Life, Environmental and Geo Sciences Committee Opinion Paper

Career Paths in Multidisciplinary Research

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SCIENCE EUROPE
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Career Paths in Multidisciplinary Research

Context

Research in life, environmental and geosciences has markedly changed over the last few years as advances in high-throughput technologies and rapid progress in computational science have provided increasing possibilities for data collection and processing. While traditionally scientific progress was achieved by individual research groups focusing on specific discipline-related problems, nowadays the emerging trend is towards larger, multidisciplinary projects. Achieving increased knowledge and understanding of biological systems or geo-systems requires the successful integration of diverse types of data. As a result, scientific progress often relies on research performed by large collaborative teams that combine experimentalists and specialists in fields such as bioinformatics, systems biology, satellite-based methodologies, numerical modelling and possibly other fields such as physics or engineering.

Similarly, understanding the complexity of the Earth's dynamics in its broadest sense requires a multidisciplinary approach. Monitoring the Earth's system from space satellites, aircraft and globally distributed ground stations produces large data sets that are collected using geodetic, seismic, magnetic, and spectrometric and microwave techniques. In this setting, current integration efforts aim at bridging the knowledge gap between the atomic structure of the Earth and long-term, large-scale geophysical and geochemical processes.

Another example of a large-scale multidisciplinary endeavour can be provided by environmental field studies. These are conducted by teams of various experts collecting a wide range of inter-dependent large data sets for subsequent analysis and modelling.

Bioinformatics and systems biology are fast-growing disciplines that focus on modelling and multivariate biological data analysis using advanced computing techniques designed to study regulatory networks, cells, organs, organisms and populations. In this context, it is very common to integrate research involving high-throughput technologies such as next-generation sequencing, proteomics, metabolomics and advanced imaging and the subsequent functional analysis of specific genes or proteins. Adopting such an integrative approach requires close and iterative co-operation within a multidisciplinary team involving on the one hand experimental researchers, and on the other complementary data analysis performed by specialists in computational biology. Data processing includes annotation, statistical analysis, application of mathematical models, text and data mining, curation and long-term storage. The results of such analyses frequently

support or suggest subsequent analytical approaches. Currently, these efforts are conducted by scientists relying on national and/or international research infrastructures dedicated to data handling and knowledge management. The generated data often become available to the scientific community at large through freely available data access models, thus providing other scientists with a basis for comparison and validation of obtained results.

The geosciences were one of the early users of high-performance computing for data handling and data analysis, in particular in the fields of earthquake seismology and seismic exploration methods. Furthermore, there has been considerable progress in quantitative numerical modelling of processes in the atmosphere, the oceans, the solid Earth, and their interactions. New data acquisition methodologies in remote sensing, Earth-oriented space research, marine sciences, and climate research provide data sets that can be integrated by teams of scientists from different disciplines.

The trend towards multidisciplinarity suggests that this approach is becoming key in fostering scientific progress. However, assigning appropriate credit to individual scientists for their contribution to the work, and for career advancement, raises a number of challenges. One of these is linked to bibliometric indicators currently used to evaluate success in research but which do not capture the weight of individual contributions within multidisciplinary teams. These indicators were developed in the past for the assessment of projects carried out in small research teams, which were frequently composed of a student and a supervisor. In these cases, the authorship on a peer-reviewed publication clearly indicated the role and involvement of each contributor. However, in the life sciences, the scientific output of an individual continues to be mostly measured by the number and impact of papers, where the crucial first authorship (leading effort) or last authorship (guidance of the project) is still perceived as the key indicator of the intellectual contribution. This particular tendency persists even though scientific publications in many disciplines are characterised by increased multi-authorship resulting from the rapid rise of ‘Big Data Science’, and more generally the emerging collaborative research culture. As a result, the importance given to first and last authorship is often no longer an accurate indicator of the individual’s actual involvement, and thus fails to show the equally valuable contributions of the various other experts involved.

Moreover, current guidelines for assigning authorship differ between disciplines. While in geosciences the authors are usually listed based on the weight of their relative contribution, in mathematics and theoretical computer sciences authors are placed in alphabetical order. In physics, as opposed to the life sciences, equal importance is given to conference proceedings as to standard peer-reviewed publications.

In the above-mentioned context, scientists often struggle to demonstrate their achievements because indicators tracking the success of an individual within a multidisciplinary team are yet to be established. This, in turn, poses a significant challenge when the researcher applies for promotion, employment, tenure, fellowship and grants.

