Lesson development

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Lesson objectives

- Describe the data science module you intend to develop
- Identify desired skills to teach
- Write learning objectives for in-class data science module
- Design formative assessments to monitor learning progress

Overview

Today we will start work in earnest on your data science modules! We will start with a review of reverse instructional design, then provide an opportunity to brainstorm with your peers on your module ideas. We will then move into working with learning objectives and assessing student's progress.

Reverse instructional design

Backward design is an instructional design model that starts with identifying the desired outcomes of a learning experience, including core skills and concepts that students need to acquire. These identified outcomes are used to develop course content and assessments to measure students' progress towards these outcomes.

In essence, the backward design process has three stages:

1. Identify the practical skills we aim to teach.
2. Design formative assessments to give an opportunity for our students to practice and integrate these skills.
3. Identify what we need to teach for our students to acquire these skills.

This approach ensures that all the skills you teach work together to meet the over-arching goals of your curriculum. It also reduces the risk that you won't teach a concept students need in order to be able to master the skills you aim to teach. Similarly, it avoids teaching topics that do not help you (and your students) meet our goals.

Reducing distractions is part of our lesson design as we strive to reduce cognitive load on students. To this end, we will also talk about how to develop lessons centered around a narrative and a data set students can relate with quickly.

Exercise

In groups, describe the data science module you would like to deploy in your classroom. Start by sharing the **course** you will teach the module in, then the **audience** for the module (i.e. who the students are). Then provide a general description of the tool or resource you want to teach your students.

Provide feedback to other group members on their ideas. Some things to consider: in the spirit of "teach the most useful first", how does this idea fit? What what is the knowledge or skills that students will need to bring to this lesson (this is that "intrinsic" cognitive load we talked about).

Practical skills

We emphasize teaching "good enough practices" - concrete skills that are accessible and likely to make an immediate positive impact on students' work. Teaching defensive programming, how to use spreadsheets effectively, or how to organize files consistently across research projects, are practical skills that can save a lot time when students apply them in their own work.

When developing a new module, the first step is to identify the skills that will be the most immediately useful to students and have the biggest impact on their work. This will vary a lot, so having a clear idea of your lesson's intended audience is critical at this stage.

Exercise

Based on the discussions you had with your group, take a few minutes to list the skills you want your students to come away with after completing the class module. Add this list of skills to the collaborative document.
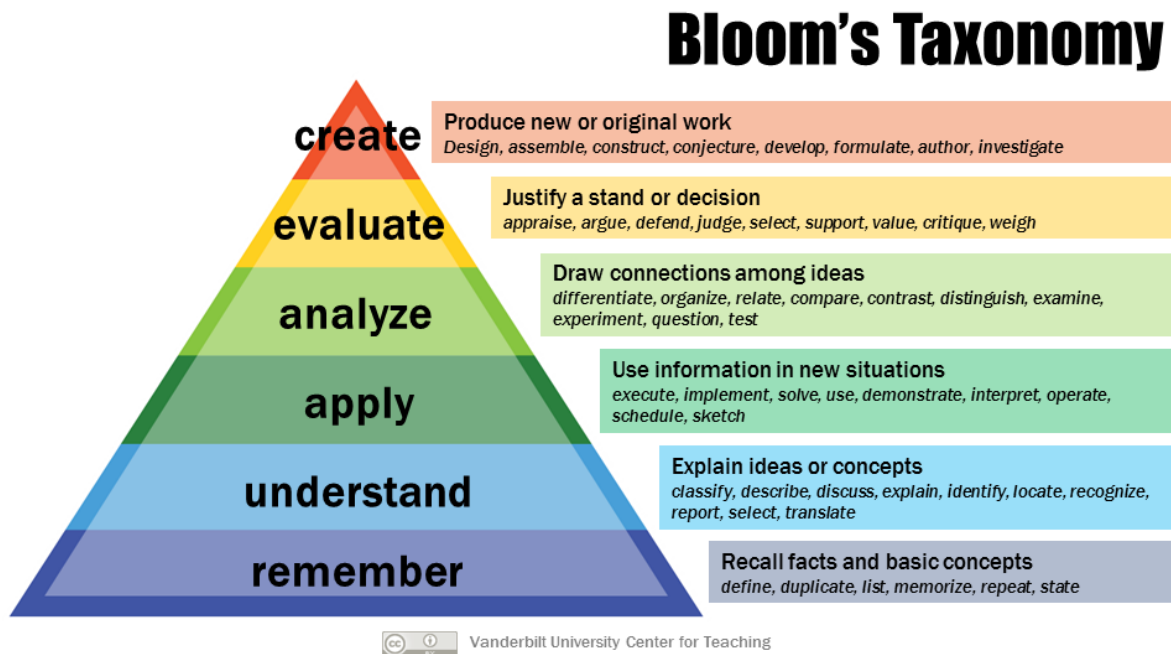

