Journal of Academic Ethics
https://doi.org/10.1007/s10805-024-09527-6

Teaching Scientific Integrity in Academia: What and How Students Want to Learn?

N. Sira[1] · M. Decker[2] · C. Lemke[2] · A. Winkens[2] · C. Leicht-Scholten[2] · D. Groß[1]

Accepted: 18 March 2024

Abstract
Training in scientific integrity continues to be an important topic in universities and other research institutions. Its main goal is to prevent scientific misconduct and promote good scientific practice. However, there is still no consensus on how scientific integrity should be taught. Moreover, the perspective of those who receive such training is often underrepresented. Yet it is precisely their interests and needs that must be considered when developing educational programs. Against this backdrop, we conducted a mixed-methods study with the goal of capturing students' perspectives on the teaching of scientific integrity. Using our online Scientific Integrity course, we explore what specific aspects of digital teaching on scientific integrity are valued, and explore other topics of interest from students' perspectives on scientific integrity. The article presents (1) students' self-assessment before (Q1) and after (Q2) taking the online Scientific Integrity course at the RWTH Aachen University in Germany (2) students' feedback on the course format, video, exam, organization, and support (Q2) (3) a list of other topics of interest in the area of scientific integrity (Q2). The research outcomes demonstrate an improvement in the study participants' self-assessment after following the online course and there is a general satisfaction among the students in regard to the course digital format and its components although a desire to have more exchange and discussion was expressed. Further topics of interest in the area of scientific integrity that study participants would like to learn about have a practical appeal and among others include research pressure, examples of applications, preventive measures, theory of science, citation rules, funding of university research. Although the results relate to our course, they provide insight into students' perspectives on online teaching of scientific integrity. Thus, they may be helpful to higher education institutions developing online courses on scientific integrity that are tailored to university students.

Keywords Scientific integrity teaching · Digital teaching · Scientific integrity in academia · Students' evaluation

Extended author information available on the last page of the article

Published online: 28 March 2024

Introduction

Teaching Activities on Research Integrity

Numerous trainings on research integrity have been conducted in the past decades but information on what works and what does not work in these training are still inconsistent (Hoven et al., 2023a). Single studies may suggest that teaching responsible conduct of research is not effective and may even harm should it tempt students to overemphasize avoidance of ethical problems, to have excessive confidence in their ability to deal with ethical problems, or to overstress their ethical nature (Antes et al., 2010). Most researchers, however, affirm that the implementation and promotion of research integrity in research-performing and research-funding institutions may have a positive impact on responsible conduct of research (Bero & Kuhlman, 2011; Brkic et al., 2012; Kretser 2019, Fisher 2002). The case-based ethics training, together with codes of conduct and forecasting content, leads not only to better knowledge acquisition but also to a more frequent use of sensible strategies as well as to a better decision ethicality (Harkrider et al., 2012). Learning may begin with experience (Argote, & Miron-Spektor, 2011) and supplying accurate content, such as ethical domains, norms, and behaviors, seems to play a crucial role in designing effective ethics instruction (Antes et al., 2009).

A Need to Evaluate

For decades, there has been a pressing need to better categorize and evaluate the content of the research integrity resources (Steneck, 2013; Hoven et al., 2023a) and what else if not the students' feedback on teaching is a valuable source of information that may be used to evaluate and improve teaching offers (Seldin, 1997; Flodén, 2017). To empower education on responsible conduct of research, learners should be involved in determining what is taught (Hoven et al., 2023b). Students' perspective on scientific integrity teaching is underrepresented and to the best of our knowledge, no studies have been conducted to explore which topics of scientific integrity undergraduate or graduate master's students want to learn about. Some studies present the perspective of the stakeholders and researchers discussing which topic areas organizations should focus on to strengthen research integrity (Sørensen et al. 2021). Further research deals with academics' perception (including scientists, academic teachers and students) of research integrity and ethical training in academia (Kalinowska et al., 2020), inquire on students' perception of the effectiveness of education in responsible conduct of research (Plemmons et al., 2006), evaluate the effects of such teaching on ethical decision making (Antes et al., 2010), study the student perception of preparedness for responsible conduct of research (Kondakci et al., 2022) or of engagement in academic dishonesty (Stephens et al. 2021). Most of the studies take into consideration only the doctorate students while in our study we examine the master's students' perspective. Studies dealing with the students' perspective on Scientific Integrity are limited: Hermeking and Priess-Buchheit (2022) have conducted a study of the trainers' perspective on the research integrity teaching functionality based on the Path2Integrtiy Learning Card program, thus assessing whether the adopted program worked for the students however assessing from the trainers perspective; Zollitsch et al. (2022) have developed the instruments to evaluate success of the training in responsible conduct of research consisting in the content-specific or case-

based scenarios students and expert have to assess in a form of questionnaire; finally Valeva et al. (2022) presents a cultural comparison of the university students' mindset on research integrity. Therefore the purpose of the current paper is to shed light on this underrepresented focus group and its needs and wishes. It has to be noticed, that part of the questions was already used in our previous study (Sira et al., 2022) in which the outcomes of the winter 2020/2021 on these close-ended questions were presented. We take into account that scientific integrity teaching should be collocated at an early phase of the career; thus, in order to contribute to the development and attractiveness of these courses among the students, we focus on the student's perspective on scientific integrity.

The Case of the Online Course "Scientific Integrity" and its Evaluation

Since winter 2020/2021, we offer an online course Scientific Integrity as a compulsory curriculum activity for all masters' students the RWTH Aachen University. In the study mentioned above (Sira et al., 2022), we provided an overview of the course topics and intended learning outcomes of the five modules. Since summer 2021, the number of modules has been expanded from five to six, now covering the following topics:

1. What is Scientific Integrity?
2. Recommendations for Safeguarding Scientific Integrity.
3. Scientific Misconduct.
4. Social Responsibility and Research Ethics.
5. Diversity in Science.
6. Dealing with Research Data and Conflicts of Interest.

The course has an online self-learning structure and does not provide face-to-face components. The learning material of the digital course is available in the Moodle online learning platform and consists of explanatory videos of 10- to 20 min duration and script document of the videos for every module mainly based on the German curriculum of Good Scientific Practice (Sponholz 2012, 2019). Whereas most of the videos have a presenter's mode with the lecturer explaining the contents, two videos consist in a dialogue between the lecturers. Further course sections include case studies (based on Gundersen, 2017) and exam example questions. While the exam example questions have a practical appeal, the part with the case studies has a self-reflection nature: it presents some well-known case studies on the topic of academic misconduct as well as short example situations from everyday life where students are invited to think about possible actions to take. A conclusive part of the course consists in a 30-minutes online exam. According to the intended learning outcomes, after a successful completion of the course students develop their knowledge of: principles of scientific integrity; definition, forms, and relevance of scientific misconduct; relevant normative issues in science, such as conflicts of interest or misconduct, and possible solutions; understand the relevance of research ethics and diversity in science, and reflect on their own responsibility in research and science (Sira et al., 2022). With the introduction of the sixth module, students also learn about the tasks of research data management and possible forms of collaboration in science.

In the previous study (Sira et al., 2022), we outlined the online course Scientific Integrity of the RWTH Aachen University, and conducted a quantitative case study explaining to

what extent teaching of Scientific Integrity meets genuine interest among master's students. The study involved master's students of the RWTH Aachen University who were asked to anonymously fill out Questionnaire 1 (Q1) before starting the course and Questionnaire 2 (Q2) after completing the course. The questionnaires were based on the intended learning outcomes of the course as well as general questions about scientific work and consisted of three groups of questions: background, interest, and awareness. The background section inquired on the participants' gender, nationality, and respective academic faculty through multiple-choice responses. Additionally, it was asked whether the course was mandatory and whether study participants had already taken a similar course. The interest group of questions explored whether study participants were interested in the topic, whether they would take the course even if it were not mandatory, whether they believed that the knowledge and competencies learned would be useful in their academic or professional life, and whether they enjoyed doing scientific work. Finally, the awareness questions addressed the ability to describe a concept of scientific integrity, to perform scientific work, and to recognize scientific misconduct. In this section, study participants were also asked to indicate their ability to understand scientific literature and quote a source. Answers to both interest and awareness question groups could be selected from a five-step scoring scale "strongly agree, agree, neither agree nor disagree, disagree, strongly disagree." Based on the online questionnaires filled out before starting the course (Q1) and after completing the course (Q2), it was found that the implemented course achieved a satisfactory acceptance among master's students: accordingly, 57% of study participants initially (Q1) strongly affirmed to be interested in the topic; this percentage increased to 65.3% at the end of the course (Q2) (Sira et al., 2022).

External to our previous study and independent from both questionnaires, after every exam session we offered course participants a possibility to express their satisfaction with technical implementation and handling of the digital course, to show their interest in further topics, and to write some notes or comments to the proceeding or content of the course. The feedback was not conceptualized as part of the study, it either had an explorative character aiming at having student's perspective on every exam session. Indeed, under further notes and further topics of interest course participants indicated numerous details on their perspective, thus it was decided to collect also the qualitative feedback and include the open-ended questions into our study with the aim to better represent the student perspective on scientific integrity. In particular, based on the non-structured comments it was decided to structure our questions in the following sections: course format, videos, content, exam, organization and support.

The questions of the previously conducted quantitative study were adopted and enriched with open-ended questions to collect qualitative feedbacks on the course format, videos, content, exam, organization and support. With this novel mixed-method study we aim at understanding qualitatively and quantitatively the students' view on Scientific Integrity teaching. In particular, we study what and how students want to learn through: (1) students' self-assessment before (Q1) and after (Q2) following the online course Scientific Integrity (2) students' satisfaction feedback on the course format, video, exam, communication and exchange (Q2) (3) the list of further topics of interest in the area of scientific integrity that students would like to learn about (Q2).

Methods

Participants and Process

We provided two questionnaires that students had to fill out before (Q1) and after (Q2) taking the course. The course-oriented and interest questions for the pre- and post-evaluation were implemented on the Moodle course platform. The study was conducted as part of our online offerings during the Summer 2022 and Winter 2022/2023 semesters and aimed to (1) better understand the issues identified in the previous study regarding student interest in participating in the program and (2) make possible improvements to meet student needs and interests. Whereas the previous study analyzed the students' attitude and interest in following the course in a quantitative way throughout the choice questions, the current research adopts a mixed semi-qualitative method which includes open-ended questions. Thus, similar to the previous study, we quantitatively evaluate the students' interest in the subject, their progress during the course and changes in their attitude towards the topic of scientific integrity; additionally, in the current study we focus on the students' satisfaction on some online-course-specific aspects as well as on the topics of scientific integrity domain students would like to learn about. The evaluation before the course (Q1) was generally maintained, the evaluation after the course (Q2) was modified to introduce more open-ended questions and collect in such way more qualitative results. The newly introduced questions regarded theoretic, organizational and technical aspects, and were implemented in addition to the previously existing background, interest and awareness questions which also have been extended.

Content and Instruments

The background, interest and awareness sections already mentioned in the introductive part of this paper have been adopted from the previous study.

The course-specific questions asked students to express their opinion on the course content, format, videos, exam, communication, and exchange. Most of these questions have single-choice answers on a five-step scoring scale and additional open-ended questions where survey participants can specify their answer or write some additional comments and thoughts. Questions about contents ask whether students would like to have more contents, and which specific contents they would like to learn about; the multiple-choice answer can be selected between the following options, based on the non-structured feedback received from the students after the exam sessions in the previous semesters:

- none
- research ethics
- consequences of academic misconduct at German universities
- practical legal consequences in the event of scientific misconduct
- dealing with research pressure
- examples or applications
- statistics on the mentioned topics
- data security
- open access

- dealing with conflicts of interest
- dealing with and problems with / from peer review processes
- science communication
- scientific work
- others, namely: (free text)

Regarding the content, study participants can specify further topics of scientific integrity of their interest in an open-ended format.

The surveys were available in the online learning room of the course: Q1 was available for every student registered to the course in the beginning of the course, Q2 was available after the exam for two weeks. The study has been approved by the Ethics Commission of the Medical Faculty of the RWTH Aachen University (EK22-346). In accordance with data protection regulations, no personal information was collected, i.e., no student names or matriculation numbers were registered. After accomplishment, the surveys answered in two languages (English and German) were grouped, translated and analyzed. For the analysis we considered all the questionnaires that have been completed. Quantitative part of data, after grouping and translating was examined manually through graphic representation with the aid of spreadsheets. The comparison took into consideration the percentages of the different replies based on the number of respondents who answered to the question. Qualitative data has been analyzed manually with a methodological approach of qualitative content analysis (Mayring, 2000). First, to categorize the students' comments, a deductive analysis took place: data was examined with regard to specific pre-determined course aspects. Second, with an inductive approach, qualitative data was analyzed to induce further aspects and categories. Finally, qualitative data was translated, selected for representativeness and relation to the course, categorized and filtered on repetitions. In the following section, we present the outcomes of the surveys collected in summer 2022 and winter 2022/2023 that have been combined together to permit a better visualization.

Results

The participation in both surveys was as follows: 3928 students have completed the Q1 and 1827 the Q2. Therefore, based on the relation to the number of the students that have registered to the course and had access to the learning room, the response rate to the Q1 is 76.2% and 35.4% to the Q2. Both response rates were calculated with the reference to the number of the students that were present in the learning room and were asked to fill out the questionnaires. For both semesters, a total of 3768 students have participated in the exam and based on our exam statistics 99% of the students registered for the exam have passed the exam. Together with the background, interest and awareness questions enriched by qualitative comments, we present a comprehensive image of the Scientific Integrity course perception and satisfaction among master's students. The next section presents the students' background, interest and self-assessment and is followed by the course specific feedback regarding the content and format, learning videos and exam of the course, as well as communication, support, and exchange within the course.

Background, Interest and Self-assessment

Based on the background questions outputs, most of the survey respondents are male (63% are male, followed by 34% female and 0.5% other), German (64% are German, followed by 27% of the Non-EU and 6% of the EU citizens) and appertain to the Mathematics, Computer Science and Natural Sciences or Mechanical Engineering areas of study. Our results respect the RWTH Aachen University realities (RWTH Aachen University, 2023). About 93% of the respondents declare the course to be mandatory for them, and about 90% state they have never followed a course on "scientific integrity" in the past.

Regarding the interest questions: in the post survey, the percentage of "(strongly) agree" increased; therefore, most of the respondents state to be interested in the topic "scientific integrity" and willing to participate or register to the course even if it were not mandatory for them. Additionally, most of the respondents believe that the skills gained during the course will be useful for their academic or professional life, and affirm they like to work scientifically. Figure 1 presents the complete feedback of the interest questions on Q1 and Q2.

Based on the self-awareness assessment (Fig. 2), the awareness of being able to describe "scientific integrity" in own words has remarkably increased after the completion of the course. The awareness questions also included a statement on the ability to conduct scientific work, on knowing how to quote a scientific source, and on the ease of understanding scientific literature.

Even though the transfer of knowledge for the practical application of scientific work—such as the production of scientific papers—was not part of the course Scientific Integrity, we can still see a slight change in the self-assessed awareness: in comparison to Q1, in Q2,

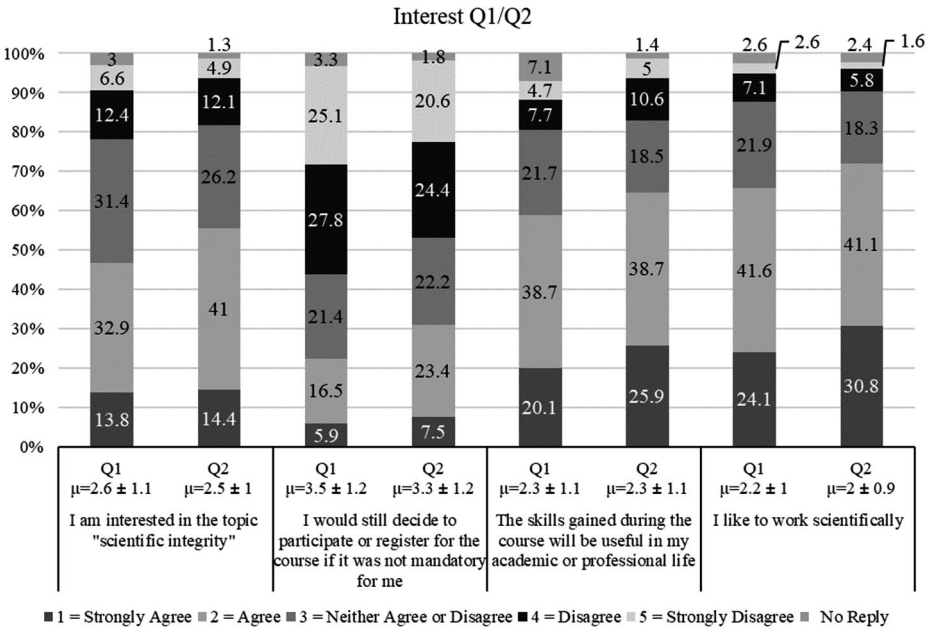


Fig. 1 Interest questions. The rating scale went from 1 = "Strongly Agree" to 5 = "Strongly Disagree". A low mean value (μ) therefore means a high level of agreement. The mean value is presented together with the standard deviation ($\mu = \mu \pm \sigma$)

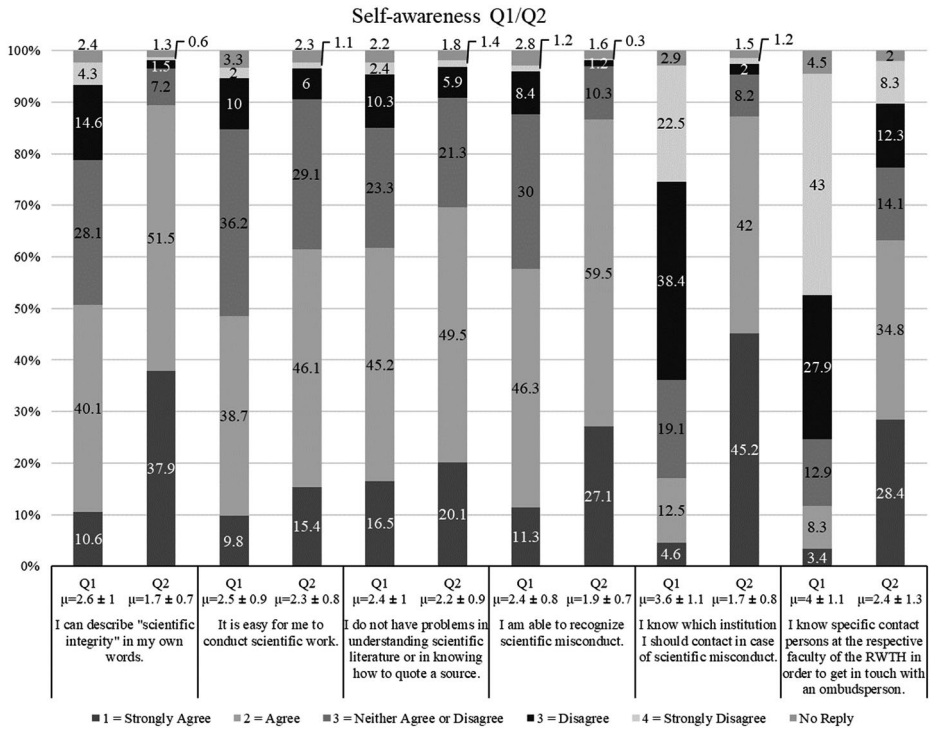
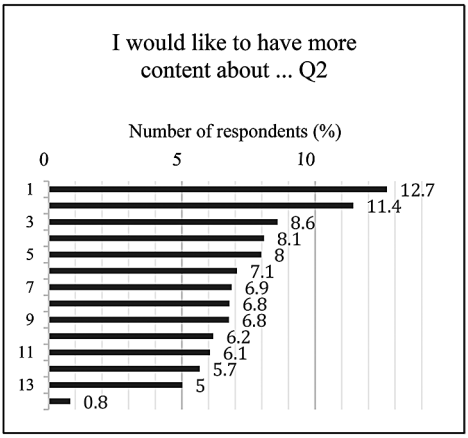


Fig. 2 Self-awareness about scientific work, integrity and misconduct. The rating scale went from 1 = "Strongly Agree" to 5 = "Strongly Disagree". A low mean value (μ) therefore means a high level of agreement. The mean value is presented together with the standard deviation ($\mu = \mu \pm \sigma$)

after having completed the course, more study respondents state that it is easy for them to conduct scientific work and to understand/quote scientific literature. The second group of self-awareness statements regarded scientific misconduct. This topic was also covered in the online course, thus some improvement in the self-awareness evaluation was expected. The first statement was general, and tested the students' ability to recognize scientific integrity; the second was more specific and inquired whether the students knew which institution they have to contact in case of scientific misconduct; finally, the last was the most specific and asked whether students know specific contact persons at the respective faculty of the RWTH Aachen University to turn to in order to get in touch with an ombudsperson. All the statements demonstrate an increase on the self-awareness about scientific misconduct. Figure 2 presents the complete feedback of the self-awareness statements dealing with scientific integrity, scientific misconduct and working scientifically collected with the Q1 and Q2.

Course-Specific Feedback: Content, Format, Videos, Exam, Communication, Support and Exchange

This second part of the results was collected through the adoption of the mixed method consisting in quantitative and qualitative data: after the multiple-choice, close-ended questions, study participants were asked to express further comments on singular aspects of the course.



1	Dealing with research pressure
2	Examples or applications
3	Practical legal consequences in the event of scientific misconduct
4	Dealing with conflicts of interest
5	Consequences of academic misconduct at German universities
6	Data security
7	Scientific work
8	Dealing with and problems with / from peer review processes
9	None
10	Statistics on the mentioned topics
11	Research ethics
12	Open access
13	Science communication
14	Others, namely: (free text)

Fig. 3 Selection of topics for further content

Fig. 4 Further topics of interest expressed in the format of open-ended comments

Theory of science
Further preventive measures
A refresher on citation rules
P-hacking
RWTH-specifics
More practical examples
Disadvantages of diversity
Funding of university research
Dealing with scientific misconduct in the working groups

Consequently, we present the results of these questions. For every section, we first presented the close-ended question, and second the open free text comments summary.

In the content section, students were asked about which topics they would like to examine in more depth. Figure 3 presents the complete feedback of both semesters and it may be noticed that a topic that attracts most of the interest of the students is "Dealing with research pressure", followed by "Examples of applications". A multiple-choice, as well as open-ended comments were possible in this section.

The open answer to the question on the content gave the students a possibility to suggest further topics that were not present in the list. Consequently, we present a summary of the comments on the contents. According to the Q2, students would generally like to have more practical examples and would be interested to have further content, in Fig. 4 we present a summary of the qualitative feedback. Every category was defined in an inductive way based on the students' comments, some comments were grouped into a bigger category. Please note that we only present the topics which were not already included in the quantitative section presented in Fig. 3.

In the format section, study participants were asked to provide their feedback on the course format: thus, to strongly agree, agree, neither agree nor disagree, disagree, strongly disagree on the statements regarding course structure, format in general, format of the interviews-videos and technical user-friendliness of the digital teaching offer. Figure 5 presents the outcomes.

In the same section on the format, study participants could also express further ideas and comments in a free-text-form on the format of the course (Table 1). Consequently, we present the comments that have been selected based on the (1) relation to the course (2) relation to the mentioned aspect (3) repetition. Based on the relation to the mentioned aspect of the course some comments were reorganized to the appropriate categories. Finally, while we tried to represent all the aspects identified in the students' statements, the double statements that were dealing with the same aspect were presented only once.

Videos on the six topics constitute an important part of the course. The outcomes demonstrate that most of the study participants (84%) strongly agree that the length of the videos was appropriate to the format. Free-text comments and further comments provide some opinions on the videos of the course (Table 2).

Our study results show that most of the study participants (90%) are satisfied with the technical user-friendliness of the digital exam. Regarding the length and scope of the exam, most study participants agree that time was sufficient. However, according to the open text question (Table 3), some study participants complain that more time should be available to complete the exam and 30 min are not sufficient. Additionally, in the close-ended questions students select what they would like to have in order to prepare for the exam: most study participants (63.3%) wish to have a mock exam as a preparation for the exam; some (13.1%)

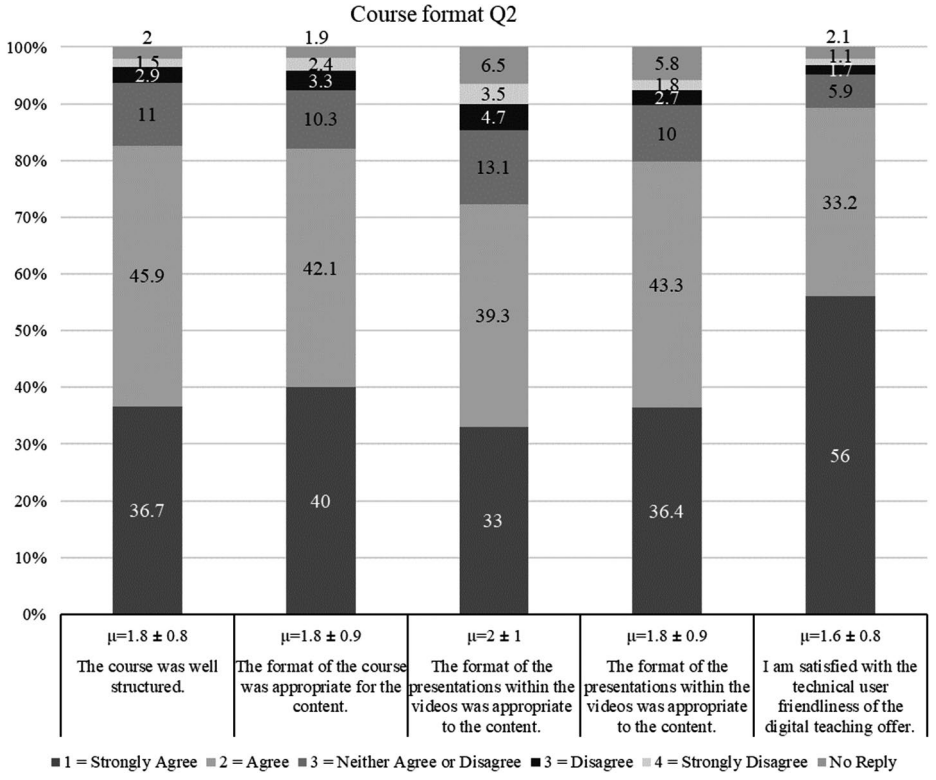


Fig. 5 Course format. The rating scale went from 1 = "Strongly Agree" to 5 = "Strongly Disagree". A low mean value (μ) therefore means a high level of agreement. The mean value is presented together with the standard deviation ($\mu = \mu \pm \sigma$)

Table 1 Comments on the format of the course (selected comments)

Aspect	Statements
Course format	• I think the entire format was way too superficial. • I would have found it better if people met in a room and discussed the topics and instead of having an exam, attendance was compulsory. • The digital format goes very well with everyday student life. It offers students freedom, with arbitrary pauses and repetitions of the videos, one can master difficult points. In some respects, the digital format sounds even better than the on-site lectures. Personally, I'm happy with the format and it's helpful to me. • The format was very disappointing. Complex scenarios that require correspondingly complex considerations were packed into a yes/no multiple-choice structure. It would be much better to work interactively in groups on the topic. • In my opinion, the flow of one topic to another in each session/video/slide is not smooth. (For example, in the 1st session, after explaining about definition of scientific integrity, the topic suddenly jumps to research as knowledge gain, then suddenly jump to principles of scientific integrity, then move back to criteria of research. This jumping patterns made me really hard to understand the context. This course is amazing and very beneficial, therefore, I hope this small suggestion could bring a bit improvement towards the course.) • I completely agree with the importance and relevance of this topic in general but the document of DFG was given as a source and not as the most relevant part of the learning materials. I think the importance of the pdf should have been more emphasized during the lectures or in the information document.
Course videos	• Videos were very well designed, almost like a podcast, which made listening very easy. • The interviews are a good idea. So it doesn't look too frontal. • I would have liked to have slides included in the interviews videos. • The dialogue format for a lecture was very clear and varied, one listens more intently to such a lecture than monotonous frontal teaching, particularly exciting and pleasant was to hear two parties in a discussion. • The interview format was unfavorable, lectures better.
Course exam	• The difficulty of the exam was not appropriate. Neither to the provided videos and slides nor the fact that this module comes with 0 CPs. *(CP—abb. Credit Point— author.)* • I would prefer a controlled exam. • With all due respect, the material was fine and the explanation and interviews were well done. However I don't see the point to have an exam in the middle of the semester. RWTH is already a very intensive university, adding the stress of an additional exam is not necessary in my opinion. This course content could have very well been a required reading when doing the master thesis (or bachelor thesis if it is required for that too). People don't need to do an exam which asks you if you remember by heart bullet point definitions.

would appreciate a question-and-answer session, other wishe to receive more organizational information (8.1%), and further reading (6.5%); some also state they would like to have more time to prepare in advance (5%). Further options of activities that study participants would like to have to prepare for exam were expressed in the free-text comments:

- a mock exam
- more exercises, example tasks and scenarios to practice on
- personal consultation hours
- examination in person
- answers to the sample situations
- a live lecture
- a mini test after each chapter to deepen the content
- more information about what and how exactly is queried

Table 2 Comments on the videos (selected comments)

Aspect	Statements
Quality	• The videos were professionally edited, I really liked the editing/production. Improvement: with subtitles. • In some parts of some lectures, a high pass filter that was applied made the sound less understandable. • The audio was not centered in the interview format. This is very uncomfortable to listen to, especially when using headphones, since the person on the left can usually only be heard in the left audio channel and on the right only on the right. Mono audio or a re-recording would be better here.
Content	• The interviews were relatively distant from the slides; some slides were not taken up in the interviews. Personally, I was able to follow the lectures with slides better and better understand what each video is about. • I always find it easier to understand content when I still have a graphical representation of content and how it relates to one another. Like e.g. in the case of authorship, that there are normal authors, honorary authors. A sham authorship was then mentioned verbally and it was not clear to me how this is now related to the first two mentioned.
Length	• I found it particularly positive that there were several shorter videos instead of one 2-hour video.
Accessibility	• Make videos available for download so that you can use them without the Internet. • …when I tried to watch the videos on mobile devices (Ipad), the videos jumped every few seconds, which made watching very uncomfortable. (It wasn't a problem on the PC).

To determine whether study participants were satisfied with communication, organization and exchange, they were asked to express their opinion on these aspects of the course through close- and open-ended questions. The results of the close-ended questions show that most of the students agree that the communication before starting the course, as well as communication and support during the course, were satisfactory. The opinion on the necessity to have more content-related exchange with contact persons changes, as 35.5% (strongly) agree, 29,8% (strongly) disagree and about 21% of the study participants neither agree nor disagree. Regarding the possibility to have further exchange, most study participants selected experts from the respective areas as persons they would like to have more exchange with. This option was selected by 36.9% of the study participants. On second place was exchange with fellow students, an option selected by 33.6%. Further options for exchange were contact persons, selected by 25.1%. Only about 4% of the study participant admitted they would like to have other types of exchange that were not listed in the selection bar. Further opinions on possible exchanges students wish are presented in Table 4.

Some general opinions on the organization, communication and support expressed by the study participants in the free-text window are presented in the Table 5. Finally, the last question inquired whether, after completing the course, study participants would recommend it to their fellow students and colleagues: 48.7% of the responders (strongly) agree on this statement, other 23.9% neither agree nor disagree and 19.7% (strongly) disagree. Therefore, it may be stated that most of the study participants would recommend the course to their fellow students and colleagues.

Table 3 Comments on the exam (selected comments)

Aspect	Statements
Length	• The time length of the exam is a bit tight, it would be nice to have some more extra minutes. • I don't have enough time. 30 min not suitable for foreigners.
Timetable	• If the allowed time of starting the exam to be later into evening will be great, as lectures or seminar are occupying the middle of the day time slots.
Communication in advance	• I would recommend distributing the dates evenly throughout the year and also providing more information yourself and getting the faculties and student councils to provide more information: not only to the students but also to the assistants, who usually did not have to study this subject, because they (a) did not study at the RWTH Aachen University or (b) studied in a period in which this subject was not yet compulsory.
Place	• Taking an online exam is always too stressful for me because I am scared of possible technical issues. That is why I would prefer exams in person. • It would be nice if the exam could also be written on site. At home I often lose the connection and sometimes it stays off for hours, which causes a lot of stress during exams. Also, the performance is so poor that sometimes it takes a very long time for something to load.
Content	• The content of the exam and the purpose of the course are not coherent. • Some of the formulations in the exam were very complicated. • Question about scientific misconduct in antiquity is irrelevant. Questions about crash test dummies or patches are very subject-specific. • I'm pretty sure that parts of the exam didn't appear explicitly in the lessons. • I don't understand how querying definitions or wording helps me with the integrity of academic papers. In my opinion, the last tasks in the exam and the case study were good tasks and also queried the meta level and not the stupid reproduction of formulations.
Format	• I would like an examination in person and much less multiple-choice. • Examination was generally fair. • The structure of the subject and the type of examination is very appropriate for this subject. • I don't know if the concept of the exam at the end really makes sense for this topic. Ultimately, it is primarily about students dealing with the topic. Unfortunately, the knowledge of this course is difficult to test in this type of exam, even if it is important knowledge. Perhaps a better alternative would be to offer one-day seminars or something similar.
Results	• I think it's a pity that the result will not be announced immediately. Since the questions are read out automatically. • It is unclear to me when and where the results can be seen.

Table 4 Comments on possibilities of further exchange (selected comments)

Aspect	Statements
Practical examples and real cases	• A seminar could be held twice a semester to give more practical examples about good scientific practices for young scientists. • Victims and/or the accused people from the cases of scientific misconduct. • The contact persons of my faculty in the event of possible misconduct, contact persons whom I should contact first in the event of an incident. • Maybe invite an ombudsperson so they can tell about their experience. What cases did they oversee? Everything anonymous, of course.
Platform for discussion	• Perhaps an open zoom meeting could be held shortly before the exam, in which interested students can participate for further exchange/discussion. • It would be nice if there were opportunities to exchange ideas about the topics and work on them. It might not be that easy with the amount of students attending the course, but you could maybe add some kind of forum where you create study groups or areas where you can ask questions.

Table 5 Comments on the organization and support within the course (selected comments)

Aspect	Statements
Organization	• For such an important topic it would actually be very nice if you could deal more with the content/discuss the topics with others. • One could provide further offers such as lecture series or a real lecture with CP to interested students. In my course, for example, there is no such thing. • The individual topics are presented in a very structured and understandable way, but it might be even nicer if the whole thing could even take place as a seminar? Of course, the number of participants is huge, so it's probably very difficult to implement, but I think it would simply have more nutritional value if you could experience it more actively and maybe exchange ideas with students from other courses… Maybe would a full-day workshop similar to the courses at the IT center be an option?
Communication during the course	• I liked that the lecturer was gendering consistently and fluently. I experienced this for the first time and was positively surprised.
Communication in advance	• Personally, I found out about this course more by chance in my second semester and that it is a compulsory course. Notification of the course would have been good at the beginning of my first semester. Or you inform the students at the beginning of each semester.
Supervision	• I found the supervision in the course sufficient. However, I noticed very strongly how much information I was still missing about scientific work. I would wish, for example, that the supervising persons at the institutes could provide more support and enlightenment when preparing the bachelor thesis. I felt very lost with the first version of my bachelor thesis because it was my first written version of a scientific work and I lacked support for good scientific work, such as: How do I correctly refer to sources? Which sources should be consulted for the current state of research?… Information on scientific misconduct and the importance of good scientific practice is also welcome.
Support	• At the beginning of the exam there were technical problems that caused uncertainty. However, this was solved very quickly by the supervisors and communicated immediately. I found that very good!

Discussion

The teaching/learning process involves activities of both the teacher and the learner (Maciel et al., 2004) and can therefore be seen as bidirectional. As is true for all types of teaching, also research ethics lecturers care about the outcomes of their teaching (Kalichman 2012). Thus evaluation, in particular students' feedback on teaching, reveals to be a valuable source of information that may be used to improve the course (Seldin, 1997; Flodén, 2017; Valeva et al., 2022) by understanding the perspective of those who receive a teaching offer. In particular, our evaluation has already contributed to the course improvement in the past. For example, based on the students' feedback, all videos got subtitles, a new section with case studies has been implemented, and an anonymous forum for asking questions related to the exam has been created. Therefore, by introducing a qualitative part to our surveys, we aimed at collecting students' feedback and further opinions study participants want to express. In this respect, a combination of the closed-questions-section and open-questions-section satisfied our expectations. It has to be mentioned that the part of the study regarding topics of interest has an explorative character; thus, it has to be understood that the qualitative comments we present are single comments and these may not necessarily reflect all possible opinions or positions. Therefore, we propose a qualitative part to be taken in consideration together with a quantitative part on the further topics of interest.

Background, Increased Interest and Self-Perception

The results on the background, interest, and self-perception questions confirm that interest and self-perception regarding scientific integrity increase after completion of the course. While some results meet the expectations due to the direct relation between a question and course topics, as for example the ability to describe scientific integrity in own words; some quantitative outputs, for example those regarding the general ability to work scientifically and to understand scientific literature, demonstrate a slight improvement after completion of the course even though these topics were not addressed during the course. Thus, our discussion will have a particular focus on the participants' course-specific feedback on the course content, format, videos, exam, communication and exchange.

Improvement in Knowledge and Skills and Wish to Have More Content

The outcomes of our study demonstrate that study participants self-assess an improvement in their knowledge and skills. Although behaviors are not easy to assess (Plemmons et al., 2006), the fact that first, most of the study participants would recommend the course to their fellow students and colleagues and second, that there is a general curiosity to have further topics discussed in the course may suggest that students potentially may discuss on research ethics outside the course. Moreover, when study participants state, as in our open-ended comments, that now they can notice how much information they were missing, we can interpret this as process of reflection, and therefore assume that after following the course, students are more sensible to the topics dealt within the course. Additional to the topics of the course, some study participants expressed the wish to have more content about how to deal with research pressure and more examples of application, as well as practical legal consequences in the event of scientific misconduct which may demonstrate a general positive attitude towards the teaching offer. As mentioned by Kalichman (2016) positive attitude and continued learning, among other outcomes, may be positive evidence that teaching responsible conduct of research works. These may be demonstrated through, for example, an improved ethical decision-making skill or increased awareness of authorship standards (Kalichman, 2016). Regarding the further topics presented in Fig. 3, we do believe that the top-three-topics presented above may suggest that students need to have more concrete and real examples in general, an outcome that is also confirmed by the open-ended question regarding further contents presented in Fig. 4. This finding would demonstrate a necessity to introduce more experiential learning dealing with concrete cases into the courses structure and confirms the insights published by Valeva et at. (2022) where the authors report the German university students' feedback underlying the importance of the applied approach in research integrity training. Practically-oriented courses that emphasize experiential learning are known to support the acquisition of knowledge and to promote the capacity of judgement consisting in, for example, professional ethical decision-making engagement and anticipation of consequences (Katsarov et al., 2022). In particular, the most promising case-based teaching strategies such as storytelling, rotatory role playing, theatrical performance (with the "ConScienceApp"), a problem to debate (fishbowl technique), the dilemma game (with the "Dilemma Game" tool) or a flipped classroom actively engage the students so that the delicate topics of research integrity are thoroughly understood and reflected on. (Koterwas et al., 2021).

The open-ended questions allowed us to collect some topics that study participants would like to learn about. From theory of science to P-hacking, the disadvantages of diversity, further preventive measures and RWTH-specifics, study participants state to be willing to learn even about more complex topics such as dealing with scientific misconduct in a working group, as well as funding of university research. Most of these topics are concrete examples that may be classified as practical examples of application and belonging to the list of topics presented in Kalichman (2016) which among others include: use of statistics, managing research group, research misconduct, and managing budgets. Others may be generalized to the main topics recommended in the German curriculum of Good Scientific Practice (Sponholz, 2019).

General Satisfaction with the Course Format and Technical User-Friendliness

Regarding the course format, most of the single-choice questions demonstrate that study participants are satisfied with the course format and the technical user-friendliness of the offer. Moreover, they (strongly) agree that the format—as well as the interview-format within the videos—is appropriate for the content. On the one hand, the open-ended comments provide comments of appreciation regarding the digital format that fits well into everyday students' life, the structure of the course and short videos that are almost like a podcast which is easy to follow and to listen to. On the other hand, study participants see the format of the course as too superficial or even disappointing, and suggest that a live lecture with possibility of discussion should be introduced, either instead of the course or in addition to the course for interested students. The opinion of the students provided through the open-ended comments also differ in regard to the exam. While the multiple-choice questions outcomes show that there is a general satisfaction with the technical user-friendliness of the digital exam and regarding the length and scope of the exam, time was sufficient; in the open-ended comments some critics regarding the both aspects may be found. Similarly, in the single-choice feedback on the communication, organization and exchange within the course suggest that while most of the students agree that the communication about the course in advance, as well as communication and support during the course were satisfactory, in the open-ended questions is stated that students should be notified in advance about the compulsoriness of the course. As possible platforms for exchange, study participants suggest to use an open online meeting shortly before the exam, a forum where the groups and areas for asking questions can be created, or even to introduce further offers as a lecture series or a real lecture with credit points. Being that currently the course is a compulsory activity for all master's students and it is a requirement that has to be fulfilled before registering for the master's thesis, generally no credit points are foreseen. While there are comments where we directly do not have a decisive voice, most of the comments provide a valuable list of aspects that students approve or disapprove in our digital offer.

Conclusion

When designing instructional activities related to the area of scientific integrity, it is not sufficient to fully map the topics of this field. Rather, it is equally important to consider students' needs, interests, and preferences.

Our study allowed to collect valuable data describing students' perspective on Scientific Integrity digital teaching, in particular what and how they want to learn. The research outcomes confirm an improvement in the study participants' self-assessment after following the online course Scientific Integrity at the RWTH Aachen University. Moreover, a novel questionnaire section demonstrates a general satisfaction among the students in regard to the course digital format and its components including videos, online exam, distance communication and exchange. Finally, the outcomes provide further topics of interest in the area of scientific integrity that study participants would like to learn about: most of these have a practical appeal and among others include research pressure, examples of applications, preventive measures, theory of science, citation rules, funding of university research. Although the results relate to our course, they provide some insight into students' perspectives on online teaching of scientific integrity and add to the discussion on effectiveness of research integrity courses and teaching programs. Thus, they may be helpful to higher education institutions developing online courses on scientific integrity that are tailored to master's students.

Online courses, among other advantages, enable learning at one's own time and pace (Hoven et al., 2023b). From this point of view, our outcomes confirm that there is a general satisfaction among the students in regard to the course digital format and its components, although there is a desire to have more exchange and discussion. While some students would prefer to have such interaction in person, in a form of a workshop or seminar, other would be interested to have an online platform for exchange, for example a forum, where questions can be asked and discussed.

A final consideration that needs to be addressed is the fact that such courses have to be updated often and cannot have a static concept, since the topics of scientific integrity are growing along with the digital transformation and alone the national and international guidelines on good scientific practice are subject to frequent changes. A constant evaluation can allow to collect valuable feedback from the course audience and thus improve the already existing teaching offer in relation to the participants preferences as well as to the further actualities that may arise in a society. Creating a course which represents not only the necessities of academia but also figure on the needs and interest of the target students in its developments should be a priority in the high education system.

Funding Open Access funding enabled and organized by Projekt DEAL.

Declarations

Conflict of interest No potential conflict of interest was reported by the author(s).

References

Antes, A. L., Murphy, S. T., Waples, E. P., Mumford, M. D., Brown, R. P., Connelly, S., & Devenport, L. D. (2009). A meta-analysis of ethics instruction effectiveness in the sciences. *Ethics & Behavior*, *19*(5), 379–402.

Antes, A. L., Wang, X., Mumford, M. D., Brown, R. P., Connelly, S., & Devenport, L. D. (2010). Evaluating the effects that existing instruction on responsible conduct of research has on ethical decision making. *Academic Medicine: Journal of the Association of American Medical Colleges*, *85*(3), 519.

Argote, L., & Miron-Spektor, E. (2011). Organizational learning: From experience to knowledge. *Organization Science*, *22*(5), 1123–1137. https://doi.org/10.1287/orsc.1100.0621.

Bero, B., & Kuhlman, A. (2011). Teaching ethics to engineers: Ethical decision making parallels the engineering design process. *Science and Engineering Ethics*, *17*(3), 597–605.

Brkic, S., Bogdanovic, G., Vuckovic-Dekic, L., Gavrilovic, D., & Kezic, I. (2012). Science ethics education: Effects of a short lecture on plagiarism on the knowledge of young medical researchers. *Journal of B U ON: Official Journal of the Balkan Union of Oncology*, *17*(3), 570–574.

Fisher, E. (2022). Engaging with societal challenges in responsible innovation. *Journal of Responsible Innovation*, *9*(1), 1–5. https://doi.org/10.1080/23299460.2022.2063910.

Flodén, J. (2017). The impact of student feedback on teaching in higher education. *Assessment & Evaluation in Higher Education*, *42*(7), 1054–1068.

Gundersen, L. C. (2017). Appendix A: CASE STUDIES FOR SCIENTIFIC INTEGRITY AND GEOETHICS PRACTICE. In Scientific Integrity and Ethics in the Geosciences, L.C. Gundersen (Ed.). https://doi.org/10.1002/9781119067825.app1.

Harkrider, L. N., Thiel, C. E., Bagdasarov, Z., Mumford, M. D., Johnson, J. F., Connelly, S., & Devenport, L. D. (2012). Improving case-based ethics training with codes of conduct and forecasting content. *Ethics & Behavior*, *22*(4), 258–280. https://doi.org/10.1080/10508422.2012.661311.

Hermeking, N., & Priess-Buchheit, J. (2022). What's integrity got to do with it? Second-year experiences of the Path2Integrity e-learning programme. *FACETS*, *7*(1), 110–125.

Hoven, M. V., Lindemann, T., Zollitsch, L., & Prieß-Buchheit, J. (2023a). A taxonomy for Research Intergrity Training: Design, Conduct, and improvements in Research Integrity courses. *Science and Engineering Ethics*, *29*(3), 14.

Hoven, M. V., Mol, H., & Verhoeff, R. (2023b). Evaluating empowerment towards responsible conduct of research in a small private online course. *International Journal for Educational Integrity*, *19*(1), 16.

Kalichman, M. (2016). Responsible conduct of research education (what, why, and does it work?). *Academic Medicine*, 91(12), e10.

Kalichman, M. (2012, December). Why teach research ethics. In Practical guidance on science and engineering ethics education for instructors and administrators: papers and summary from a workshop (Vol. 12).

Kalinowska, K., Koterwas, A., & Dwojak-Matras, A. (2020). The Perception of Research Integrity and ethical training in the Academic Community. *EDUKACJA Quarterly*, 152(1).

Katsarov, J., Andorno, R., Krom, A., & van den Hoven, M. (2022). Effective strategies for research integrity training—a meta-analysis. *Educational Psychology Review*, *34*(2), 935–955.

Kondakci, Y., Zayim Kurtay, M., Kasikci, K., S., & Önen, Ö. (2022). *Graduate student perceptions of preparedness for responsible conduct of research: A mixed methods study* (pp. 1–18). Ethics & Behavior.

Koterwas, A., Dwojak-Matras, A., & Kalinowska, K. (2021). Dialogical teaching of research integrity: An overview of selected methods. *Facets*, *6*(1), 2138–2154.

Kretser, A., Murphy, D., Bertuzzi, S., Abraham, T., Allison, D. B., Boor, K. J., Dwyer, J., Grantham, A., Harris, L. J., Hollander, R., Jacobs-Young, C., Rovito, S., Vafiadis, D., Woteki, C., Wyndham, J., & Yada, R. (2019). Scientific Integrity principles and Best practices: Recommendations from a Scientific Integrity Consortium. *Science and Engineering Ethics*, *25*(2), 327–355. https://doi.org/10.1007/s11948-019-00094-3.

Maciel, D., Branco, A. U., & Valsiner, J. (2004). Bidirectional process of knowledge construction in teacher-student transaction. Communication and metacommunication in human development, 1.

Mayring, P. (2000). Qualitative content analysis. *FQS*. https://doi.org/10.17169/fqs-1.2.1089.

Plemmons, D. K., Brody, S. A., & Kalichman, M. W. (2006). Student perceptions of the effectiveness of education in the responsible conduct of research. *Science and Engineering Ethics*, *12*, 571–582.

RWTH Aachen University. (2023). "Zahlenspiegel 2022." Retrieved March 15, 2024. https://www.rwth-aachen.de/global/show_document.asp?id=aaaaaaaabdbomkn

Seldin, P. (1997). Using student feedback to improve teaching. *To Improve the Academy*, *16*(1), 335–345.

Sira, N., Decker, M., Kordtomeikel, F., Winkens, A., Leicht-Scholten, C. & Groß, D. (2022). Chore or desire? Students' response to online lessons in scientific integrity. *Accountability in Research, 2022*, 1–18. https://doi.org/10.1080/08989621.2022.2145956

Sponholz, G. (2019). Curriculum für Lehrveranstaltungen zur guten wissenschaftliche Praxis. Accessed August 25, 2023. https://ombudsman-fuer-die-wissenschaft.de/2693/curriculum-fuer-lehrveranstaltungen-zur-gwp.

Steneck, N. H. (2013). Global research integrity training. *Science*, *340*(6132), 552–553.

Valeva, M., Dankova, P., & Priess-Buchheit, J. (2022). Students' mindsets on research integrity—a cross-cultural comparison. *FACETS*, *7*(1), 528–542.

Zollitsch, L., Wilder, N., & Priess-Buchheit, J. (2022). The development of a four-tier test to evaluate trainin g in responsible conduct of research [version 2; peer review].

Authors and Affiliations

N. Sira[1] · M. Decker[2] · C. Lemke[2] · A. Winkens[2] · C. Leicht-Scholten[2] · D. Groß[1]

✉ N. Sira
nsira@ukaachen.de

[1] Institute of History, Theory and Ethics in Medicine, Medical Faculty, RWTH Aachen University, Wendlingweg 2, 52074 Aachen, Germany

[2] Research Group Gender and Diversity in Engineering, RWTH Aachen University, Wendlingweg 2, 52074 Aachen, Germany