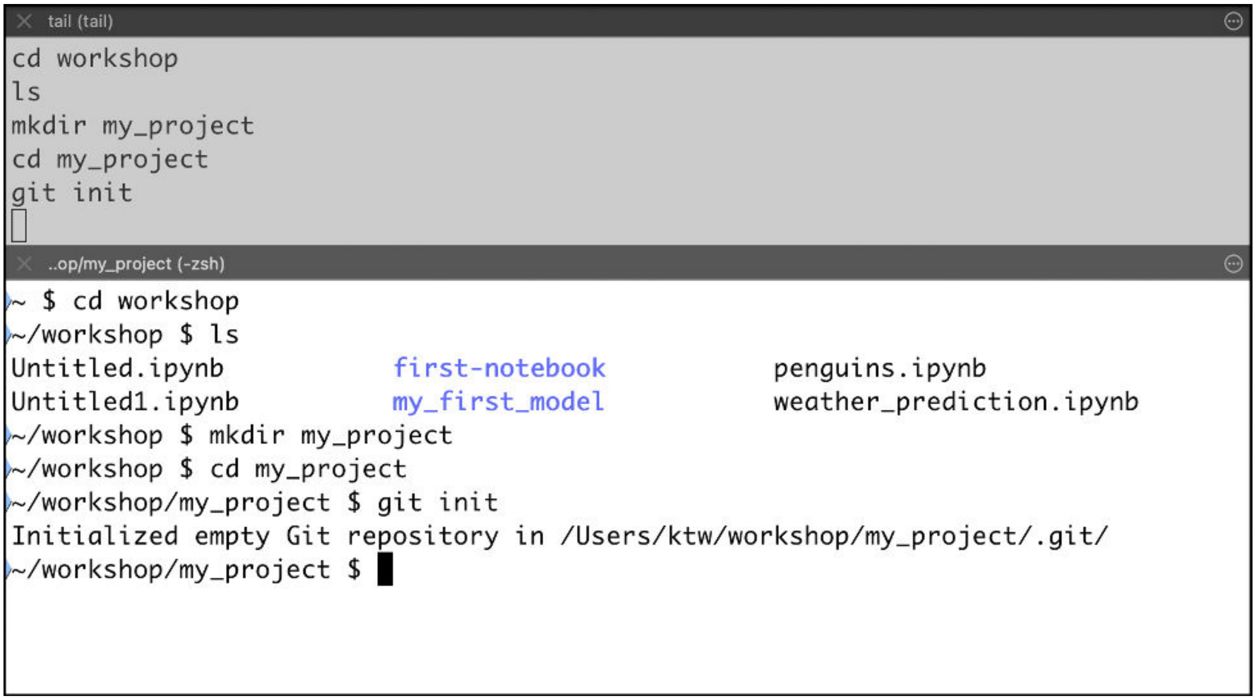


Fig. 2: One way to set up your shell with light background, large font, simple prompt and shell history.

8.2.2 Screen sharing

- Many learners will have a smaller screen than you.
- You should plan for learners with only one small screen.
- A learner will **need to focus on both your screen share and their work**.
- Sharing your a whole screen is probably a bad idea if you want the learners to do anything at the same time.
- If you constrict yourself, then your experience is more similar to that of a learner.

Vertical sharing:

- CodeRefinery and ENCCS have recently started trialing a **vertical share** system, where you share a vertical half of your screen.
- This allows learners with one screen to display your screen side-by-side with their own applications.
- Zoom provides a "Share a part of screen" that is good for this.

8.2.3 Shared workshop document

Questions and frequent feedback is very important for interactive workshops, but questions in the main room doesn't scale to large rooms. Also, it's likely that only a few (extrovert) participants will do most of the talking while others will not feel as comfortable speaking up.

A strategy shared by the Carpentries, CodeRefinery and ENCCS is to use a shared workshop document where learners can ask questions on the fly. The document can also be used to collect all relevant information for a workshop, including links to material and technical instructions, as well as for formative assessment questions and to take notes from group work. Out of many possible platforms, ENCCS uses HackMD.

Some features of HackMD and how it compares to other modes of communication:

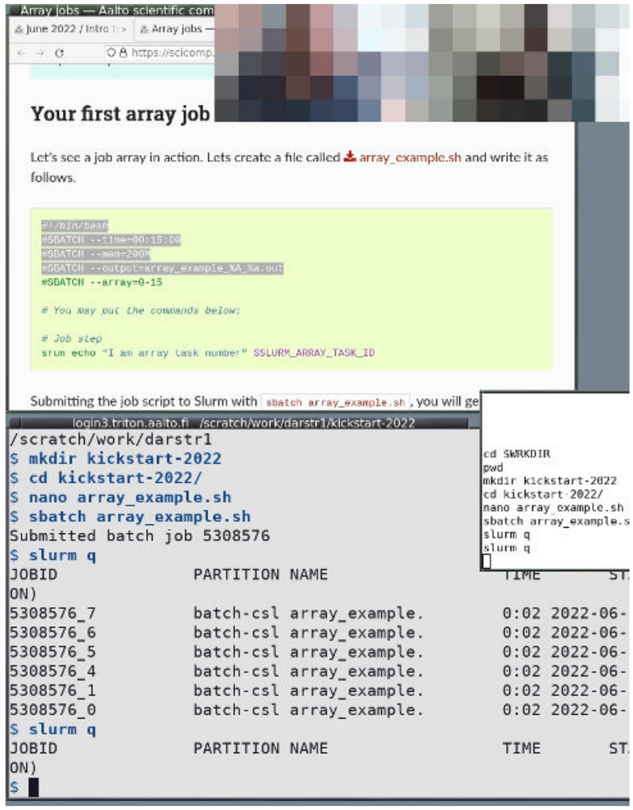


Fig. 3: Example of vertical screen share with lesson material above and terminal below

