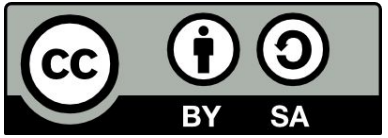
Open and Reliable Science teaching formats

Loek Brinkman, Daniel Oberski, Henk Aarts

This set of teaching formats is a products of the Innovation in Education project (FSO): ‘Open and Reliable Science in Bachelor Education’ at Utrecht University, the Netherlands



Welcome!

Here you find a set of teaching formats to integrate practices related to Open and Reliable Science in your curricula. The teaching formats are organised in four categories:

Accessibility, Transparency, Reliability and Science in Society.

Within each of these categories, we provide teaching formats where students have either the role of **user of knowledge** or **producer of knowledge**. Assignment can be integrated in courses, practicals and, notably, in the bachelor thesis.

We have aimed for **easy-to-implement** formats that require little to no background knowledge, and are applicable to a **wide range of disciplines**. Some teaching formats arguably fall under multiple categories. In those cases, the teaching format is listed in the category that we thought most suited. The teaching formats are designed for bachelor students of the faculty of Social Sciences, but can also be used in other contexts.

This list is far from exhaustive. You are encouraged to **share your own teaching formats** and/or **add suggestions** in the empty slides below. As such, this slidedeck may grow and evolve over time. The dynamic slidedeck can be found at www.bit.ly/OSteachingformats. Static versions of this document are stored at FigShare [link].

Topics and teaching formats

Student as...	Accessibility	Transparency	Reliability	Science in Society
... user of knowledge 	Creative Commons licences Open Access Preprints Reuse of data, materials and code	Open Science Badges Preregistration	Assessing strength of evidence Determinants of false positives Filedrawer problem Registered Reports Reproducibility	Appreciating Team Science Common Language International Sources
... producer of knowledge 	Creative Commons Licences Privacy issues: GDPR The FAIR principles for sharing	Preregistration of your research Sharing data, materials and code	Reproducible coding: GitHub Reproducible coding: R Markdown Power analysis Replicating work of others	Collaboration on CREPE Communicating outside academia

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from Noun Project

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Student as <u>user</u> of knowledge

Accessibility

Creative Common Licences

By: Loek Brinkman

Learning objective: understanding Creative Common licenses
Time: 10 minutes

Whenever you use data/code/materials of others, it is important to know what you are allowed to do with it. This is specified in a licence. A class of popular licences in science are the Creative Common license. You can discuss these six Creative Common license with students, to make sure they understand what they mean when they encounter them. Here's a description of the licences, as provided by Creative Commons:

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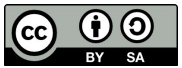

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Open Access
By: Loek Brinkman

Learning objective: raise awareness of Open Access papers
Time: ranging from 10 seconds to 30 minutes

A very easy thing thing you can do as an instructor is, whenever students read or search for scientific literature, to ask them whether the articles were Open Access or not. This question may be a starting point for a discussion on the benefits of Open Access publications.

If you want to dive deeper into the topic of Open Access, you can introduce students to the various formats of Open Access publishing: e.g. full open access journals (gold), open access repositories (green), (see https://www.openaccess.nl/nl/wat-is-open-access). An interesting aspect of publishers is how money flows in this system: Who pays for the research? Who pays for publishing? Who pays for access? Is this desirable / ethical?

Slides to introduce Open Access and a format to start a discussion are part of this slidedeck.

