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Grant Proposal

Towards Open Science within Health Care Technology and Management Education

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Abstract

Lack of research reproducibility, restricted access to scientific knowledge to citizens, fake news (on social media) and limited citizens' involvement during scientific knowledge generation are phenomena which negatively affect the relationship between Science and society. Unfortunately, students, who will be the next scientists, practitioners and citizens, are not educated to address these scientific and societal challenges. Teaching Open Science (OS) principles to students may equip them to deal with these challenges during their future career. OS refers to any endeavour aiming to make one's research more open, inclusive, accessible, reproducible and replicable. Therefore, OS is expected to address these challenges by promoting: open and reproducible research, publicly available scientific knowledge, public engagement of (scientific) experts within society and greater citizens' involvement in Science. OS consequently promises to transform the relationship between Science and society. This teaching innovation will introduce Health Care Technology and Management students with the theoretical underpinning of OS and will let students practise OS during a group project. The teaching activities will comprise a series of interactive lectures and practical assignments. Key topics of this teaching innovation are an introduction to OS and FAIR principles, pre-registration, performing open reproducible research, open peer-review and practise public outreach. The teaching materials and activities will be co-created with students who already participated in this course to ensure the OS content matches students' knowledge, interests and needs. Dissemination efforts

will be undertaken during the entire duration of the project to increase awareness concerning the importance of teaching OS within educational curricula.

Keywords

Open Science, Health Technology Assessment, simulation model

Problem analysis, innovation and expected results

Formulation of the problem

Lack of research reproducibility (Baker 2016), restricted access to scientific knowledge in the public domain, fake news (on social media) (Bates 2020) and limited citizens' involvement during scientific knowledge generation are phenomena which negatively affect the relationship between Science and society. Unfortunately, students, who will be the next citizens, scientists and practitioners are not educated to address these scientific and societal challenges.

Teaching Open Science (OS) principles to students may equip them to deal with these challenges during their future career. OS refers to any endeavour aiming to make one's research more open, inclusive, accessible, reproducible and replicable, as described in the UNESCO Recommendation on Open Science (UNESCO 2021) and the FAIR principles (Wilkinson et al. 2016). Therefore, OS is expected to address these challenges by promoting: open and reproducible research, publicly available scientific knowledge, public engagement of (scientific) experts within society and greater citizens' involvement in Science. OS consequently promises to transform the relationship between Science and society.

Due to the important role of higher educations' institutions in educating future citizens, scientists and practitioners, they should adequately prepare these future generations for practising and engaging with OS. Developing an OS mindset and skillset is becoming increasingly important and should become an essential part of academic curricula (de Knecht et al. 2021). An OS mindset means that students develop a "*(self-)critical attitude towards the academic system and scientific knowledge*" (de Knecht et al. 2021). This comprises an understanding of the benefits of OS and of the barriers for implementing OS. The OS skillset encompasses the skills needed to make one's research open and to navigate and participate in the scientific knowledge generation process and debate.

Currently, OS practices are mostly promoted amongst academics through Open Science Communities (Armeni et al. 2021), courses (Kuchma et al. 2018, Kramer and Bosman 2017) and open educational resources (FOSTER 2022, Delft University of Technology 2022, FORRT 2022). Only a handful of initiatives focusing on teaching OS principles to (university) students are reported in the (scientific) literature and online (Steinhardt 2020, Jekel et al. 2020, Cook et al. 2018, Hanna et al. 2021). These initiatives focusing on

teaching OS principles to (university) students were mostly implemented outside the Netherlands (except for one) and were specific to a study programme (e.g. Anthropology (Steinhardt 2020), Archaeology (Cook et al. 2018), Biology (Hanna et al. 2021). These initiatives mainly focused on teaching a specific aspect of OS (e.g. (re-use of) open data (Cook et al. 2018), replication (Jekel et al. 2020), collaboration (Steinhardt 2020), except for one Canadian innovation which aimed to teach the Open Science mindset over the entire research cycle to bachelor students (Hanna et al. 2021). These previous initiatives have embedded OS within their teaching by letting students use available digital tools used by researchers to make their research more open (Steinhardt 2020, Jekel et al. 2020). This shows that available digital (research) tools may be used during educational activities to teach the OS skillset to students, such as pre-registration, Open data, data re-use and collaboration. Additionally, previous initiatives have concluded that:

