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Collecting and characterizing existing and freely accessible research integrity educational resources

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ABSTRACT

In addition to effective training practices, well-structured educational resources are important for developing successful research integrity training programs. A considerable amount of educational material has been developed in the last years, but there is a necessity to find better ways to assess and categorize the already existing resources. We collected 237 freely available online RI educational resources with the aim to describe them in as much detail as possible using a set of well-defined criteria. We developed a grid that gives a full description, based on our 21 criteria, for each collected resource. Mainly videos and online RI training are present in our collection. Worldwide, resources are mainly from the US, whereas in Europe mainly from the UK. In the majority of the cases, the educational resources are not customized, presenting the big three (falsification, fabrication, and plagiarism) as the most addressed topics. Making RI educational resources easily accessible might help to increase awareness about the topic. Moreover, the characterization we provide might help researchers and students to deal with daily RI-related issues, to look for the right tool at the right time, and might help institutions and trainers to develop new trainings without the need to develop new tools.

Abbreviations: CITI: Collaborative Institutional Training Initiative; COPE: Committee on Publication Ethics; ENERI: European Network of Research Ethics and Research Integrity; ENRIO: the European Network of Research Integrity Offices; EU: European Union; NIH: National Institutes of Health; NSF: National Science Foundation; NRIN: the Netherlands Research Integrity Network; ORI: the Office of Research Integrity; PPT: powerpoint; QRP: questionable research practice; RI: research integrity; RCR: responsible conduct of research

KEYWORDS

RI educational resources; research integrity; freely available resources; RI training material; RCR educational resources

1. Introduction

Promoting research integrity (RI) and fostering responsible conduct of research (RCR) became central at the institutional level ("Promoting research integrity: a new global effort" 2012). Besides imposing norms and rules, education is one possible way to promote RI within the academia (Resnik 2012). Promoting knowledge, skills, and attitudes should be the main rationale for learning goals in RI-

related education (Antes and DuBois 2014; DuBois and Dueker 2009). Besides the development of common professional standards and learning goals, the importance and the need to have adequate RI training programs were stressed (Steneck 2013; ALLEA 2017; Forsberg et al. 2018). Moreover, adequate RI training has been set as a minimum requirement by some funding organizations. For example, researchers funded by two federal agencies in the US, NIH and NSF, are required to participate in RCR training sessions (Phillips et al. 2018). Similarly, within the European context, the European Molecular Biology Organization (EMBO) set the same requirement for its long-term fellow and young investigators (EMBO 2020). Scientific misconduct can not only be attributed to intentional bad practices of some scientists (Bouter 2015), but it may occur due to the lack of knowledge and tools of many others (Kalichman 2006). Besides good training programs, RI educational tools are also important as support during the training sessions. Nowadays, common and freely accessible online materials are already available on the websites of different (inter)national organizations and EU funded projects (e.g., NRIN, ORI, ENERI, ENRIO). However, these collections are limited to specific topics, educational tools, and scientific disciplines. An extensive overview of what is available, in terms of educational resources, is lacking.

This study has multiple objectives. First, it aims to collect freely available online RI educational resources, developing an up-to-date library more inclusive than the ones already existing. The mentioned library will be entirely available soon within the online platform “The Embassy of Good Science”. Second, it aims to develop a grid in which each resource will be extensively described (Supplementary file 1 – RI educational resources characterization grid). One important step was to identify those criteria that will be useful to describe and categorize each educational resource in as much detail as possible. As a consequence, it might help institutions and trainers in their efforts to develop RI training programs, using common educational materials that have already been developed and that are fully available. The collection might also serve as an important resource in self-training and in self-education. More than this, the collection might help single researchers to easily find tools and resources to deal with their daily RI-related issues. In addition, the creation of this extensive library might help to understand better what are the needs and lacunas of existing RI educational resources. Finally, we offer a set of recommendations specifying what typologies of resources should be developed.

2. Methods

2.1. Collection of resources

We collected educational resources from September 2018 to March 2019, using Google as the main search engine. Different subsequent steps characterized the search process. Firstly, we identified single keywords and key

sentences to look for freely available online RI educational material. In the first online search, we used the same keywords as used by Heitman and Bulger (Heitman and Bulger 2005): “responsible conduct of research” (RCR), “research integrity” (RI), “scientific integrity research ethics”, “science ethics”, and “ORI”. Secondly, we implemented the starting list and added several other keywords and key sentences: “academic integrity”, “research integrity educational material”, “RCR educational material”, “research integrity training programs”, “RCR training programs”, “research integrity educational practices”, and “RCR educational practices”. Finally, starting from our preliminary results, we increased the number of resources using the snowballing process. We took into consideration only resources freely accessible, at least in English or in other languages but with English subtitles. We did not consider any exclusion criteria regarding the type of educational resources, contents or the type of customization.

2.2. Exceptions

In order to have the broadest overview possible of addressed topics and contents, we also included four educational resources developed by for-profit companies that are available only through a personal and/or institutional account. These resources have been developed by the Collaborative Institutional Training Initiative (CITI) program, company based in the US, and by Epigeum, a spin out-company from Imperial College London. Although the educational resources developed by these companies are not freely available, they are used by a significant number of universities and research institutions worldwide (Phillips et al. 2018; EPIGEUM 2019).