For more inspiration: check out this Twitter thread by @JeroenSondervan:
https://twitter.com/jeroenson/status/1145991269124059136

Preprints
By: Loek Brinkman

Learning objective: introduce students to preprints
Time: 10 minutes

As some point in the curricula, students are introduced to the system of peer-review. While peer-review is one of the hallmarks of science, it also slows down the process dissemination of knowledge. Preprints are versions of manuscripts that are not peer-reviewed (yet). They are often uploaded to preprint servers at the same time that they are submitted to a journal. Preprint therefore contain cutting-edge findings, but the information does not have the status of a scientific article (yet). Preprints are very popular in a.o. mathematics, physics and astronomy, and is getting increasingly popular in psychology. Examples of preprint servers are: bioRxiv, PsyArXiv, MediArxiv and SocArXiv. There are also issues with preprint. E.g., how do the readers (in particular non-academics) evaluate and interpret preprints? Do preprints count as research output for researchers? Should preprint servers perform quality control of their preprints or should all submissions be accepted? See for example this article on the surge of COVID-19 related preprint and the need for quality control.

- Have students search and read a preprint
- Discuss the value and strength of evidence of the information
- Should preprints become the norm in academia? How should this take shape, in terms of quality control, communication and evaluation?

Reuse of data, materials and code

By: Loek Brinkman

Learning objective: Raise awareness amongst students on how they benefit from the efforts of others
Time: 5 minutes

In many practical courses, students use data, materials and code created by others. Whenever this is the case, you can increase awareness of the fact that someone somewhere has put in efforts, which now enables the student that he/she can benefit from it. Can you identify the person who created and shared this data/material/code? How is that person endorsed for her/her efforts?

Another aspect that you can highlight is: what makes it that you can reuse this data/materials/code? Is it findable? How is it documented? This information is particularly important if you want to share data/materials/code in the future (also see assignments on sharing data/materials/code).

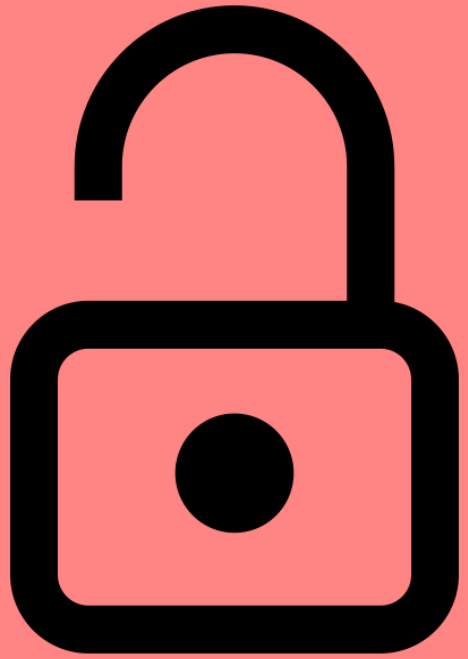
A related question is: what are you allowed to *do* with this data/materials/code? This topic is treated in a separate teaching format (‘Licences’) which you can combine with the current teaching format.

[PLEASE ADD YOUR TEACHING FORMAT HERE]

By:

Learning objective:

Time:



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Student as producer of knowledge

Accessibility

Creative Common Licences

By: Loek Brinkman

Learning objective: understanding Creative Common licences
Time: 10 minutes

Whenever you share data/code/materials of others, it is important to indicate what others are allowed to do with it. This is specified in a licence. A class of popular licences in science are the Creative Common license. You can discuss these six Creative Common license with students, to make sure they understand what they mean and that they can select the appropriate licence if they want to share their data/materials/code. Here's a description of the licences, as provided by Creative Commons:

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Privacy issues: GDPR

By: Loek Brinkman and Jasper de Groot

Learning objective: Know how to handle personal data
Time: 60 - 120 minutes

Since 2018, to General Data Protection Regulation (GDPR) has come in force, which specifies how you should handle personal data.

Research Data Management support of Utrecht University has developed a checklist to make sure research project comply with GDPR.

You can present students with a case of a research project, for which they follow the checklist to see whether the project is GDPR compliant.

This checklist is also very much suited to be applied to the research projects in the bachelor thesis.