1. students appreciate this evolution of Science towards increased transparency and collaboration (Hanna et al. 2021),
2. students become aware of the difficulties in applying OS principles (e.g. making data re-usable) (Cook et al. 2018) and
3. students find it challenging to participate and contribute to open scientific efforts (Steinhardt 2020).

These initiatives show that embedding OS principles and skills within higher education is feasible; however, these initiatives were mostly narrow in scope, most did not cover the entire research cycle and did not always contain an application of OS principles. This may be problematic since the OS skillset can only be obtained by “doing OS”.

Beside these initiatives, groups of students have set-up Students Initiatives for Open Sciences (SIOS, for example, in Twente (SIOS-Twente (2022))). However, these SIOS remain limited in number and scale and may only attract an already-interested public.

Innovation and expected results

The current teaching innovation will be introduced during the “Advanced simulation for health economic analysis” course from the Health Care Technology and Management specialisation of the Industrial Engineering and Management Master programme. During this course, students have to develop a health economic simulation model, which provides the perfect opportunity to apply OS practices and develop their OS skillset concerning open reproducible research. Currently, the teaching curriculum of this Masters' programme does not address OS.

This teaching innovation will address how practising OS affects the entire research cycle and encourage students to apply OS principles during their project. This teaching innovation will be composed of a series of interactive lectures and practical assignments. The lectures will provide the theoretical background of OS and the practical assignments will focus on the implementation of OS within their project. A group reflection on the benefits and barriers to OS for Science and society will conclude this teaching innovation. This project is innovative in three ways: the participating student group, the topic (health

economics) in which OS principles will be implemented and the teaching of both theoretical and practical applications of OS (which was lacking in most previous initiatives).

At the end of this redesigned course, students will be able to:

1. describe OS principles,
2. understand the benefits and barriers to OS (develop an OS mindset) and partake in the debate on the role of Science in society,
3. develop an OS skillset (beginner's level) by being able to navigate and use digital tools facilitating the implementation of Open Science.

This project fits within theme 4 "Open theme" since OS is an important element of the strategy of the Dutch Ministry for Education, Culture and Science towards a sustainable future (Ministerie van Onderwijs, Cultuur, en Wetenschap 2019). Additionally, "Education & Skills" is one of the pillars of the European Union strategy towards an OS future, which makes this teaching innovation relevant within the international context (European Commission 2021). Finally, the University of Twente's vision is to embrace OS by 2030, making this educational innovation highly relevant from an institutional perspective (University of Twente. 2021).

OS is here to stay, hence the experiences, materials and results of this teaching innovation will be shared with the educational community through an Open Access publication, the development of open educational resources and presentations at conferences. In this way, other education professionals will be aware of this teaching innovation and will be able to re-use the developed materials.

Project plan

This section describes the project plan, risk analysis, project team and plan for dissemination.

Overview of the project plan

The project contains five activities:

1. [May 2022–October 2022] Development of a survey to assess students' knowledge concerning OS and carrying out the survey amongst the students who will participate in the teaching innovation.

Recruitment of two student assistants to co-create the teaching materials for this teaching innovation. The students assistants and I will use this period to sharpen our knowledge of (teaching) OS by consulting available (teaching) resources on OS (Kramer and Bosman 2017, Kuchma et al. 2018FORRT 2022, FOSTER 2022, Kramer and Bosman 2017, Kuchma et al. 2018, Delft University of Technology 2022).

2. [October 2022–February 2023] Development of the teaching materials.