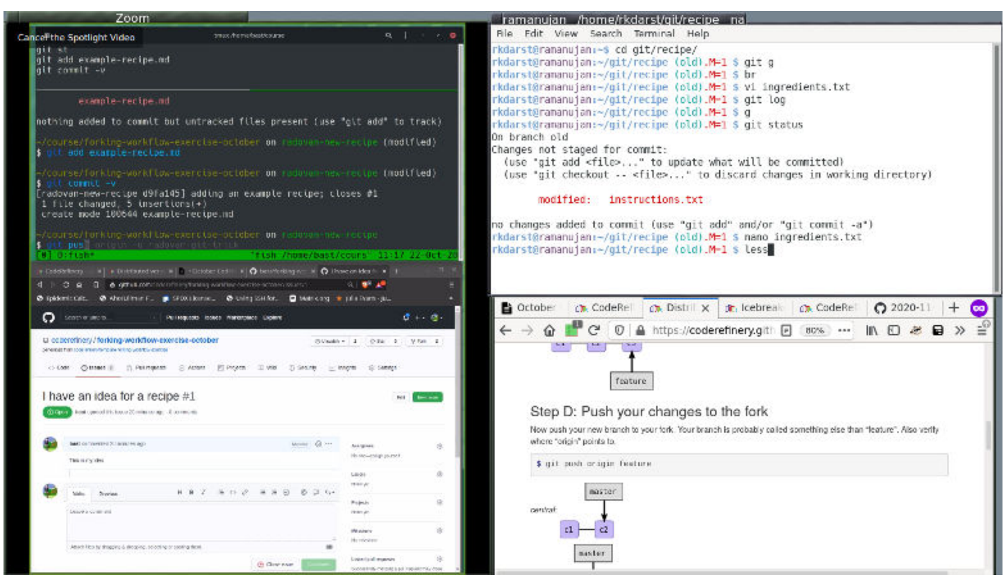


Fig. 4: Example of how a learner can arrange their screens. Instructor screenshare on the left, own windows on the right.

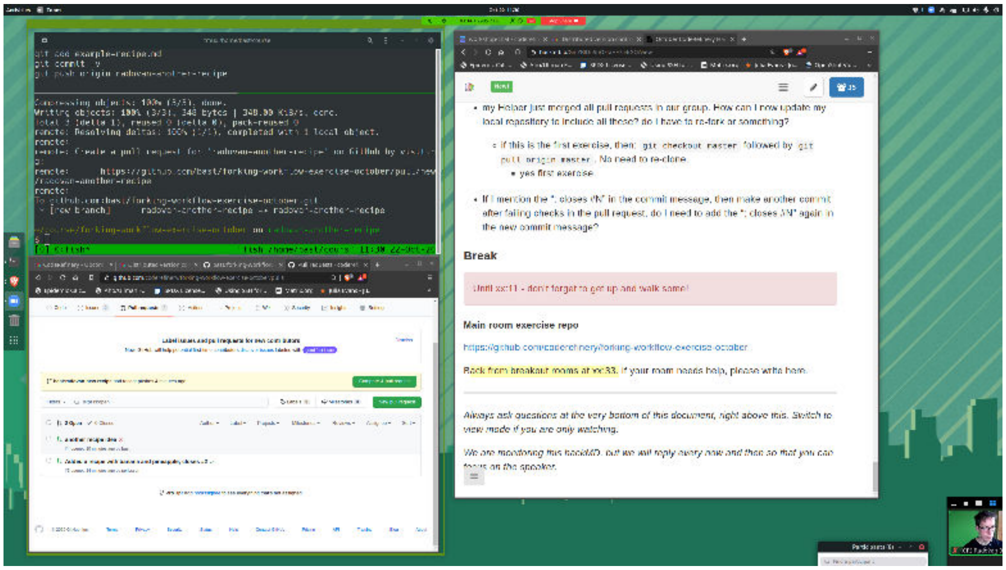


Fig. 5: Example of how the instructor can arrange windows. Zoom is sharing a portion on the left, the right side is free for the shared document, teaching notes, chat with other instructors etc.

- Chat is not good enough, you can't easily reply to old things and finding earlier information is difficult.
- HackMD allows threaded replies and follow up later.
- You need some other instructors/helpers to watch HackMD and provide answers, bring relevant questions to your attention, and let you know how things are going.
- Learners can ask anonymously.
- Learners don't have to worry about interrupting the flow.
- The document stays online and can be revisited by learners to remind themselves of valuable Q&A and discussions.
- Disadvantage: can produce cognitive overload, warn people to not follow too closely.
- With too few people, it can turn out to be very quiet.
- Example: https://hackmd.io/@enccs/dl-intro-feb2022

Breaking the ice

A shared workshop document is useful to get learners engaged in a workshop from the start, and also for breaking down social barriers and facilitating networking in groups.

Some strategies for icebreaker questions:

- Use both social and scientific/professional icebreaker sessions.
- Have breakout rooms in small groups to complete a small social task, multiple times with new groups.
- Alternatively, start every day with an icebreaking activity in new breakout rooms to be used that day.

8.3 Team teaching

Demonstration-based teaching require two different types of focus:

- Doing the mechanical steps as a demonstration
- Explaining why you are doing it

This is a lot for one person to keep in mind, so can multiple people work together for this? Team teaching idea:

- One person is doing the demonstrations
- One person is giving the commentary about what they are doing
- The lecture becomes a discussion between two people instead.

Co-teaching

Wikipedia: Co-teaching or team teaching is the division of labor between educators to plan, organize, instruct and make assessments on the same group of students, generally in the a common classroom,[1] and often with a strong focus on those teaching as a team complementing one another's particular skills or other strengths.

Advantages:

- The course seems very interactive, much more so than expecting students to speak up. The co-teacher can take on the "voice of the audience".
- Quicker preparation time since co-teachers can rely on each other in unexpected situations.
- One co-teacher can be effectively learning at the same time and thus acting as the "voice of the audience" in another way.
- Great way to onboard new instructors - extensive training and preparation no longer needed.
- More active minds means better able to watch and react to other feedback, such as HackMD or chat.
- Less workload - one person does not have to prepare perfectly, any uncertainty can usually be quickly answered by the other.

Disadvantage:

- Requires two people's time
- Requires coordination when preparing (slows you down in preparation)
- Unfamiliar concept to most people

8.3.1 Strategies

In reality, these strategies are mixed and matched even within a lesson, and there are many things between these:

- One person gives lectures, one does the typing during demos.
- "Interview": One primarily doing the "teaching", one guiding by asking questions - either as an interviewer or as a virtual learner.

Things that don't work (are not team teaching):

- Dividing up a lesson into parts, each person gives different parts independently.

8.4 See also

- Instructor introduction - has a lot of tips for new instructors, but also more things about the workshop.
- Instructor tech setup
- Lesson preparation hints (more focused on in-person)
- HackMD mechanics and HackMD helpers.
- Team teaching

Instructor note

- 15 min teaching
- 30 min exercises

CHAPTER

NINE

COLLABORATIVE LESSON DEVELOPMENT

Questions

- What tools and methods can be used to collaboratively develop training material?

Objectives

- Explain how the Sphinx lesson template works.
- Learn collaborative workflows for developing lessons.

This episode focuses on **organisational** and **technical aspects** of collaborative lesson development.

Discussion

This session is about **collaborative** lesson development. What advantages do you see in developing lessons collaboratively and sharing lessons (making material accessible)? What difficulties are there?

9.1 Lesson templates for static sites

Why static sites?

- Decentralized (in terms of organization/namespace)
- Forkable
- Anybody can suggest changes
- Sphinx-based
  - Example: this lesson
  - Starting point: sphinx-lesson
  - Documentation
- Templates can be freely re-used

Explore a Sphinx lesson (10 min)

- Open this very lesson in GitHub (it uses the same format as typical CodeRefinery and ENCCS lessons) (you can also click on the "Edit on GitHub" link in the top-right corner).
- Browse the files and understand the general idea. Check out at least these and use HackMD to record their functions:
  - .github/workflows/sphinx.yml
  - content/conf.py
  - content/index.rst
  - content/lesson-development.md
- If you want, try to make a pull request to this lesson. It doesn't have to have any significant content, it can be a pure test pull request.

Create your own lesson (10 min)

Use the sphinx-lesson-template to create a new lesson of your choice.

- Click "Use this template" and choose a name and where you want to create it. Make it Public and don't select "Include all branches"
- After the new repository is created, wait a couple of minutes before the `gh-pages` branch is created by the automatic GitHub Action. Then go to "Settings" and click "Pages" from the left menu. There select `gh-pages` under the Branch section. Don't change from "/ (root)".
- After a few minutes, there should be a new box at the top of the "pages" page showing "Your site is live at https://.github.io/". Click the link to see your empty lesson!
- If you want to try out different functionality, go to https://coderefinery.github.io/sphinx-lesson/ and have a look at the episodes under "Basic Syntax". You can create new episodes in Markdown, RST or a Jupyter notebook and include them in `index.rst` under "The lesson" (make sure to use consistent indentation)

9.2 Contributing to existing lessons

Our lessons are **collaboratively developed** and some are created by many people. We encourage everyone to contribute to the lessons.

Lessons should be reviewed often - essentially, before each workshop by the instructor of that workshop. This can be a quick review, looking at issues and fixing easy things, or more thorough.

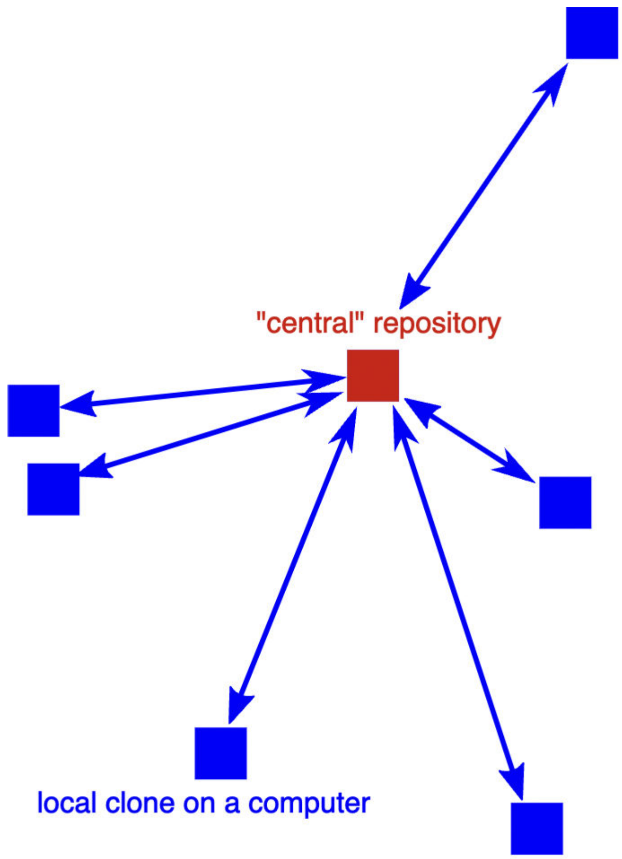
Every so often, there is an extensive hackathon period of fully revising a lesson and making major improvements.

CodeRefinery has a lesson-review checklist to guide the review process.

9.3 Collaborative workflows

There are two main ways to collaborate on lesson (or code) development on a repository-hosting website like GitHub, GitLab or Bitbucket.