The FAIR principles for sharing data

By: Loek Brinkman

Learning objective: Familiarize students with the FAIR principles
Time: 30 - 120 minutes

Sharing data, materials or code is only useful is if it is shared such that it is Findable, Accessible, Interoperable and Reusable. These are the FAIR principles, which are further specified in The FAIR Guiding Principles for scientific data management and stewardship. A nice format to introduce the FAIR principles is by using the brochure 'A FAIRy tale', in which the FAIR principles are introduced in fairytale story.

A possible teaching format is:

- Split the group in four, each group has one topic:
  - Findable, Accessible, Interoperable, Reusable
- Students read the sections of the FAIRytale regarding their topic (30-45 minutes)
- Students present to fellow students (4x 5 minutes)

Importantly, students should strive to implement the FAIR principles when sharing data, materials or code. As a supervisor, you can use the FAIR principles as a check-list, to evaluate whether students comply with the FAIR principles.

Slides to introduce the topic of Open Data and a format to start a discussion are part of this slidedeck.

Also, see the information of UU RDM support on How to make your data FAIR

[PLEASE ADD YOUR TEACHING FORMAT HERE]
By:

Learning objective:
Time:

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from Noun Project

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Student as <u>user</u> of knowledge

Transparency

Open Science Badges
By: Loek Brinkman

Learning objective: Familiarize students with Open Science badges
Time: 15 minutes

An increasing number of journals use Open Science Badges to indicate whether certain Open Science practices have been followed, such as: preregistration*, open data* and/or open materials*. (1) You can start by asking students whether they know what these practices entail, and whether they have encountered these badges before. (2) You can redirect students to this webpage and ask them to check which journals that support these badges are relevant to them. Moreover, you can discuss whether such badges are useful indicators of the credibility of the reported findings and whether the use of such badges would motivate researchers to make their workflows more open (answer: they do!)

*see teaching formats on these topics for more information on these practices

Preregistration
By: Loek Brinkman

Learning objective: Familiarize students with preregistation
Time: 10 - 60 minutes

Preregistration is the documentation of the analysis that are planned on the data *before* the data is collected or analysed. The preregistration can be included in a publication and warrants that the analyses are conducted as planned. Discuss with your students why this is important. What can happen when different analyses are performed (researchers degrees of freedom) and only a selection of these analyses are reported? You can also mention the phenomenon of hindsight bias and how preregistration can protect against it.

In addition: Hand out a set of articles for which the analyses were preregistered. Did the authors follow their preregistration? Where did they deviate? How is this discussed in the article?

Instructors who want to familiarize themselves with preregistration may find these introductory slides useful, made by Anita Eerland

[PLEASE ADD YOUR TEACHING FORMAT HERE]

By:

Learning objective:

Time:

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Student as <u>producer</u> of knowledge

Transparency

Preregistration of your research

By: Loek Brinkman

Learning objective: Enable students preregister their research project
Time: 60 minutes

Preregistration is the documentation of the analysis that are planned on the data *before* the data is collected or analysed. The preregistration can be included in a publication and warrants that the analyses are conducted as planned. A easy and popular platform to preregister research projects i AsPredicted.org. Students can follow the steps on the website for their preregistration. Alternatively, instructors can also use the forms of AsPredicted.org for internal use (without sharing the preregistrations with the rest of the world). Additional information can be found in these slides by Reine van der Wal, a researcher sharing her experiences with AsPredicted.org. Within the research masters Social and Health Psychology, preregistration has become mandatory for all master theses. Please have a look at these slides by Anneloes Kip, one of the research master students who had to preregister her thesis, to hear here (mosty) positive experience with this procedure.

Another platform to preregister studies is the Open Science Framework (OSF). The procedure on OSF is more flexible and also has a template for preregistration of qualitative research.

Sharing data, materials and code
By: Loek Brinkman

Learning objective: Enable students to work with the Open Science Framework (make a project, upload and share data/materials)
Time: 90 minutes

The Open Science Framework is a platform where you can share data and materials with the rest of the world, for free and with infinite storage.