Learning activities addressing each research cycle phase will be developed. The research cycle phases are: preparation, discovery, analysis, writing, publication, outreach and assessment (inspired by a Summer School of the University of Utrecht on OS (Kramer and Bosman 2017)).

To efficiently develop the learning materials, the "*adopt, adapt, develop*" principles will be followed. Existing online resources and courses will be consulted during the development (Kramer and Bosman 2017, Kuchma et al. 2018FORRT 2022, FOSTER 2022, Kramer and Bosman 2017, Kuchma et al. 2018, Delft University of Technology 2022). Since these resources are mostly aimed at researchers, they will be adapted to meet the students' knowledge, interests and needs.

The developed teaching activities will:

- introduce OS principles for each phase of the research cycle,
- provide practical examples of implementing OS principles and
- provide an opportunity to apply OS practices.

Even though I will address all phases of the research cycle, key teaching activities will focus on introducing OS and FAIR principles, pre-registration (Wharton Credibility lab - University of Pennsylvania 2022), performing open reproducible research using a combination of open-source software (R and Github), engage in open peer-review and perform public outreach (e.g. using the "up-goer five" method (Rowan 2013)).

3. [February 2023–April 2023] Teach the course.

Students (working in pairs) will have to apply at least one OS principle when developing their health economic simulation model. To ensure a diversity of OS principles are addressed by student groups, each group will have to apply a different OS principle on their project. During the final session of this teaching innovation, the Open Science mindset of students will be assessed by performing the "key-terms" game (Fernandes 2014) to introduce a discussion on the benefits and barriers to OS. Students will then have to showcase how they adhered to the OS principles. The group adhering the most adequately to OS principles will be elected by students and will receive a small prize. The criteria on which the most Open group will be selected will be decided upon by students during the course, after having seen examples of OS practices.

4. [April 2023] Evaluation of the teaching innovation.

Students' knowledge concerning OS will be re-assessed using the same survey as in activity 1 and additional questions concerning the quality of the teaching materials and activities relating to this teaching innovation. During the final discussion on OS with students, feedback on the teaching innovation will be gathered.

5. [July 2022–August 2023] Dissemination activities.

Dissemination activities will be undertaken during the entire duration of the project. The current proposal will be uploaded to Research Ideas and Outcomes Open Access journal

(RIO 2022) and progress of the project will be shared and promoted via social media (LinkedIn). The final results will be shared through an Open Access publication and congress presentation(s).

Evaluation and risk analysis

This project will be considered successful when the following criteria have been met:

1. all groups of students have applied adequately at least one OS principle when developing their health economic simulation model (objective assessment),
2. the level of students' knowledge concerning Open Science has increased between the survey taken under step 1 and step 4 (objective assessment),
3. students have developed an OS mindset as demonstrated during the second survey and the final group discussion (subjective assessment).

There is always a risk that students do not fully engage with the developed teaching activities. Hence, I have introduced the requirements of applying at least one OS principle to their project and of actively participating during the last teaching activity to successfully achieve this teaching innovation. The competition element (the most Open group will win a prize) aims at increasing students' engagement during the teaching activities and OS. Finally, experience tells that students' response rate to online survey may be low. Therefore, students' knowledge on OS will be tested during the first and last teaching activity using a polling system, such as Wooclap.

Composition of the project team

Xavier Pouwels is an assistant professor in health economics and member of the Open Science Community of Twente (OSCT). He is leadership-member of the Open Source Models Special Interest Group of ISPOR, the largest international health economics and outcomes research community. Xavier has the theoretical knowledge of OS principles and the practical skills to implement these principles within health economic modelling. Both these skills are required to teach OS, which is still an evolving field of research and education within health economics. Xavier has successfully achieved his University Teaching Qualification. He is the lecturer during the "Advanced simulation for health economic analysis" course and teaches courses on health economics, which he continuously updates through the implementation of novel teaching methods, such as interactive applications for students. Xavier recently received a grant to implement challenge-based learning within these courses. Xavier will be responsible for project planning, developing the materials, teaching, evaluating and dissemination of this project.

Student assistants will be recruited at the beginning of this project, by advertising this project at the end of the 2021-2022 edition of the "Advanced Simulation for Health Economic Evaluation" course. These student assistants will co-create with Xavier the teaching materials that will be used during this teaching innovation. Their role will be to discuss and advise on which OS topics are of interests (and should receive more emphasis) for participants in the course. They will participate in designing, testing and

disseminating the teaching materials. They will provide feedback on the connection of the teaching materials with previous students' knowledge, the difficulty of these materials and the time investment required to perform the developed teaching activities (to ensure it does not jeopardise the other learning objectives of the course).

Hendrik Koffijberg is the course coordinator of the course in which this teaching innovation will be implemented. He is a member of the OSCT and of the scientific advisory committee on pharmaceuticals' reimbursement from the National Health Care Institute. Naomi van der Linden is an experienced health economic modeller, reviewer of health economic models and teacher in health economics. Both Hendrik and Naomi will advise on how OS skills may be implemented within the existing course and will provide input on how OS will affect health economics research and health policy-making.

Helma Vlas, senior consultant of the Centre of Expertise In Learning & Teaching at the University of Twente (UT), will support the choice of design, implementation and evaluation of the educational activities in collaboration with Xavier and the student assistants.

Markus Konkol is OS officer at the Faculty of geo-information science & earth observation and an expert in computational research reproducibility. He will advise on the most appropriate methods and tools to teach open reproducible research principles to students.

Qian Zhang, member of the Digital Competence Centre at the UT, will advise on which digital tools are the most appropriate to use during this teaching innovation, considering the Dutch setting and legislation.

The research team is described in Table 1.

Table 1.

Composition of the project team.

Name	Organisation	Function	Role in this project
Xavier Pouwels	UT	Assistant Professor	Project planning, material development, teaching, evaluation and dissemination.
Student assistants (to be recruited)	UT	Students	Co-creation of the teaching materials
Hendrik Koffijberg	UT	Professor/ Section chair HTSR	Project advisor on the impact of Open Science on health policy-making
Naomi van der Linden	UT	Assistant Professor	Project advisor on the implementation of Open Science within health economics
Helma Vlas	UT	Educational Consultant CELT	Advisor on educational activities
Markus Konkol	UT	Open Science Officer	Project advisor on teaching open reproducible research
Qian Zhang	UT	Data steward	Project advisor on digital tools for Open Science

Plan for dissemination

The research proposal will be uploaded on the Research Ideas and Outcomes Open Access journal (RIO 2022). The proposal, process and results will be discussed during meetings of the Health Technology and Services Research (HTSR) section. The developed learning materials and results will be archived on Zenodo (European Organization For Nuclear Research and OpenAIRE 2013) for any teacher to reuse them. The process and results of the project will be reported in a pre-print journal article and then converted to an Open Access journal article. All publications relating to this project will be shared on the LinkedIN account of X. Pouwels and of the HTSR section and on the HTSR and OSCT websites. The OSCT webpage will be used to disseminate the open educational resources which will be produced during this teaching innovation. I will present this teaching innovation within an OSCT meeting at a health economics conference (iHEA, LOLAHESG) and an educational conference (e.g. “Onderwijs Research Dagen” (ORD 2021)).

Based on students’ feedback, the teaching innovation will be updated and tailored to be implemented within the “Health Economic Modelling” course of the Health Sciences Master (already approved by the course coordinator Hendrik Koffijberg). Programme directors of other curricula will be approached to discuss further implementation of this teaching innovation at the University of Twente.

This dissemination plan fits the NWO Open Access strategy.

Funding program

Comenius Teaching Fellows 2022 (https://www.nro.nl/calls/comeniusprogramma-teaching-fellows-2023)

Grant title

Towards Open Science within Health Care Technology and Management Education

Hosting institution

University of Twente

Conflicts of interest

None

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