Figure 1: Image credit: Vanderbilt University Center for Teaching

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Exercise

Now, looking at those skills, revise them so they are learning objectives. Consider where on Bloom's taxonomy those learning objectives would be. Add the learning objectives to the collaborative document.

Designing assessments

Once you have identified these high-impact skills, the lesson content should be designed to create frequent opportunities for students to practice these skills while exemplifying the tasks they perform in their daily work. Live coding and hands-on formative assessments that students can directly relate to should allow them to envision how they can start using the skills taught with their own data as soon as the class session is over.

Aside: keep material close to feedback

In much of traditional Western instruction, students are presented with new material during course time and then sent home to practice applying the concepts learned on their own. A major limitation of this approach is that students often encounter difficulties in trying to apply their new knowledge or skills and need to troubleshoot on their own, without support. Education research shows that novices learn best when they are given feedback and coaching in real time while practicing their new skills so that errors are corrected and missteps redirected before mistakes have a chance to become discouraging or ingrained in students' memory.

To this end, we should provide frequent opportunities for students to practice new skills. To be helpful in providing useful feedback, these opportunities need to both be:

1. narrowly targeted to the skills that have been taught (i.e. not to depend on untaught concepts), and;
2. diagnostic (instructors should be able to tell what the student is misunderstanding based on how they answer the question).

Exercise

Pick one of your learning objectives from above and design an assessment for you as an instructor to assess how well the student understands the concept being taught. Remember to make the assessment:

1. Narrowly targeted to the skills that have been taught
2. Diagnostic to provide you information on potential misconceptions

When you have finished drafting the assessment, add it to the collaborative document.

Exercise

Now share your learning objective and the accompanying assessment with your group. Taking turns, review your peers' assessments addressing these two questions:

1. Is the assessment narrow enough to focus on the skills being taught?
2. Are there additional misconceptions that might be caught?

This is the start, and we will have more time to write assessments for your learning objectives. Also note that your list of skills and learning objectives can change as you develop your lesson.

Homework

Next week you will have opportunities to teach a *very* short part of a lesson (on the order of 3-5 minutes). Now is the time to start thinking about what you would like to teach. We will have a bit more information in the next session, and if you have questions about what we will ask of you, please feel free to start asking questions now.

Feedback on the day

Your instructor will ask for you to provide feedback on this session.

Extra: Backwards design in assessments

The assessments in a lesson should be a mixture of direct applications and synthesis. A direct application is a straightforward implementation of a concept that students have just been exposed to, while synthesis requires students to integrate recently learned skills with skills that were covered earlier in the lesson. Learning is reinforced when you explicitly point out how the skills seen in earlier parts of the lesson are being integrated in the assessments.

Formative assessments help students further their learning by having a chance to put into practice the skills being taught. They also help you monitor the level of understanding in the classroom, and potentially catch misconceptions in the student's mental models that can be corrected in real time, before they become ingrained.

When starting to design assessments, it is helpful to start by planning the *last* exercise of the class. This will help you keep the big picture in mind and ensure that the rest of the exercises you develop lead up to this larger goal. These final assessments are also the most likely to be "unscaffolded", and so are easier to develop without detailed knowledge of the various types of exercises we will discuss later. Such a final assessment may include an assessment of multiple (or even all) of the learning objectives for your lesson.

Exercise

Draft a final assessment to assess some or all of the learning objectives you listed in the previous exercise. This can be more open-ended than some of the formative assessments we have talked about previously, but don't leave your students confused about what they are supposed to do. e.g. "Describe evolution" might be a bit to vague. It may not necessarily be something that would take place synchronously (i.e. it could be homework) or during the same class period (i.e. group work during the next class).