Students can start by setting-up a project page, upload data or materials, collaborate on eachothers projects and make their project public. You can use these slides, made by Anita Eerland, as a step-by-step tutorial.

If you want more background knowledge on working with the Open Science Framework, please watch the webinar 'OSF 101'.

[PLEASE ADD YOUR TEACHING FORMAT HERE]
By:

Learning objective:
Time:

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from Noun Project

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from Noun Project

Student as <u>user</u> of knowledge

Reliability

Assessing strength of evidence
By: Loek Brinkman

Learning objective: Additional tools to assess strength of evidence
Time: 60 - 120 min
Prerequisite: Knowledge of *statistical power* and *effect-sizes*

A crucial skill for any students is to assess the strength of evidence of claims in literature. In most curricula, some form of the hierarchy of scientific evidence is introduced, that range from case reports (weak evidence) to meta-analyses (high evidence). A nice extension to this hierarchy are the curated replications studies on the website Curate Science (see separate teaching format) or the format of Registered Reports (see separate teaching format).

A step further is to familiarize students with the determinants of false positives (separate teaching format) and the markers of evidence that follow from that:

- How likely was the hypothesis?
- Wat was the power of the study
- How (un)likely is it that authors exploited researchers degrees of freedom?
- Have the observations been replicated?
- What was the p-value, the effect-size and the confidence interval around the effect-size?

Determinants of false positives

By: Loek Brinkman

Learning objective: Familiarize students with the determinants of false positives
Time: 60 - 120 minutes

In 2005, John Ioannidis published the influential paper: 'Why most published research finding are false', in which he describes four determinants of false positives:

- The likelihood of the hypothesis
- Statistical power
- Alpha-level
- Researchers degrees of freedom

An accessible introduction to this topic is provided in this blogpost by Felix Schönbrodt, which includes a free interactive Shiny-App that students can use to see the effects of different values of these determinants. Slides to introduce this teaching format are can be found in this slidedeck (see section: Evaluating Literature)

After introducing the topic, ask students to play around with the Shiny-app. What values do they think are likely for each of the four determinants? How do these number relates to recent large scale replication attempts, that assess the replicability of articles of social sciences around 50 percent?

From the determinants of false positives, a number of markers can be identified to assess the credibility of an articles. These are discussed in a separate teaching format (assessing strength of evidence).

Filedrawer problem
By: Loek Brinkman

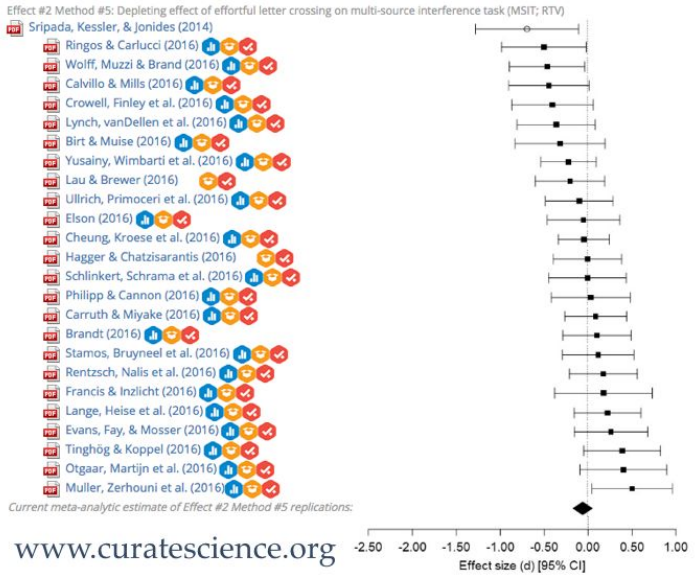
Learning objective: Familiarize students with the filedrawer problem
Time: 15 minutes

You can use the example on the right from the website Curate Science, where the bars represent the effect-sizes of the ego-depletion effect (and confidence intervals), amongst different studies.