2.3. Characterization criteria

Although this section shows the development of the characterization criteria, their selection and the following development of the grid (Additional file 1 – RI educational resources characterization grid) must be considered as an intermediary, but equally important, results of this study. After completing our collection, the following step was to identify criteria to describe every single educational resource in as much detail as possible. The selection of the criteria was carried out in parallel with the analysis of the resources. At first, we started by extrapolating the first criteria Kalichman recommends (Kalichman 2014): learning goals, the audience, contents, and teaching tools. We implemented the list, ending with 21 criteria (Table 1) that allow us to qualify each resource.

This step led us to develop a grid that contains a full description of each RI educational resource we collected (Additional file 1- RI educational resources characterization grid). As recommended by Kalichman (Kalichman 2014, recommendation 4), we included in our collection any kind of educational

Table 1. RI educational resources characterization criteria.

1- name of the educational resource	12- teaching approach (group/standalone)
2- resource type	13- teaching approach (active/passive)
3- country of development	14- virtue(s) mentioned
4- author(s)/institution(s)	15- norms, codes, guidelines mentioned
5- date/last update (if applicable)	16- instruction for trainers
6- URL	17- language(s)
7- DOI (if applicable)	18- duration (if applicable)
8- addressed topic(s)	19- final evaluation/assignments
9- discipline customization	20- evaluation form available
10- level customization	21- number of users (if applicable)
11- learning goal(s)	

tool to promote active learning participation. However, blogs and newspaper articles were not taken into consideration. The first seven criteria in our list are important in order to clearly identify every single resource. Within this first block, defining the resource type (criterion 2) is particularly important for those stakeholders who are looking for a specific typology of educational material. Criteria 8 to 15 are important to describe educational resources. Since RI is an evolving field, we took into consideration all possible topics (criterion 8) (Kalichman 2014, recommendation 3). Therefore, we looked at the content present in the resources, without limiting our categorization to any topic. We searched for the presence of specific customizations related to scientific domains (criterion 9) and the career level (criterion 10).

Defining the customization is important to identify if a specific resource has been developed for a particular audience (Bulger and Heitman 2007). According to the scientific domain (criterion 9), we decided to categorize our resources using the subdivision found in the RCR basic course (CITI Program): biomedical sciences, engineering, natural sciences and physics, humanities, social sciences, plus specific customization for the administrative sector. Regarding the learning goals (criterion 11), knowledge, skills, and attitude were described as the main ends to achieve during a RI training (Kalichman and Plemmons 2007). However, we also added awareness to our list of possible learning goals, since some resources are developed with the intent to make researchers more aware of issues on the topic of RI. Identifying if the educational resource implies an active or passive teaching style (criterion 12) (Michel, Cater, and Varela 2009), or implies to be in a group, or the resource is also usable alone (criterion 13), is useful for trainers in the organization of training sessions. Ethical virtues are becoming more present in different (inter)national guidelines and codes of conduct and important in the development of good character traits of each researcher (Resnik 2012). Therefore, we decided to verify their presence within the educational resources (criterion 14). In addition, also from the European Commission, there is a call to consider the importance of virtues and virtue ethics as an alternative in RI education. The EU programme SwafS-27-2017

aims to implement a European “train-the-trainers” programme with regard to RI. The programme encourages to give more focus to a virtue ethics approach in embedding ethics and integrity into the research setting. Within the programme, the EU funded project VIRT²UE (grant agreement N 787580) aims to develop a train-the-trainer program using a virtue-based teaching approach, highlighting the principles of the ALLEA code. Criteria 16 to 19 provide useful information and tools for trainers and training developers. Criteria 20 and 21 give us extra information about how users may assess the resource.

3. Results

In total, we collected 237 educational resources on the topic of RI. Four of them, developed by Epigeum and CITI program, are available solely to subscribers. The other 233 resources are freely available online and reachable using the URL addresses we provide on our descriptions (Additional file 1- RI educational resources characterization grid). Some educational resources are already a collection of single educational tools. Therefore, the total number of single RI educational tools is much higher than 237. For instance, the COPE case studies collection, identifiable in our grid as one resource, is made by more than 500 single case studies (COPE website 2019). The educational resources have been identified and listed in the characterization grid mainly depending on whether they are grouped or not in the respective websites. For example, in some cases a single educational material is allocated as a single resource (e.g., the ORI’s interactive movie “The Lab”), in others, a collection of educational materials is allocated as a single resource (e.g., ORI’s video case studies).

The results discussing the RI collection are presented following the most relevant criteria: resource type, country, author(s)/institution(s), topic(s), customization, learning goal(s), teaching approach, virtue(s) mentioned, guideline(s) mentioned and language(s).

3.1. Resource type (criterion 2)

Our collection is made by 18 typologies of educational resources. The most represented are videos (64) followed by online training programs (50), textbooks (28), and case studies collections (24) (Figure 1-RI educational resources type). Videos were developed with the main purpose to raise awareness and discussions within the scientific community (e.g., “Is There a Reproducibility Crisis in Science?”). Moreover, in the category of videos, there are also different available webinars (e.g., “First Insubria International School in Methodology, Ethics and Integrity in Biomedical Science”). Examples of online training programs are the *Introduction to Responsible Conduct of Research* developed by Nicholas Steneck for The Office of Research Integrity (ORI website), and

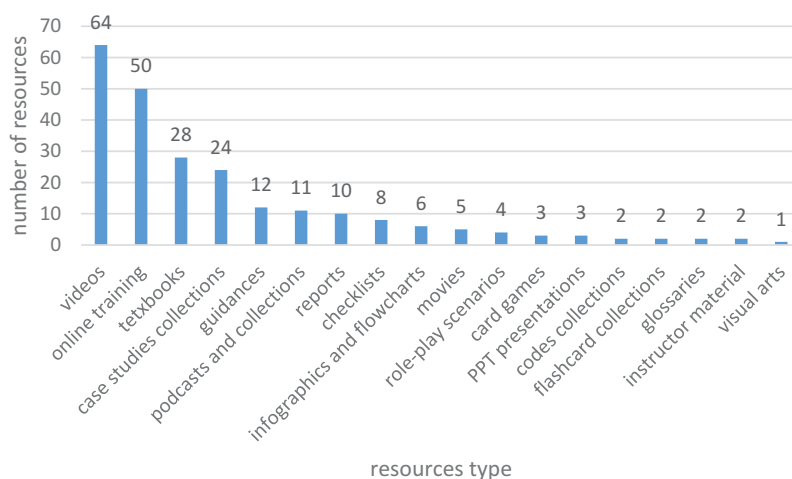


Figure 1. RI educational resources type.

Upright developed by the PRINTEGER project. While *Doing Global Science* (IAP Inter academy and Cabezas 2015) and the *ENERI manual on RI and ethics* (ENERI project) are examples of RI textbooks, the Committee on Publication Ethics (COPE) website provides an extensive collection of cases on publication ethics. This characterization, based on the type of resource, is not always straightforward due to the ambiguous descriptions online. For example, the *introduction to Responsible Conduct of Research* mentioned above might be categorized as online training as well as a textbook since it is available in the ORI's website as a web module and as a textbook.

3.2. Country (criterion 3)

Looking at the country of origin, around 43% of the resources have been developed in the US (102/237), whereas around 34% within the European context (80/237) (Figure 2- Country of development). Considering the situation in Europe in further detail, educational resources were mainly developed in the UK (23/80), the Netherlands (14/80), Germany (12/80), or developed or already collected by multinational EU consortia (13/80) (Figure 3- RI resources developed in Europe).

3.3. Author(s)/institution(s) (criterion 4)

Although a significant number of resources were developed within academia (91/237), it was not always clear who precisely developed the educational material. Within this group of resources, only in 23 cases, the authors were clearly identifiable and, all of them were RI experts. While 93 educational resources were stocked in the website of RI-related national or international associations (e.g., ORI, National Institutes of Health and Finnish National Board

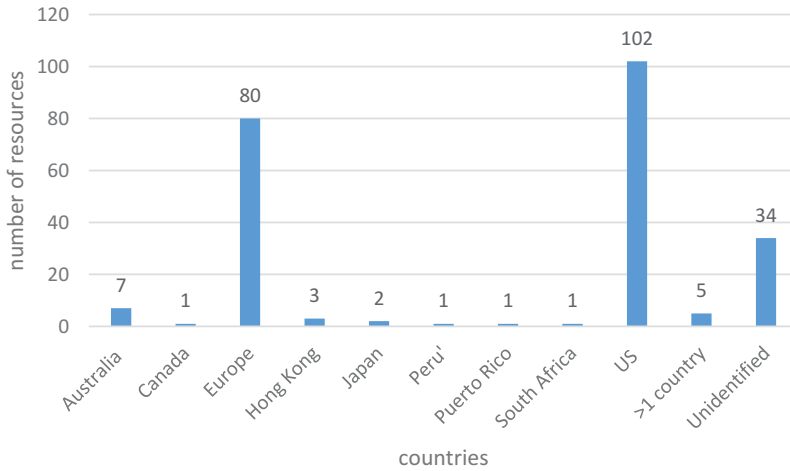


Figure 2. Country of development.

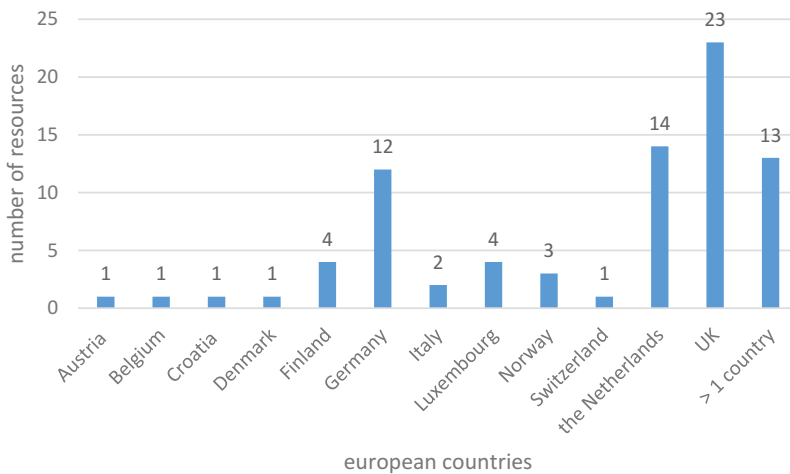


Figure 3. RI resources developed in Europe.

on RI), 22 resources were stored in publication-related organizations' websites. Four resources were developed by private companies specialized in education. The other educational resources were stored in different online platforms.

3.4. Topics (criterion 8)

We identified 25 different RI-related topics (Figures 4 and 5- Addressed topics). Around 65% of the resources presented research misconduct-related topics (155/237), around 55% publication ethics-related issues (130/237), and around 36% data management-related issues (86/237). Those three were the most addressed topics in our RI collection. Although 27 resources contained RI-related issues, they were too general to identify properly as a specific topic.

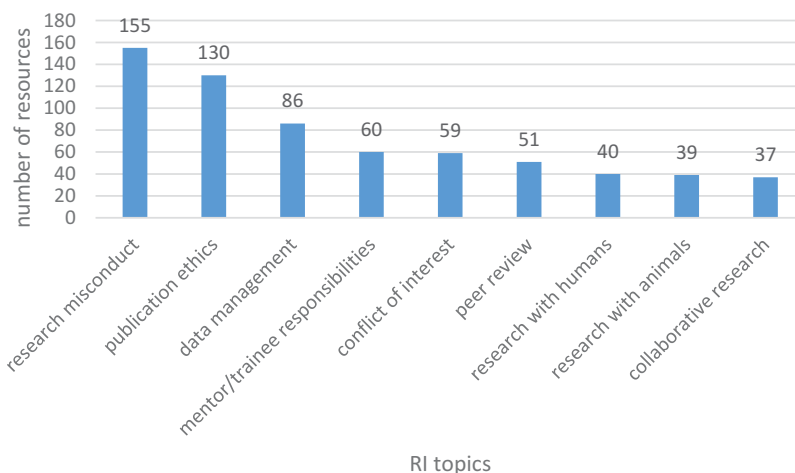


Figure 4. Addressed topics.

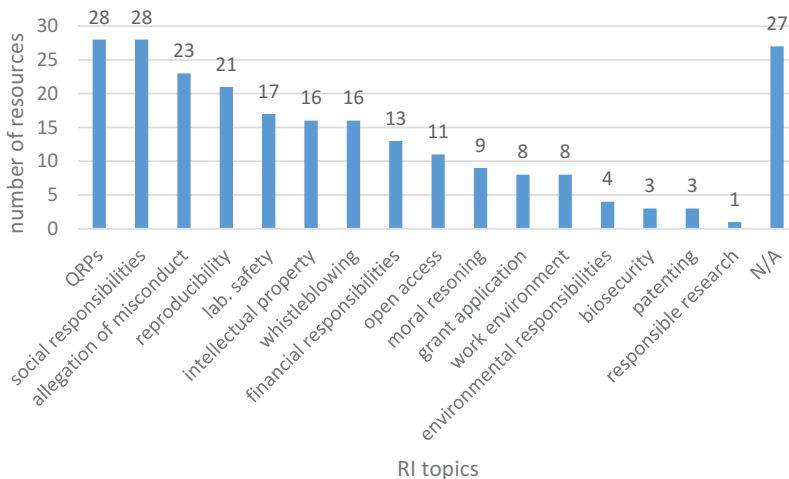


Figure 5. Addressed topics.

Regarding topics addressing research misconduct issues (155), falsification, fabrication, and plagiarism (FFP) were addressed together in the same resource 86 times. Ten resources addressed falsification-related issues, 7 fabrication-related issues, and 42 plagiarism-related issues. In addition, image manipulation was addressed in 10 resources. Among the 130 resources on publication ethics-related issues, 77 of them were about authorship-only related issues. Looking at the US and European context separately, the most frequently addressed topics were on research misconduct-related issues (FFP) (49 in the US and 24 in Europe), on authorship (37 in the US and 26 in Europe), and on plagiarism-related issues (11 in the US and 25 in Europe).

3.5. Customization (criteria 9 and 10)

In around 53% of the RI resources worldwide, no specific customization based on the scientific domain was mentioned (152/237) (Figure 6- Scientific discipline customization). This suggests that each educational resource may be used independently by the field of expertise of each researcher. Customization based on the scientific domain is present in the remaining 47% of the resources (85/237). Those resources are customized depending on five different scientific domains: biomedical sciences (74/84), engineering (21/84), natural sciences and physics (22/84), social sciences (11/84), and humanities (5/84). In addition, 1% of the resources shows a specific customization tailored for the administrative sector (2/237). Looking at the US and European context separately, resources without any specific customization were around 51% in the US (52/102) and around 82% in Europe 152 (66/80). Resources tailored for biomedical sciences were around 48% in the US (49/102) and around 18% in Europe (14/80). In both contexts, educational resources tailored for other disciplines were in total around 1%.

Seventeen resources were compatible with all possible career levels: bachelor, master and doctoral students, junior and senior researchers, professors, and trainers and administrators. The majority of the resources can be used by all kinds of trainees, independently on their career level.

Within the collection, 76 different resources have been developed preferably for trainers and educators. However, only 25 out of 76 resources contain resource instructions. Thirteen resources also cover financial responsibilities-related topics; therefore, administrators can also use them. For instance, the Peer Review Card Exchange Game (Tokalić and Marušić 2018) has a full set of instructions as a supplement to give trainers insights about the exercise.

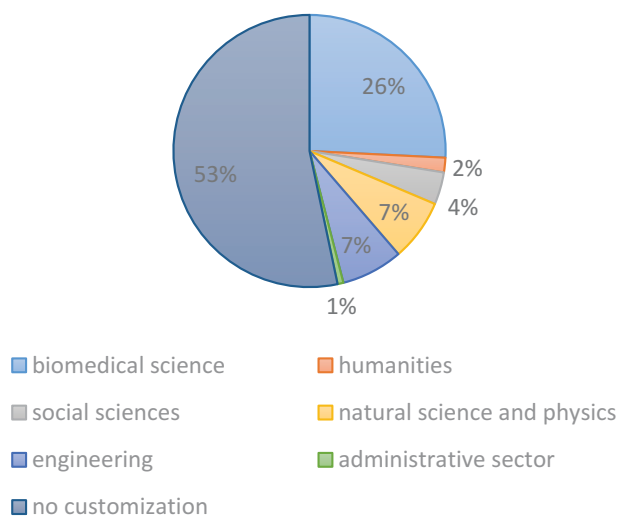


Figure 6. Scientific discipline customization.

3.6. Learning goal (criterion 11)

The majority of the resources were developed to achieve multiple learning goals at the same time, namely knowledge, skills, attitude/behavior, and awareness. However, 91 resources do not deliver any information related to knowledge or for achieving new skills. They were more related to raising awareness about general RI-related problems and with influencing attitude/behavior. Thirty-one resources delivered only knowledge and RI-related skills without minimally looking at promoting discussions.

3.7. Teaching approach (criteria 12 and 13)

While around 57% of the resources implied passive participation on behalf of the trainees (134/237), around 13% implied (pro)active participation and active learning (31/237). The remaining 30% implied a mixture of (pro)active or passive participation, depending on what teaching approach was adopted.

Around 2% were usable only in-group (6/237), whereas 80% of the resources were meant to be used as an individual (189/237). Eighteen % (42/237) may be used in-group or alone depending on the learning goal trainers want to achieve for their trainees.

3.8. Virtues (criterion 14)

Within the collection, 68 resources mentioned a very wide range of virtues (68/237) (Figure 7- list of virtues). Honesty (35), fairness (23), transparency (19), and accountability (16) are the four most represented virtues in the resources.

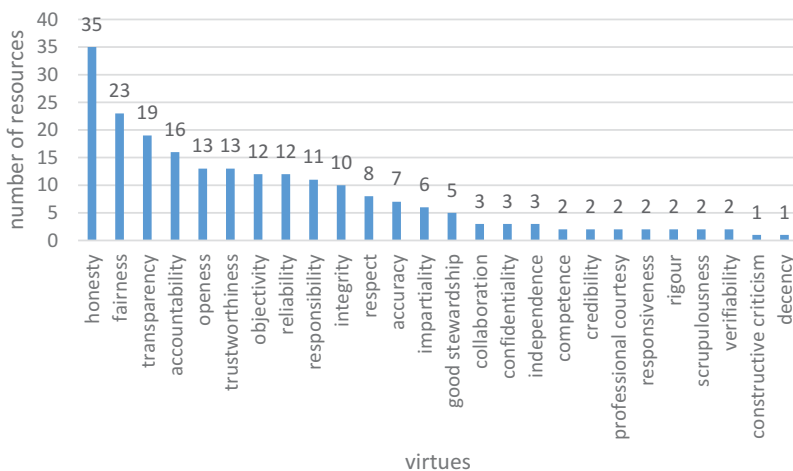


Figure 7. List of virtues.

3.9. Guidelines (criterion 15)

(Inter)national guidelines and codes of conduct were mentioned in 77 educational resources (77/237). The content of the guidelines depended on the country of development and on the addressed topics. Amongst the 77 resources worldwide that contained guidelines, around 34% of them are European resources (26/77). Among the European resources mentioning guidelines, 13 resources (13/26) mentioned an ALLEA document. Nine resources (9/13) mentioned the European Code of Conduct for Research Integrity (ALLEA 2017). Two of them (2/13) referred to the Memorandum on Scientific Integrity (ALLEA 2003), one (1/13) to the ALLEA 2011 and one (1/13) an ALLEA document, without specifying it.

3.10. Language and extra information

Twenty-one resources were available in at least another language, next to English. Regarding the criteria related to the user experience, the presence of an evaluation form, where it is possible to leave comments and to rate the resource, was present in 59 resources. A section defining the number of users was present in 55 resources.

4. Discussion

We found a great variety of freely available educational resources on different RI-related topics (Figure 1- RI educational resources type). The development of a characterization system makes each resource easily accessible, making the collection extremely easy to navigate. Therefore, the following creation of the educational resources grid (additional file 1- RI educational resources characterization grid) is important to allow researchers, trainers, and students to navigate in the collection and to look for the material they need in the easiest way possible. The grid and the characterization system provide a possible basic framework for the categorization of any educational resource. All these resources may be used independently within training sessions when those are organized by institutions, or used by single researchers. For example, online training programs provided by the ORI, the *Upright* online training and the interactive movie “The Lab” might be of great utility for those people working in institutions without a proper RI education program. Similarly, at the institutional level, the “Dilemma Game” developed by the Erasmus University Rotterdam, the COPE case studies collection and the ORI’s video case studies are good examples to foster discussion during RI training sessions organized within already developed training sessions. Moreover, these resources might also be used as a model for the development of new resources. Although other RI collections are already available (e.g., ORI, ENRIO, ENERI, etc.), this collection

is much more inclusive than the others. We included any typology of educational resources on any topic related to RI. The main added value of this study is the creation of a broad RI library that makes possible to identify precisely each resource via a characterization system based on precise criteria. This is of great help in dealing with RI-related issues in daily practice.

In addition, our collection will be fully available within an open-source online platform. “The Embassy of Good Science” (<https://www.embassy.science/>) is an initiative by two EU funded projects that aims to provide RI-related information via an online platform. The platform guarantees the possibility to keep our collection of RI educational resources fully open-source. However, the platform is still under development and for the moment, less than 100 resources are available (<https://www.embassy.science/resources>, last access January 2020). Around 43% of the resources in our collection were developed within the US context. It is not surprising that the majority of the resources are from the US, where the National Institutes of Health (NIH) has been requiring all grant applicants to have training in RI since 1990 (Phillips et al. 2018). However, around 82% of the universities in the US adopt the CITI’s online module on RCR (Phillips et al. 2018).

Research misconduct, publication ethics, data management, mentor/trainee responsibilities, conflict of interest, peer review, research with humans, research with animals, and collaborative research are the most addressed topics within our collection. Similarly, those same nine are the ones outlined by ORI as fundamental to build up RI educational curricula. However, new RI-related topics such as financial, societal, and environmental responsibilities are getting much more attention over time from many RI experts. (Watts et al. 2017; Bouter et al. 2016; Schaller-Demers 2015). Surprisingly, only 21 resources mention reproducibility-related issues even if the reproducibility crisis seems to receive more and more attention (An 2018).

The majority of the resources are not tailored for any particular scientific domain (around 53%). Most of the customized resources are particularly tailored for biomedical sciences (26%), addressing contents such as human and animal involvement in research, lab safety, and environmental responsibilities. Other typologies of customization are just present marginally. As already reported in the literature, only educational resources specific for biomedical sciences have been largely developed, without focusing on other scientific discipline customizations. (Bulger and Heitman 2007). Only a few resources are customized for disciplines such as humanities, social sciences, natural sciences, and engineering. Therefore, there is an urgent need to tailor specific RI resources for these scientific fields. Particularly interesting is the fact that we found resources about specific RI-related issues not exclusive to the research environment (Schaller-Demers 2015). Indeed, two online training programs are customized for the administrative staff who support researchers, dealing mainly with financial-related issues.

Within our collection, a (pro)active teaching approach is explicit in less than 15% of the resources. The resources focus mainly on providing knowledge-related information, implying a passive approach on behalf of trainees. This finding is not in line with what we found in the literature. In fact, several studies provided evidence that a (pro)active approach in RI and ethics education has a major impact in terms of efficiency (Hyytinen and Löfström 2017; Todd et al. 2017; Michel, Cater, and Varela 2009). However, the total number of educational tools using this active approach is low.

Although a great variety of virtues is mentioned in different resources (Figure 6- list of virtues), solely a few resources provide those. Virtues are mentioned in less than 30% of the resources. Within the list of virtues, it is possible to find the four principles highlighted in the European Code of Conduct (ALLEA 2017). Similarly, honesty is the most addressed virtue in our collection as well as in different national guidelines (Godecharle, Nemery, and Dierickx 2013) and university guidelines (Aubert Bonn, Godecharle, and Dierickx 2017). Given that, in our collection, resources that are using a virtue-based approach is absent. The lack of educational materials using a virtue-based approach to RI training was already underlined by Pennock and O'Rourke (Pennock and O'Rourke 2017).

The principle-based approach, consisting of following rules and obligations, is the most used approach in promoting RI (Resnik 2012). Similarly, the collected educational resources are based on the same approach, providing knowledge-related information. RI educational resources using a virtue-based approach are lacking. Instead of focusing on the development of the moral character of researchers, RI education is focused on complying with guidelines and rules (Pennock and O'Rourke 2017). Although at this stage, one approach prevails on the other, both have great value in promoting RI and RCR and both should be applied simultaneously within RI education (Resnik 2012).

5. Recommendations

Recommendation 1: in the development of new RI educational resources, priority should be given to topics like societal, financial and environmental responsibilities.

Existing educational resources are addressing almost exclusively the standard ORI's nine core topics. Therefore, there is no urgent need to develop resources on those topics. Moreover, recent literature emphasizes the need for more attention to topics like societal, financial, and environmental responsibilities (Watts et al. 2017; Bouter et al. 2016; Schaller-Demers 2015).

Recommendation 2: in the development of new RI educational resources, priority should be given to scientific disciplines other than biomedical sciences, such as social sciences, humanities, engineering, and natural sciences and physics

Existing resources are mainly tailored for biomedical sciences. Therefore, there is no need to develop resources tailored for biomedical sciences. The literature emphasizes the need for attention to scientific disciplines like humanities, social sciences, and natural sciences (Bulger and Heitman 2007).

Recommendation 3: in the development of new RI educational resources, priority should be done to material implying a (pro)active participation rather than a passive.

Most of the existing educational resources imply passive participation of the users. Therefore, there is no need to develop resources implying passive participation. The literature emphasizes the need for attention for a (pro)active teaching approach because such an approach is more effective as a delivery method (Hyytinen and Löfström 2017; Todd et al. 2017; Michel, Cater, and Varela 2009).

Recommendation 4: in the development of new RI educational resources, priority should be given to those that give more attention to scientific virtues and a virtue-based teaching approach.

Existing educational resources focus on giving knowledge-related information, using a norm-based teaching approach. Therefore, there is no urgent need to develop more resources implying a norm-based teaching approach. The literature emphasizes the need for attention for scientific virtues and a virtue-based approach as a delivery method (Pennock and O'Rourke 2017; Resnik 2012). However, both approaches should be applied in promoting RCR and RI (Resnik 2012).

6. Limitations

Although we collected many educational resources, the limitation of this study is due to the fact that we were able to characterize resources mainly in English or subtitled in English. This aspect can be compensated by making the grid open source and letting other people implement the collection with educational resources in other languages.

7. Conclusion

This study gives us an overview of what is freely available online, in terms of RI educational resources. Making educational material fully accessible will help to increase the awareness on the topic. Having RI educational resources

easily accessible to everyone will help researchers deal with daily RI-related issues and look for the right tool at the right time. The development of this resource collection will also help institutions and trainers develop new and different RI training sessions without the need to develop new tools. Not only making them accessible but also giving researchers a full description of the resources is of extreme importance and it will help them choose which resource better matches their needs.

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Authors' contributions

D.P. and K.D. conceived and designed the study. D.P. collected and analysed the educational resources with the contribution of S.A.. D.P. wrote the first drafts of the manuscript with the contribution and the supervision of K.D.. All authors approved the manuscript for submission.

Availability of data and materials

Additional file 1 – RI educational resources characterization grid

The additional file contains a full description, based on our characterization criteria, of each of the 237 resources we collected for this study.

Disclosure statement

DP and KD are amongst the founders of the platform “The Embassy of Good Science”. The platform is an initiative by the two projects EnTIRE and VIRT²UE and founded by European Union’s Horizon 2020 research program under grant agreement N 741782 and 787580.

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References

- ALLEA. 2003. *The Memorandum on Scientific Integrity*.
- ALLEA. 2011. *The European Code of Conduct for Research Integrity*.
- ALLEA. 2017. *The European Code of Conduct for Research Integrity*. Revised ed.

- An, G. 2018. "The Crisis of Reproducibility, the Denominator Problem and the Scientific Role of Multi-Scale Modeling." *Bulletin of Mathematical Biology* 80 (12): 3071–3080. doi:10.1007/s11538-018-0497-0.
- Antes, A. L., and J. M. DuBois. 2014. "Aligning Objectives and Assessment in Responsible Conduct of Research Instruction." *Journal of Microbiology & Biology Education* 15 (2): 108–116. doi:10.1128/jmbe.v15i2.852.
- Aubert Bonn, N., S. Godecharle, and K. Dierickx. 2017. "European Universities' Guidance on Research Integrity and Misconduct." *Journal of Empirical Research on Human Research Ethics* 12 (1): 33–44. doi:10.1177/1556264616688980.
- Bouter, L. M. 2015. "Commentary: Perverse Incentives or Rotten Apples?" *Accountability in Research* 22 (3): 148–161. doi:10.1080/08989621.2014.950253.
- Bouter, L. M., J. Tjink, N. Axelsen, B. C. Martinson, and G. Ter Riet. 2016. "Ranking Major and Minor Research Misbehaviors: Results from a Survey among Participants of Four World Conferences on Research Integrity." *Research Integrity and Peer Review* 1 (1): 17. doi:10.1186/s41073-016-0024-5.
- Bulger, R. E., and E. Heitman. 2007. "Expanding Responsible Conduct of Research Instruction across the University." *Academic Medicine* 82 (9): 876–878. doi:10.1097/ACM.0b013e31812f7909.
- COPE. Accessed March 2019. <https://publicationethics.org/guidance/Case>
- Dilemma Game. <https://www.eur.nl/en/about-eur/strategy-and-policy/integrity/research-integrity/dilemma-game>
- DuBois, J. M., and J. M. Dueker. 2009. "Teaching and Assessing the Responsible Conduct of Research: A Delphi Consensus Panel Report." *Journal of Research Administration* 40 (1): 49–70.
- EMBO. Accessed February 2020. <https://www.embo.org/science-policy/research-integrity>
- ENERI manual. "Research Integrity and Ethics." <http://eneri.eu/e-manual/>
- "First Insubria International School in Methodology, Ethics and Integrity in Biomedical Science." *YouTube videos*. Accessed 20 May 2019. https://www.youtube.com/playlist?list=PL9wdu0_Er9E1ezVGDUBUE4rSvpSb-TVWs
- Epigeum. Accessed March 2019. <https://www.epigeum.com/>
- Forsberg, E. M. et al. 2018. "Working with Research Integrity-Guidance for Research Performing Organisations: The Bonn PRINTEGER Statement." *Science and Engineering Ethics* 24 (4): 1023–1034. doi:10.1007/s11948-018-0034-4.
- Godecharle, S., B. Nemery, and K. Dierickx. 2013. "Integrity Training: Conflicting Practices." *Science* 340 (6139): 1403. doi:10.1126/science.340.6139.1403-b.
- Heitman, E., and R. E. Bulger. 2005. "Assessing the Educational Literature in the Responsible Conduct of Research for Core Content." *Accountability in Research* 12 (3): 207–224. doi:10.1080/08989620500217420.
- Hyytinen, H., and E. Löfström. 2017. "Reactively, Proactively, Implicitly, Explicitly? Academics' Pedagogical Conceptions of How to Promote Research Ethics and Integrity." *Journal of Academic Ethics* 15 (1): 23–41. doi:10.1007/s10805-016-9271-9.
- "Is There a Reproducibility Crisis in Science." 2016. *TED Ed Video, 4:47, TED Ed*, December 5. <https://ed.ted.com/lessons/is-there-a-reproducibility-crisis-in-science-matt-anticole#watch>
- Introduction to the Responsible Conduct of Research, ORI, developed by N.H. Steneck. Accessed February 2019. Accessed March 2019. <https://ori.hhs.gov/ori-introduction-responsible-conduct-research>
- Kalichman, M. 2006. "Ethics and Science: A0.1% Solution." *Issues in Science* 23 (1): 34–36.
- Kalichman, M. 2014. "Rescuing Responsible Conduct of Research (RCR) Education." *Accountability in Research* 21 (1): 68–83. doi:10.1080/08989621.2013.822271.

- Kalichman, M. W., and D. K. Plemmons. 2007. "Reported Goals for Responsible Conduct of Research Courses." *Academic Medicine* 82 (9): 846–852. doi:10.1097/ACM.0b013e31812f78bf.
- Michel, N., J. Cater, and O. Varela. 2009. "Active versus Passive Teaching Style: An Empirical Study of Student Learning Outcomes." *Small Business Institute National Proceedings* 33 (1): 55–67.
- "ORI's Video Case Studies." <https://ori.hhs.gov/videos/case-study>
- ORI. Accessed March 2019. <https://ori.hhs.gov/>
- IAP, InterAcademy, and P. Cabezas. 2015. *Doing Global Science: A Guide to Responsible Conduct in the Global Research Enterprise*. Princeton University Press. https://www.researchgate.net/publication/305496842_Doing_Global_Science_A_Guide_to_Responsible_Conduct_in_the_Global_Research_Enterprise
- Pennock, R. T., and M. O'Rourke. 2017. "Developing a Scientific Virtue-Based Approach to Science Ethics Training." *Science and Engineering Ethics* 23 (1): 243–262. doi:10.1007/s11948-016-9757-2.
- Phillips, T., F. Nestor, G. Beach, and E. Heitman. 2018. "America COMPETES at 5 Years: An Analysis of Research-Intensive Universities' RCR Training Plans." *Science and Engineering Ethics* 24: 227–249. doi:10.1007/s11948-017-9883-5.
- "Promoting Research Integrity: A New Global Effort." 2012. *The Lancet* 380 (9852): 1445. doi:10.1016/S0140-6736(12)61822-4.
- "Printeger Upright, Printeger Project." Accessed March 2019. <https://printeger.eu/upright/>
- RCR Basic, CITI Program. Accessed March 2019. <https://about.citiprogram.org/en/series/responsible-conduct-of-research-rcr/>
- RCR Basic, CITI Program. Accessed March 2019. https://www.citiprogram.org/citiDocuments/Forms/RCR_Order_Form.xls
- Resnik, D. B. 2012. "Ethical Virtues in Scientific Research." *Accountability in Research* 19 (6): 329–343. doi:10.1080/08989621.2012.728908.
- Schaller-Demers, D. S. 2015. "Responsible Conduct of Research: Not Just for Researchers." *Journal of Research Administration* 46 (1): 63–76.
- Steneck, N. H. 2013. "Global Research Integrity Training." *Science* 340 (6132): 552–553. doi:10.1126/science.1236373.
- "SwafS-27-2017- Implementing a European Train-the-trainer initiative with regard to Ethics and Research Integrity." <https://cordis.europa.eu/programme/rcn/702318/en>The Lab. <https://ori.hhs.gov/content/thelab>
- Todd, E. M., B. S. Torrence, L. L. Watts, T. J. Mulhearn, S. Connelly, and M. D. Mumford. 2017. "Effective Practices in the Delivery of Research Ethics Education: A Qualitative Review of Instructional Methods." *Accountability in Research* 24 (5): 297–321. doi:10.1080/08989621.2017.1301210.
- Tokalić, R., and A. Marušić. 2018. "A Peer Review Card Exchange Game." *European Science Editing* 44 (3): 52–55.
- VIRT²UE project. <https://cordis.europa.eu/project/rcn/214892/factsheet/en>
- Watts, L. L., K. E. Medeiros, T. J. Mulhearn, L. M. Steele, S. Connelly, and M. D. Mumford. 2017. "Are Ethics Training Programs Improving? A Meta-Analytic Review of past and Present Ethics Instruction in the Sciences." *Ethics and Behavior* 27 (5): 351–384. doi:10.1080/10508422.2016.1182025.