Centralized workflow



- Typically all developers have both read and write permissions (double-headed arrows).
- Suited for cases where **all developers are in the same group or organization or project**.
- **Everybody who wants to contribute needs write access**.
- Good idea to write-protect the main branch (typically master or main).

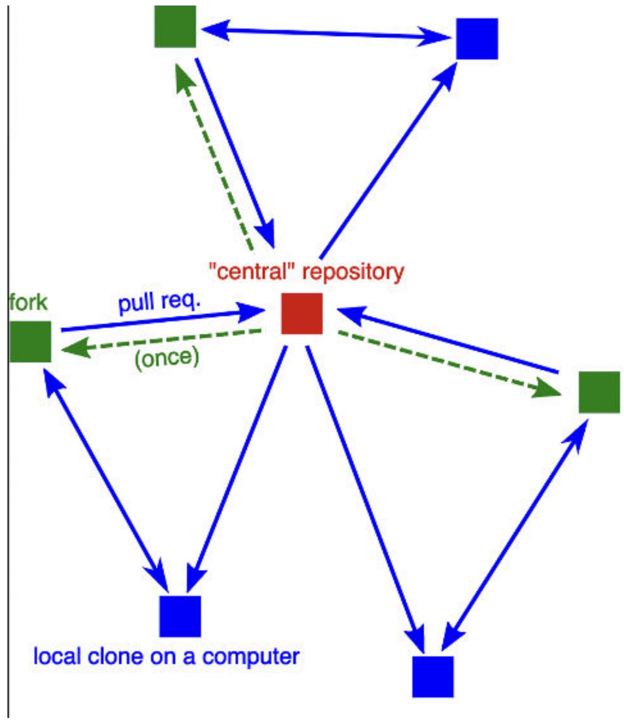
Forking workflow

In the **forking layout**, again we call one repository the "central" repository but people push to forks (their own copies of the repository on GitHub/GitLab/Bitbucket).

- **Anybody can contribute without asking for permission** (to public projects).
- Maintainer still has **full control over what is merged**.
- There is now **more than one remote** to work with.

Practice collaborative workflow (10 min)

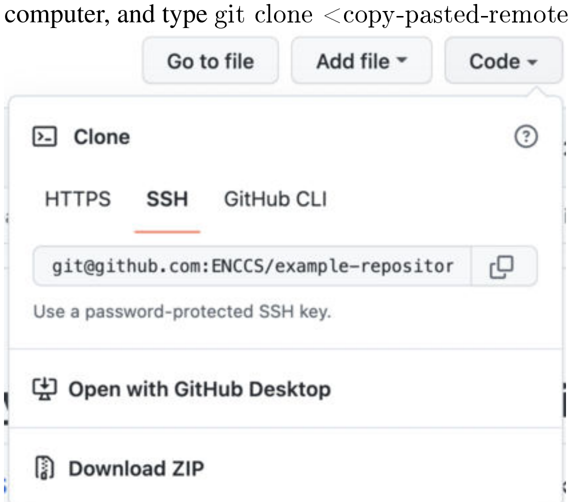
Here we will practice the forking workflow. **NOTE**: You will need a GitHub account to perform this exercise.



Centralised workflow

Forking workflow

- The maintainer of the repository will first need to add you as contributors with write permissions.
- Navigate to this example repository on GitHub.
- Clone the repository to your computer by clicking the Code button and copy-paste the name of the remote. Choose SSH if you have uploaded SSH keys to GitHub, otherwise go for HTTPS. Then go to a terminal on your computer, and type git clone <copy-pasted-remote>.

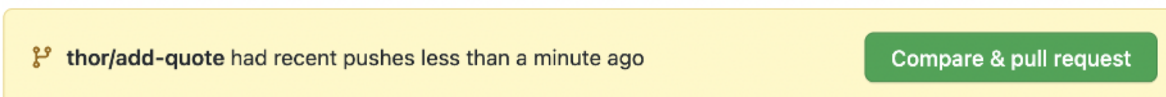


- Best practice: create a new branch in your local repository: git checkout -b <name/feature> (replace "name" with your name, and "feature" with a descriptor of your intended change).
- Now add a new plain-text file to the repository. You can create it with a terminal editor (nano, emacs, vim) or a simple text editor. In the file, add either a famous quote, a cooking recipe, a poem or something else that you like.

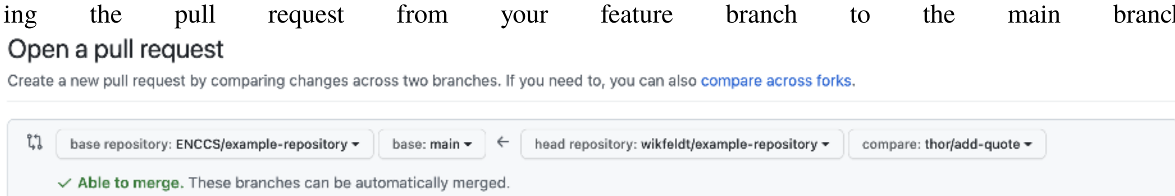
- After the file is created, *stage* it with git add <filename>.
- After staging, *commit* the file with git commit -m <some descriptive commit message>.
- Now push your commit to your fork: git push origin <name/feature>
- In the output of the push command you will see a URL for creating a **pull request**. Copy-paste it to a web browser.

```
❯ git add feynman-quote.txt
❯ git commit -m "add Feynman quote about teaching"
[thor/add-quote d0c4e13] add Feynman quote about teaching
 1 file changed, 1 insertion(+)
 create mode 100644 feynman-quote.txt
❯ git push origin thor/add-quote
Enumerating objects: 4, done.
Counting objects: 100% (4/4), done.
Delta compression using up to 8 threads
Compressing objects: 100% (2/2), done.
Writing objects: 100% (3/3), 351 bytes | 351.00 KiB/s, done.
Total 3 (delta 0), reused 0 (delta 0), pack-reused 0
remote:
remote: Create a pull request for 'thor/add-quote' on GitHub by visiting:
remote:      https://github.com/wikfeldt/example-repository/pull/new/thor/add-quote
remote:
To github.com:wikfeldt/example-repository.git
 * [new branch]      thor/add-quote -> thor/add-quote
```

You can also just go to the page of the example repository - there should be a new menu at the the top inviting you to create a pull request.

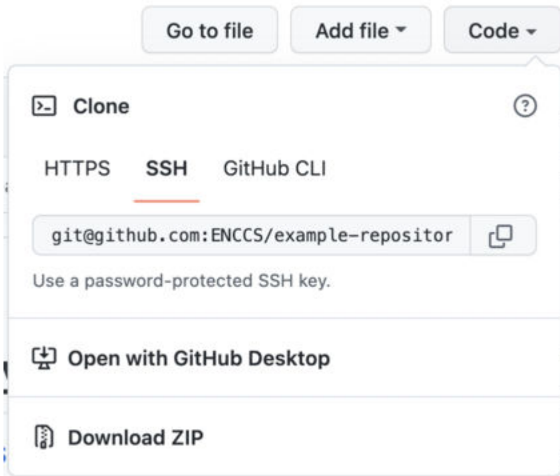


- On the "Open a pull request" page, make sure that you are sending the pull request from your feature branch to the main branch

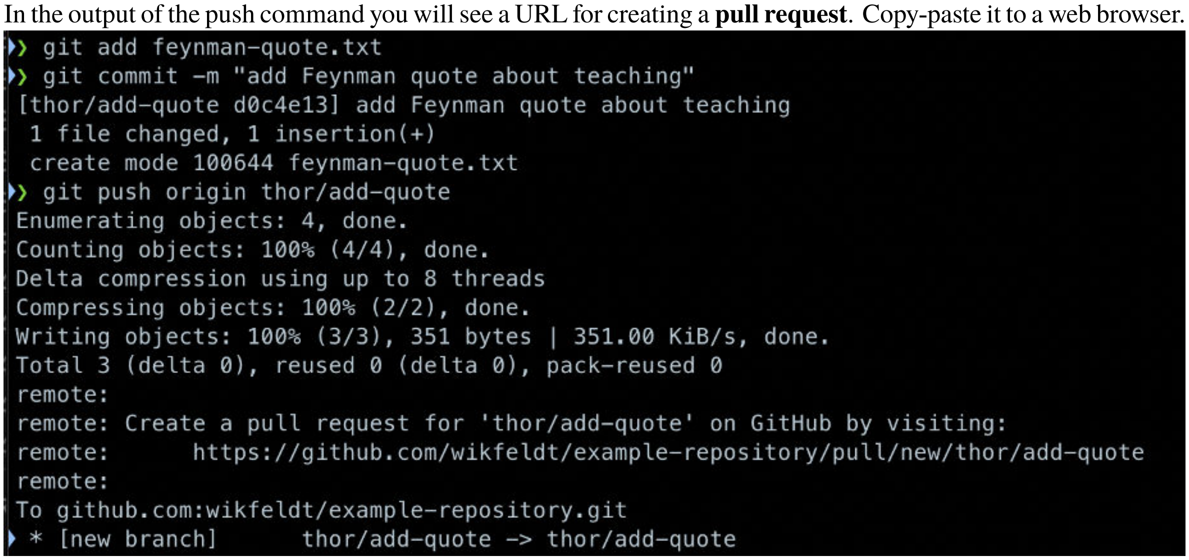


- Finally, edit the title of the pull request and add a comment (optional), and then click the green "Create pull request" button.
- You have now created a pull request and a collaborator can review your change, provide feedback if needed (e.g. to ask for changes), and then merge it into the main branch!
- Navigate to this example repository on GitHub
- Fork the repository to your own GitHub account by clicking the Fork button at the top.

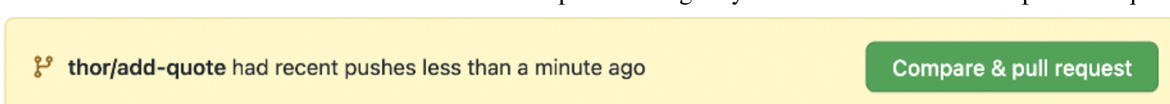
- After the fork has been created, clone the repository to your computer by clicking the Code button and copy-paste the name of the remote. Choose SSH if you have uploaded SSH keys to GitHub, otherwise go for HTTPS. Then go to a terminal on your computer, and type git clone <copy-pasted-remote>.



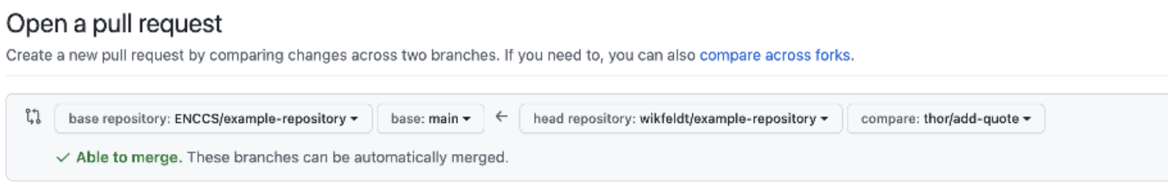
- Best practice: create a new branch in your local repository: `git checkout -b <name/feature>` (replace "name" with your name, and "feature" with a descriptor of your intended change).
- Now add a new plain-text file to the repository. You can create it with a terminal editor (nano, emacs, vim) or a simple text editor. In the file, add either a famous quote, a cooking recipe, a poem or something else that you like.
- After the file is created, *stage* it with `git add <filename>`.
- After staging, *commit* the file with `git commit -m <some descriptive commit message>`.
- Now push your commit to your fork: `git push origin <name/feature>`
- In the output of the push command you will see a URL for creating a **pull request**. Copy-paste it to a web browser.



You can also just go to the page of your forked repository - there should be a new menu at the top inviting you to create a pull request.



- On the "Open a pull request" page, make sure that you are sending the pull request from your feature branch on your forked repository to the main branch of the parent repository



- Finally, edit the title of the pull request and add a comment (optional), and then click the green "Create pull request" button.
- You have now created a pull request and a maintainer of the central repository can review your change, provide feedback if needed (e.g. to ask for changes), and then merge it into the main branch!

Bonus question: Why is it best practice to create a "feature" branch in your local repository?

9.4 Code reviews

Why code review?

In collaborative software development, it is standard practice to review each other's code changes. This serves multiple purposes:

- Others in the team learn about your changes.
- An extra pair of eyes are useful to catch bugs or suggest improvements
- It's possible (and common) to enable *automated testing* so that each pull request is tested automatically in the cloud so that the reviewer can see whether a pull request passes all unit tests.

There's no reason not to apply these practices to collaborative lesson development!

9.5 Recommendations and lessons learned

- Convert feedback about lessons and suggestions for improvements into *issues* so that these don't get lost.
- Make your lesson citable: get a DOI.
- Credit contributors (not only Git commits).
- Instructor guide is essential for new instructors.
- Lesson changes should be accompanied with instructor guide changes (it's like a documentation for the lesson material).
- Apply and validate backwards lesson design again and again.
- Make it possible to try out new ideas (by making the lesson branch-able).
- Before making larger changes, talk with somebody and discuss these changes.
- For substantial changes we recommend to first open an issue and describe your idea and collect feedback before you start with an extensive rewrite.
- For things still under construction, open a draft pull request to collect feedback and to signal to others what you are working on.

Instructor note

- 60 min exercises and discussion

CHAPTER

TEN

PRACTICE TEACHING AND GIVING FEEDBACK

Goals of this teaching practice:

- In groups of 4-5 persons we will practice teaching a **5-minute segment of a lesson of your choice**.
- The section you pick should require **screen sharing** and be of some **demonstration or follow-along task** (preferably using a shell) to also practice having a good screen-sharing setup.
- After each presentation, other group members give feedback with the same 2x2 rubric as used in *Good Interactive Teaching Practices*.
- We will practice improving our 5-minute segment by taking the feedback into account.
- In both sessions you can teach the same topic/segment but if you prefer you can also change the topic/aspect for the second session.

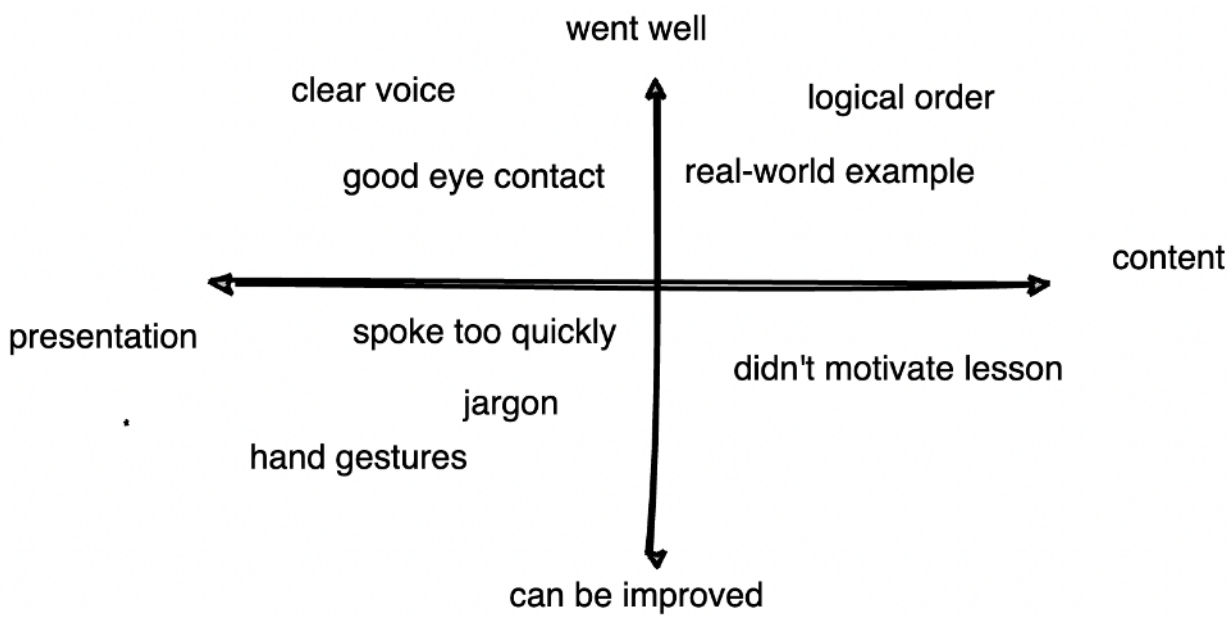


Fig. 1: 2x2 Rubric for feedback

Feedback template for shared document

You can copy-paste this template into the shared document for giving feedback:

```
Positive Content:
-
```

(continues on next page)

(continued from previous page)

```
-
-

Content Opportunities for Growth:
-
-
-

Positive Delivery:
-
-
-

Delivery Opportunities for Growth
-
-
-
```

Live coding exercise (50 min)

- We organize the breakout rooms to not only discuss one lesson/topic so that it is more interesting to listen and also probably we will all get more useful feedback.
- Give each other **constructive verbal feedback** on the teaching demos using this demo rubric.
- Write down questions (in the collaborative document) that you would like to discuss in the main room or interesting conclusions which you would like to share with others.

10.1 Discussion

Main room discussion (10 min)

- We discuss questions and conclusions which came up during the group work session.

Instructor note

- 20 min teaching
- 10 min exercises

CHAPTER

ELEVEN

ORGANISING AND RUNNING ONLINE WORKSHOPS

Questions

- What are the steps for organizing an ENCCS workshop?
- What can I learn about running my own workshop?
- What have we learned from running large online workshops?

Objectives

- Become comfortable in organising large online workshops

11.1 General workshop arrangements

- Select a coordinator, recruit instructors and helpers (at least 3 is important),
- In-person workshops: Find a good lecture room (requirements)
- Decide on a maximum number of participants based on number of instructors and helpers
- Set up workshop webpage
- Advertise the workshop
- Communicate with registered participants

11.2 Registration

- Use a powerful registration platform (for example Indico)
- Open registration well in advance of workshop
- Assume 25-30% no-shows
- Use moderated registration (registrations need to by approved)
- Set autoreplies
  - upon registration: inform that registration needs to be approved, currently on waiting list
  - upon approval: inform that registration is now completed

- Maintain a waiting list, e.g. by moderated registration
  - set maximum number of registrations in registration platform to 50% above intended number
  - accept 25% above your intended number
  - as you receive cancellations, accept from the waiting list
  - in communication with registered participants, request participants to notify of cancellation asap

11.3 Online workshop approach

11.3.1 Basic preparation

- You need more breaks than in in-person workshops
- People have a way of doing too many things and not focusing.
- "How to attend an online workshop" guide to prepare learners

11.3.2 Basic platform: Zoom

- Zoom (not the most ethical, but worked well and was available)
- Zoom mechanics: instructions for students.
  - Mostly things that are known

11.3.3 Breakout rooms, bring your own team

- Breakout rooms are
  - Static: same people across whole workshop
  - Contain one helper per room (see below)
- Team registration: accept a "team" field when registering, people on the same team are put together.
  - Gives motivations for learners to bring their colleagues and learn together.
  - More than one person learning together greatly increases update
- You need a powerful enough registration system to assign rooms and email them to people!
- We ask people to name themselves "(N) Firstname Lastname" or "(N,H) Firstname Lastname" for helpers. Then it is fast to assign them to their designated breakout rooms.
- See also: Breakout room mechanics

11.3.4 Helper training

- Each breakout room has a helper
- Helper should be a little bit familiar, but not expected to be able to answer all questions.
- Special, custom helper training since helpers make or break the workshop
- Helper recruitment:
  - Our networks
  - Team registration: if a team registers with their own helper, then they are guaranteed to get in together. "bring your own breakout room"
  - Former learners, ask them to come back.
- Two helper trainings the week before the workshop.

11.3.5 Staff roles

To reduce stress on any one person, we clearly define the different roles and try to avoid overlap. We actually have enough people for all of these, so it works well.

- Workshop coordinator
  - Registration, etc.
- Zoom host
  - Handles registration, breakout rooms, recording, Zoom chat.
- HackMD helper
  - Dedicated to watching HackMD and answering questions quickly.
  - Host on manuals
- Instructors
  - Teach, they shouldn't overlap with the above roles (but serve as expert helpers other times).
  - Usually also improve the lesson a bit before teaching
  - General staff intro in manuals
- Workshop preparation meeting
  - Get together, introduce roles, kickstart instructors
  - Workshop prep meeting in manuals

11.3.6 HackMD

- We've been using it here
- Chat doesn't work when large, written document does.
- HackMD can just about scale to ~100 person workshop. Recommend learners keep it in view mode while not editing.
- Voice questions are still allowed, but might be recorded. Staff raise important questions from HackMD to the instructor immediately.
- HackMD also allows communication when in breakout rooms.

- You can get multiple answers, and answers can be improved over time.
- HackMD mechanics and HackMD helpers.

11.3.7 Installation time

- People *have* to be ready once we start, or else everything fails.
- Consider having installation help times the week before.
- Every email emphasizes that you have to be prepared, and "requires" you to attend workshops (but really it's only)
- Installation instructions include *steps to verify*
- *Design to be easy to install and get set up.*

11.3.8 Other notes

- Make breakout sessions as long as possible: 10 minutes is really too short. 20 minutes is a good minimum time.
- Be very clear about exercise expectations
- Keep HackMD updated as a log.
- Don't combine breaks and breakout times.
- The more people you have, the more diverse audience you have and the more people overwhelmed and underwhelmed.

11.3.9 Getting/giving feedback on learners' progress

Feedback is an essential part of effective learning. Feedback is bi-directional:

- To be effective, instructors need feedback on their learners' progress. Learners can also check their progress and ask relevant questions to get clarification.
- Instructors also need feedback on their teaching. For instance, this can help them to adapt the pace, add/skip optional exercises and improve their teaching.

ENCCS uses different instruments to get feedback from learners:

- Surveys: Discussed below
- Plus one, minus one: After each day of a workshop (or after a module), ask participants to name one thing they liked and one thing that could be improved.
- Formative assessment (exercises and quizzes): we have many exercises during ENCCS workshops and also use polls to keep participants engaged and to obtain quick feedback on their progress.

11.3.10 Post-workshop survey

Immediately after a workshop finishes we ask participants to fill a standardized post-workshop survey. Survey results often contain valuable information which can and should be used to improve future workshops. ENCCS post-workshop surveys contain the following questions:

- Overall, how would you rate this training event?
  - scale 1-10
- How did you like the online format compared to an in-person event?
  - Better than in-person, Equivalent to in-person, Worse than in-person
- What did you like best about the lesson material, exercises and teaching? Where should we improve?
  - Free-form answer
- What topic did you find most interesting, relevant or useful?
  - Free-form answer
- What topic did you find least interesting, relevant or useful?
  - Free-form answer
- What did you like best regarding event organisation? Where should we improve?
  - Free-form answer
- Would you recommend this training event to colleagues and friends?
  - Yes, No, Maybe
- Will what you learned at the event be useful to you in the near future?
  - Yes, No, Maybe
- Length of course was
  - Adequate, Too long, Too short
- Depth of content was
  - Adequate, Too superficial, Too deep
- The pace of teaching was
  - Adequate, Too slow, Too fast
- The lesson material was well prepared
  - Agree completely, Agree, No strong feelings, Disagree, Disagree completely
- Hands-on exercises and demonstrations were
  - Adequate, Too few, Too many
- Which topics would you be most interested in learning about in future training events?
  - Free form answer
- Any other comments?
  - Free form answer

11.3.11 See also

- CodeRefinery maintains a number of workshop manuals with most of the "primary" information. This episode condenses this into a quick overview.

Keypoints

- There are many aspects to consider to deliver a successful workshop.
- CodeRefinery maintains a number of manuals which can be used when preparing a workshop.

CHAPTER

TWELVE

QUICK REFERENCE

CHAPTER

THIRTEEN

INSTRUCTOR GUIDE

13.1 Detailed learning outcomes

After attending this workshop, learners should:

- Know about ENCCS and the EuroCC project and why they exist
- Have an overview of ENCCS lessons and their scope
- Understand key pedagogical concepts that underpin ENCCS, CodeRefinery and Carpentry training
- Understand the significance of creating a motivating and inclusive environments during workshops
- Be familiar with backwards lesson design and be able to apply it to own lesson development
- Be comfortable teaching in-person and online using an interactive teaching style
- Be familiar with tools and workflows for collaboratively developing interactive lessons

13.2 Agenda for condensed 3-hour workshop

Time	Episode	Teaching/interaction, min
14:00 - 14:15	Welcome and introduction	10 + 5
14:15 - 14:30	ENCCS training	10 + 5
14:30 - 14:45	ENCCS lessons	10 + 5
14:45 - 15:10	Acquisition of skill	20 + 5
15:10 - 15:30	Break	
15:30 - 16:00	Lesson design	20 + 10
16:00 - 16:30	Good interactive teaching practices	20 + 10
16:30 - 16:45	Teaching mechanics	10 + 5
16:45 - 17:00	Collaborative lesson development	15
17:00	Practice: teaching and giving feedback	

13.2.1 Notes

- For extended workshop (full day/ 2 half-days), good place to split is after "Lesson design" episode and subsequent practice on backwards design.
- For extended or practical-first workshop, participants could also be encouraged to come up with a topic of a (short) presentation in advance, to be used in backwards-design and teaching/feedback practice sessions.
- First two outcomes are related to ENCCS material, but even so it can be used (skipping introduction) as a good example implementation of the concepts covered. Rest of the content is generally applicable to any HPC-related training.

13.3 Addressing preconceptions

As noted in the Introduction, the workshop primarily targets competent practitioners and experts that might want (or need) to teach their knowledge to others. This implies that most of them already have their own ways of understanding, structuring and probably even presenting relevant material, as well as selected tools and usage habits. Several concepts of this lesson may appear unusual or overhead-inducing at first glance. It might be useful to prepare an example of unique advantage for each such concept/technique that distinguishes it from the alternatives. Some suggestions (feel free to come up with your own or tailor them to your needs):

- **Backwards design** can significantly speed up initial development or major update of teaching resources, because it shifts focus from what to teach/present to what the participants are supposed to learn. This way individual contributors can choose the content that reflects their own expertise, easily exchange domain examples when preparing for specific audience, etc.
- **Interactive teaching** combines best qualities of lectures and exercise sessions widely used in academic education: precise amount of content is presented by an expert and then immediately supported by demonstration or direct application while the knowledge is fresh. Constant feedback also allows to adjust teaching speed and fix small issues at once and not "next time", after reading exit polls.
- Even if you consider certain subject matter "your child", **collaborative development** may allow you to reach larger and more diverse audiences at the fraction of effort, such as adapting setup and execution instructions for a local HPC installation by an on-site administrator.

CHAPTER

FOURTEEN

WHO IS THE COURSE FOR?

Teaching is a profession, but also something that everyone needs to be able to do to some degree, since everyone has their own personal specialties they will either teach or mentor.

This course can be relevant for different learner personas:

- **You run a practical teaching program** at your institution (for example as part of a research computing group) and would like to learn best practices for collaborative teaching of technical topics, so that you aren't re-inventing the same thing over and over again.
- **You are a technical specialist** who is frustrated with the way you currently try to teach others who need to use your software or infrastructure. You can't spend too much time to become a professional, but you know you need something more than what you've been doing. Thus, you would like to adopt some of the best practices of designing and teaching interactive, hands-on workshops.
- **You've been teaching alone**, but would like to join a collaboration network for more co-teaching and to reduce the amount of duplication of effort.
- **You are interested in teaching ENCCS lessons**, and would like a comprehensive kick-start to how ENCCS workshops work, either to join us, or teach our lessons with us or independently.

CHAPTER FIFTEEN

ABOUT THE COURSE

This course gives an introduction to

- Science and philosophy of teaching.
- How to teach interactive, hands-on workshops.
- How to design interactive, hands-on lessons.
- How ENCCS has taken the best advantage of online teaching.
- How ENCCS runs workshops.

CHAPTER

SIXTEEN

CREDITS

The lesson file structure and browsing layout is inspired by and derived from work by CodeRefinery licensed under the MIT license. We have copied and adapted most of their license text.

16.1 Instructional Material

CHAPTER

SEVENTEEN

SEE ALSO

- ENCCS lessons
- CodeRefinery manuals
- Carpentries instructor training - more intensive, but focused only on teaching.
- Carpentries curriculum development handbook
- Teaching Tech Together, a book about similar topics by someone involved in Carpentries.
- Carpentries general organizational documentation