Start with the premise that it is uncommon to publish results of which the statistical tests were non-significant. Instead, they end up in the 'filedrawer'.

Ask students: "If I have a article with a certain claim, two later articles that confirm this claim, and one later article that claims the opposite, what would you conclude (referring to the top three articles in the figure on the right and the bottom one)?

What do you conclude when you consider all these articles together (including those with non-significant findings)?



Registered Reports
By: Loek Brinkman

Learning objective: Familiarize students with the topic of Registered Reports
Time: 30 minutes

A relatively new format for publication is the Registered Report. Registered Reports are manuscripts where the peer-review process takes place *before* data collection. The initial manuscript consist of an introduction and a methods section only. When the manuscript passes the this peer-review stage, it is stated that the manuscript will be published in that journal, *regardless of the outcomes*.

You can discuss with students:

- What are the pro's and con's of Registered Reports
- How do Registered Reports prevent the 'filedrawer problem'

You can also distribute examples of Registered Report and regular articles and ask students how the articles differ, and how they assess the strength of evidence in those articles

For more information on Registered Reports, please have a look at this webinar.

This teaching format of can be discussed as a follow-up on 'Assessing strength of evidence'.

Reproducibility
By: Loek Brinkman

Learning objective: Hands-on experience with reproducing work of others
Time: 60 - 120 minutes

Reproduction of findings from the original data and code is the hallmark of verifiability. The topic can be treated in two ways:

1. **Reproducing findings from literature**

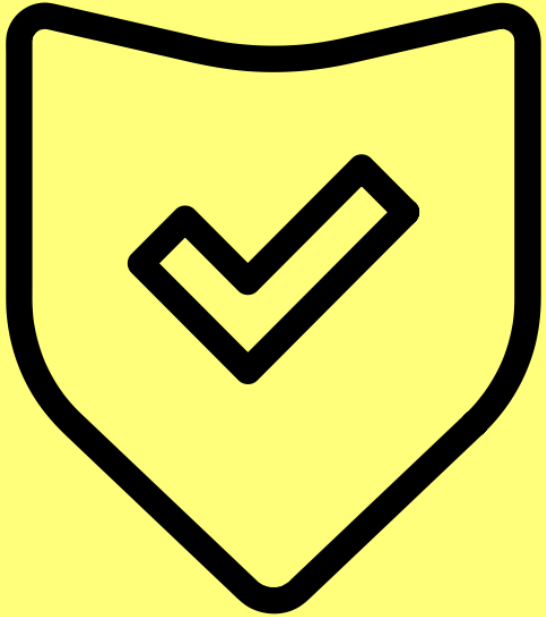
Prepare articles that have open data and open code.
To spark a discussion, you may also want to include articles for which the data is not open, or articles where the code/syntax is not included, to let students experience how difficult (or impossible) it is to reproduce findings in these cases.
As an example of the state-of-the-art, you can show this fully reproducible article in eLife, which is reproduced each time you visit the website (and allows for making real-time changes to the code).

2. **Reproducing findings of peers**

As part of a practical assignment (or in the bachelor thesis!), have students exchange their findings and their code/syntax, and ask them to reproduce the findings of their peers (note: they are not allowed to ask their peers any questions while reproducing, all the neccesary information should be there). Reproducing work also teaches students to work in a reproducible way themselves.

[PLEASE ADD YOUR TEACHING FORMAT HERE]
By:

Learning objective:
Time:



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Student as producer of knowledge

Reliability

Reproducible coding: GitHub

By: Loek Brinkman

Learning objective: Introduction to GitHub - version control and collaboration
Time: 60 minutes

All programmers know that when writing code/syntax, it is crucial to have a good version control system, to allow you to go back in time in case you make a mistake and mess up the code. GitHub is populare platform that is used for version control. Moreover, GitHub allows you to share your code with others and work collaboratively on the code.