In this Opinion Paper, the Science Europe Scientific Committee for the Life, Environmental and Geo Sciences wishes to alert academic employers, promotion and appointment Committees and European and national research funding organisations to the lack of clear evaluation metrics for scientists working in multidisciplinary teams. The absence of such metrics already has a negative impact on career paths, as many scientists hesitate to participate in multidisciplinary research. Therefore, the Committee has devised concrete recommendations to contribute to the elaboration of an appropriate evaluation framework.

Recommendations

Employers and evaluators of scientific outputs in multidisciplinary research are strongly encouraged to implement the following recommendations:

Acknowledging Contributions in Bibliometric Analysis

Current authorship-based evaluation schemes should require that multi-authored publications contain a description of individual contributions to the collaborative project. Evaluators could seek to adopt systems already used by some publishers of peer-reviewed journals. Researchers are requested to provide, upon submission of an article for publication, a detailed contribution list describing the authors' involvement in the work. This list usually includes the following types of contribution: conceiving and designing the experiments, conducting the experiments, performing data analysis, developing analytic or modelling tools, writing the paper, discussing the paper, supplying reagents and materials, and providing financial support. Such in-depth assessment of individual contributions to authorship could become the norm in evaluation schemes and allow for a fair assessment of actual contributions.

The Life, Environmental and Geo Sciences Committee of Science Europe recommends that applicants for a job, promotion, fellowship, grant and tenure are required to submit a contribution list, together with the relevant publications, to the evaluators, employers and funding organisations. The contribution list should be considered as a mandatory document for the various evaluation procedures.

Capturing the Added Value of Collaborative Research

Evaluation schemes could include the key role of participation in multidisciplinary research and consider this as an indicator of added value. In this context, a career evaluation would involve demonstrating various collaborations which were essential for multidisciplinary research, being at the same time an indicator of an individual's contribution to knowledge flow, often used to capture integration of research.

The Life, Environmental and Geo Sciences Committee of Science Europe recommends that various evaluation and promotion committees include the number of co-publications, co-patents, networking efforts and research collaborations as indicators of an individual scientist's capacity to cross the boundaries of a single discipline, and as demonstration of active engagement in multidisciplinary research.

Rewarding Research Efforts in Data Generation, Analysis and Knowledge Management

As with scientific publications, scientists who conduct complex data analysis, modelling and curation, or those who generate data sets of broad utility, should also be given credit for their work. In this context, handling of scientific data should be identified as a significant contribution by an individual to knowledge creation and management.

The Life, Environmental and Geo Sciences Committee of Science Europe recommends that making data available to the scientific community at large through freely available data access models, repositories and webometrics, be considered as output equal in importance to scientific publications. Therefore, evaluation schemes should use the number of downloads, re-use of data and ontologies as indicators of success.

Acknowledging the Development of Enabling Tools for Data Handling and Knowledge Management

Traditionally, scientists contribute to innovation with patents. However, nowadays innovation in 'Big Data Science' also happens at the level of software development used for data analysis, modelling and management, as well as for text and data mining. Many software solutions provided by experts who developed these tools are made available to the scientific community through freely available software access models.

The Life, Environmental and Geo Sciences Committee of Science Europe recommends that the development of enabling tools such as methods, algorithms and software is recognised as a significant contribution to knowledge creation and management. The success of such endeavours should be measured by the number of downloaded applications by users relying on such valuable research tools.

Conclusion

The shift towards multidisciplinary research has resulted in the crucial need to establish indicators that acknowledge the value of this approach and the individual's engagement in the process, especially as the complexity of research questions and the technology used goes beyond individual scientists' areas of expertise. In the life sciences, the rapid rise of 'Big Data Science' has led to a new generation of scientists working in multidisciplinary teams dedicated to unravelling complex biological systems. In the environmental and geosciences similar developments have taken place or are in progress. An obvious example is in climate science, where for the IPCC (Inter-Governmental Panel on Climate Change) climate assessments many hundreds of scientists are involved.

It is therefore essential to support the career development of these scientists by establishing a clear set of indicators which facilitate the evaluation of their work and demonstrate their achievements in a multidisciplinary environment. Failure to establish and implement such an evaluation framework will act as a strong deterrent for the most talented individuals to enter a career path in domains of science that require a multidisciplinary effort. Hence, the Science Europe Scientific Committee for Life, Environmental and Geo Sciences would like to urge academic employers, evaluators and European and national research funding organisations to adopt these recommendations, as they capture a wide range of outputs, contributions and activities. This in turn is expected to facilitate the advancement of career paths of scientists engaged in multidisciplinary endeavour.

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Science Europe is a non-profit organisation based in Brussels representing 52 Research Funding and Research Performing Organisations across Europe. More information on its mission and activities is provided at: http://www.scienceeurope.org. To contact Science Europe, email office@scienceeurope.org.

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