On the GitHub website, you find a step-by-step tutorial to set-up a project on GitHub, called ‘Hello World’. Ask students to complete the tutorial. As a follow-up, ask students to use GitHub the next time they write code, e.g. for an assignment, or during their bachelor thesis.

Reproducible coding: R Markdown

By: Loek Brinkman

Learning objective:
Time:
Prerequisite: Basic knowledge of R (Open source programming language)

A powerful way of working in a reproducible manner is by using R Markdown files. An R Markdown file, is an R script that produces a text document (word-file, pdf of html-file). You can use it to load raw data, perform computations and statistical tests and create visualization of your data. In addition, you can refer to variable names in your text. As such, you don't have to write down any numbers in your article: the computed values are displayed in the text. This makes it very easy to reproduce the findings in an article. You just need the raw data and the R Markdown file and you can recreate the article on the spot.

An introduction to R Markdown (with exercises) is provided in the free ebook 'R for Data Science' by Garrett Grolemund and Hadly Wickham. When students have familiarized themselves with R Markdown, you can ask them to hand in assignment in this file format, or even their thesis.

Power analysis
By: Loek Brinkman

Learning objective: Able to compute sample-sizes based on power analysis for simple experimental designs
Time: 60 min

Power analyses are performed to compute required sample sizes, based on the expected effect-size, the required power and the alpha level. Conceptual knowledge and practical experience with power analysis help students to design solid research projects with adequate power. A popular free program to perform power analysis is G*Power.

This slide-deck (see section: Power analysis), made by Loek Brinkman, can be used to introduce power analysis (includes exercises).

After introducing effect-sizes, power and power analyses, students can use G*Power to compute required sample sizes for research projects. These projects could be hypothetical cases, or actual research projects, e.g. the bachelor thesis. For a more advanced class, you can also ask students to perform power analyses based on Monte-Carlo simulations (also introduced in the slides) in R.

Replicating work of others

By: Mario de Jonge & Loek Brinkman

Learning objective: Understanding the relevance and practical experience with replication studies
Time: 60 min or more

Independent replication of research findings is viewed as a cornerstone in science. However, analyzing the publication history of the top 100 journals in educational sciences, Makel and Plucker (2014) found that only 0.13% of all published articles were replications. Moreover, recent largescale collaborative replication efforts indicate that the replicability of published findings leaves much to be desired (e.g., Open Science Collaboration, 2015). Consequently, in recent years scientists have argued that we are in crisis and that something ought to change. One idea that has been forwarded in the literature (Frank & Saxe, 2012) is having **undergraduate students perform replication research** as part of their training in experimental methods. Replication research provides students with an **excellent opportunity** to learn about conducting scientific research, the importance of reporting standards, and the value of open science.

In the present research assignment, small groups of students enrolled in an Educational Psychology course worked on a project in which they had to replicate selected findings from the literature. The replication research assignment provides an example of how replication research can be easily implemented within a Psychology course. Also, we discuss the benefits, challenges, and lessons learned from the replication research assignment. A detailed description of this assignment can be found here.

The format of replication studies is also very much suited for bachelor theses. In the Social Neuroscience Minor, we have piloted this format, and both students and supervisors value it a lot. Here we aim to replicate studies that are important to specific fields, but for which the strength of evidence is suboptimal. Students value that they contribute to strengthen the body of knowledge (‘our study really matters’). For supervisors, there is also an added benefit that it takes less time to supervise students, as the phase of formulating a research question and piloting experimental designs is much faster.

[PLEASE ADD YOUR TEACHING FORMAT HERE]
By:

Learning objective:
Time:

Created by Gan Khoon Lay
from Noun Project

Created by David
from Noun Project

Student as <u>user</u> of knowledge

Science in society

Appreciating Team Science
By: Loek Brinkman

Learning objective: Value the importance if (interdisciplinary) collaboration
Time: 30 minutes

Scientific breakthroughs don't come out of nowhere. Each finding is **build upon previous work**. In that sense, we are all standing on the shoulders of giants. It is important for students to appreciate this fundamental aspect of science from time to time. In addition, most scientific breakthroughs originate from **interdisciplinary collaborations**. Moreover, many state-of-the-art research projects are only possible because of **large scale collaborations**.

Prepare examples of scientific breakthroughs in your discipline that originate from large scale and/or interdisciplinary collaborations and discuss them with your students.

Possible examples: the Human Genome Project, large-scale replication studies (e.g. here, here or here), CERN and the Allen Brain Institute.

Common Language

By: Loek Brinkman (based on teaching format in Cultural Anthropology - Marie-Louise Glebbeek)

Learning objective: raise awareness of the effects of language barriers
Time: 10 - 15 minutes

Hand-out research articles (groups of) students with the assignment to give a recap of the article after 5 minutes. The research articles should be a mix of:

- Articles in Dutch
- Articles in English
- Articles in Spanish
- Articles in German
- Articles in French
- Articles full or jargon
- Articles that are written more accessible (e.g. the ‘significance statement’ in Journal of Neuroscience)
- Articles that are very accessible (pop-sci)

The information in the research papers is irrelevant here. Discuss who has access / can utilize the information in the articles. Is this problematic? Can you think of solutions? How useful would translations of articles be? How useful are summaries for target audiences outside academia (no jargon)? In addition, students can explore www.gettheresearch.com, a search engine optimised to present research articles as simple as possible.

International Sources

By: Loek Brinkman (based on teaching format in Cultural Anthropology - Marie-Louise Grebbeek)

Learning objective: Create awareness of your ‘filter bubble’ of information
Time: 30 minutes

Give students 20 minutes to list where the countries where the knowledge they obtain during their studies comes from. How much of this knowledge originates from outside The Netherlands. This may seem very international, but how much of this knowledge originates from outside the global north? What are the consequences of this? Is this justifiable? Or are we missing out on important developments? Take 10 minutes to reflect on this with your students

As a follow-up, you can ask students to specifically look for information on a certain topic from a source *outside* the global north. How is this information different from what you normally encounter? Is this information useful?

[PLEASE ADD YOUR TEACHING FORMAT HERE]

By:

Learning objective:

Time:

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Student as <u>producer</u> of knowledge

Science in Society

Collaboration on CREPE

By: Loek Brinkman

Learning objective: Large-scale collaborations for replication studies in theses

Time: N.A.

The Collaborative Replications and Education Project (CREP) is an initiative to allow students to work in large-scale collaborations to replicate seminal articles. On the CREP website, students can search for seminal articles they want to replicate during their theses. In addition to their own data, they will have access to the data of all other students (worldwide) who are conducting research on the same topic. Examples of studies that are available to participate in are:

Griskevicius, V., Tybur, J. M., & Van den Bergh, B. (2010). Going green to be seen: Status, reputation, and conspicuous conservation. Journal of Personality and Social Psychology, 98, 392-404.

Kool, W., McGuire, J. T., Rosen, Z. B., & Botvinick, M. M. (2010). Decision making and the avoidance of cognitive demand. Journal of Experimental Psychology. General, 139, 665. Study 3

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A step-by-step tutorial in how to get started is provided here.

Communicating outside academia

By: Loek Brinkman

Learning objective: Communicate outside academia
Time: 60 - 180 min

There are many stakeholders outside academia (general public, policy makers, politicians, industries, children) that can benefit from scientific findings, but who find scientific articles hard to digest. It can therefore be very useful to communicate results in more accessible ways.

Give students a research article and ask them to present the outcomes to a particular target audience (e.g. see above). Formats they could use are e.g. podcasts, blogs, presentations or posters. It is particularly informative to see the same information being presented to different target audiences.

This teaching format is also particularly suited to be integrated with the bachelor thesis: communicate your results to stakeholders outside academia who may benefit from your research.

[PLEASE ADD YOUR TEACHING FORMAT HERE]

By:

Learning objective:

Time: