Response from the Royal Society of Biology to the Royal Society call for views on education research

October 2016

The Royal Society of Biology (RSB) is a single unified voice for biology: advising government and influencing policy; advancing education and professional development; supporting our members, and engaging and encouraging public interest in the life sciences.

The Society represents a diverse membership of individuals, learned societies and other organisations. Individual members include practising scientists, students at all levels, professionals in academia, industry and education, and non-professionals with an interest in biology. For this response we have received significant input from the Biology Education Research Group[1], a special interest group of the RSB.

A large proportion of the policy work we do is in collaboration with other Science Learned Societies including the Association for Science Education (ASE), Institute of Physics (IoP), Royal Society (RS) and Royal Society of Chemistry (RSC). In alliance with the ASE, IoP, RS and RSC we have commissioned research to inform our policy positions and we draw on educational research in our responses to consultations and inquiries[2]. We work closely with our member organisations[3] who work within specialist areas of the biosciences when developing new policy positions and responding to consultations to ensure that we are reflecting the views of the sector. For education research within higher education, we and many of our other member organisations have worked closely with the Higher Education Academy (HEA). Last year we conducted research on issues in bioscience teaching[4]. In 2014 with the Heads of University Biosciences (HUBS), the Biochemical Society and the HEA we completed an audit of the practical work taking place in the higher education sector[5]. We also conducted research with the Physiological Society, HUBS and Academy of Medical Sciences on the status and valuation of teaching within higher education[6].

Some of our member organisations fund research, for example the Physiological Society offers grants to educational researchers[7]; the grants are aimed at researchers early in their careers or those who have recently switched from research to teaching. These grants enable awardees to carry out a piece of educational research or develop an educational resource, recipients are encouraged to disseminate their findings as widely as possible. The RSB with the HUBS special interest group also fund the sharing of educational research in the biosciences with small grants of £1000 for teaching academics to fund teaching

[1] The Biology Education Research Group https://www.rsb.org.uk/education/berg/education-research
[2] https://www.rsb.org.uk/policy/consultations/consultation-responses
[3] Organisational membership of the Royal Society of Biology https://www.rsb.org.uk/membership/organisational-membership/full
[4] Teaching and learning issues in the biosciences https://www.rsb.org.uk/images/Teaching_and_Learning_Issues_in_the_Disciplines_-_Society_of_Biology_Final_Report.pdf
[5] Audit of practical work https://www.rsb.org.uk/policy/education-policy/higher-education-policy/ug-audit-of-practical-work
[6] The status and valuation of teaching in higher education https://www.rsb.org.uk/policy/education-policy/higher-education-policy/status-and-valuation-of-teaching
[7] Physiological Society Teaching Grants http://www.physoc.org/teaching-grants

Charles Darwin House, 12 Roger Street, London WC1N 2JU Tel: +44 (0)20 7685 2550 info@rsb.org.uk
www.rsb.org.uk

and learning workshops[8]. There is also an annual spring meeting of HUBS which focuses on teaching and learning within the biosciences[9]. Many of our member organisations host meetings that focus around teaching within their specialist areas as well as having awards to specifically recognise teaching innovation and expertise.

In common with other Learned Societies, the RSB has a particular interest in what can be done to ensure the engagement of learners with our subject, to secure their knowledge and understanding and develop the skills that are needed for life now and in the future. Our proactive work with the Biology Curriculum Committee[10] to consider the future of biology education in schools is informed by current education research and will evolve as new evidence is collected on the impacts of current educational reforms. We recently hosted an event that focused on the transition from secondary school to higher education[11]. This event allowed us to gather input from the bioscience community and open up discussions surrounding the development of practical and transferable skills in biology at school. At the event we presented a document for discussion[12]; we encourage our members to engage with the work that we are doing and have the document openly available on our TalkBiology forum[13]. Our membership have suggested evidence that could be drawn upon to inform our work as well as contributed their individual expertise.

The Biology Education Research Group is a special interest group of the RSB. This group is composed of over 60 individuals who are either active in or have an interest in education research within the biosciences, this could be at school and/or university level. Individuals in this group are conducting research across a wide variety of areas from the use of arts and drama to teach biology to assessment strategies to the value of outdoor learning (see Appendix 1).

The group meets to discuss issues relevant to education in schools, colleges and higher education as well as share the research that they are undertaking with researchers in other institutions. At the Association for Science Education Annual Conference BERG members host a day of talks[14] which enables them to share their research with teachers in schools. Members of BERG have strong links across Europe and several of them have attended and presented research at the European Researchers in Didactics of Biology (ERIDOB) conferences[15]. BERG members have also contributed articles to the Journal of Biological Education[16] which has celebrated its 50th anniversary this year.

We have consulted with members of the Biology Education Research Group and the following areas have been highlighted as requiring additional educational research evidence:

Impact of current educational reforms

We believe that it is essential that the impacts of the recent educational reforms are monitored. Any evidence that is gathered can then help inform future curriculum and assessment design. A number of organisations have begun the process of collecting data and monitoring the changes, however as the reforms are implemented in stages (reformed A levels started teaching in 2015 whilst reformed GCSEs started teaching in 2016) longitudinal research studies are crucial. Research could consider the reforms impact on:

- student understanding of concepts (of substantive biology and of evidence)

[8] Teaching and learning workshop grants https://www.rsb.org.uk/education/hubs/hubs-grants
[9] Heads of University Biosciences Meetings https://www.rsb.org.uk/education/hubs/hubs-news-and-events
[10] Biology Curriculum Committee https://www.rsb.org.uk/about-us/committees/biology-curriculum-committee
[11] Transition from school to higher education https://www.rsb.org.uk/about-us/committees/biology-curriculum-committee/curriculum-committee-supporting-transition-from-school-to-higher-education
[12] Framework for post 16 biology discussion document https://www.rsb.org.uk/images/Developing_a_framework_for_post_16_biology_qualifications_-_For_transition_event.pdf
[13] TalkBiology forum https://talkbiology.rsb.org.uk/
[14] The Biology Education Research Group https://www.rsb.org.uk/education/berg/education-research
[15] ERIDOB https://www5.kau.se/eridob-2016
[16] Journal of Biological Education https://www.rsb.org.uk/education/publications/jbe

- students development of practical and transferable skills
- student engagement with the subject
- numbers of students continuing to study the subject (GCSE to A level, A level to degree)
- how content and skills are taught

Assessment
We think it is important that there continues to be research conducted on the effectiveness of different summative and formative assessment methods. We would like research to consider whether changes in assessment impact on the way biology is taught in the classroom (and in the lab and out in the field) and how assessment can be a driver for positive learning and teaching experiences.

Part of the reforms has seen the removal of coursework and the direct assessment of practical work contributing to the final grade in biology examinations at GCSE and A level. The understanding of practical work and practical skills are now being assessed through written responses to exam questions. Assessment of practical skills and the assessment of students understanding of the nature of science and the ideas and evidence underpinning practical work require different assessment approaches.

We would like further evidence collected around the effectiveness and validity of assessing hands on practical skills through written responses to exam questions. We believe that there could be great value in collaborative working between other practical subjects such as geography to compare across disciplines. In addition we would like further evidence to establish how to assess students understanding of the process of science and how practical and theory relate to each other.

Further we recommend research to develop effective ways to assess students' reasoning about the power, limitations and relevance of science – an objective included in the curriculum but widely neglected in teaching and assessment due in large part to the lack of well-developed guidance for teachers and model assessments. The "Working Scientifically" strand supports students to better understand the nature of science is often not well integrated into teaching and teachers have difficulty assessing this.

Practical work in the lab and in field
Science involves investigation, and biology along with the other sciences is an inherently practical subject. Laboratory and fieldwork is composed of several aspects, the hands on practical skills that develop with practice (e.g. manual handling skills / dexterity, ability to follow protocols, being able to work safely) alongside an understanding of the evidence which is required for decisions about the quality of data (e.g. including how the work is designed, about the sample size and representativeness, about the quality of the instruments or observations) and this sits alongside the theory. Both the theory and the practical are required for an in depth understanding of biology.

In light of the changes to curriculum and assessment methods, we would like evidence gathered on the perceived importance and value of practical work in science subjects, from the perspectives of both students and teachers.

The quantity and quality of practical work that is happening in schools needs to be monitored, as well as considering if it is developing the skills and understanding of biology's empirical basis needed for students to continue on to further study of the subject.

It would also be useful conduct research into the impact that participating (actively taking part) in practical work (in the lab and in the field) has on student learning and engagement with biology.

Curriculum content and skills
We would welcome further research into establishing what makes "an effective biology curriculum" that can be developed to meet multiple purposes, for example:

- to be engaging and provide a platform for progressing onto further study
- ensuring that it establishes the link between theory and practice

- to raise awareness of biology and biology related careers
- encourages learner independence
- develops transferable skills and supports students literacy and numeracy

We think that there is a need for further research into Threshold Concepts in Biology[17], how learners understanding of concepts progress from early years through to higher education, this would be helpful in informing future curriculum development.

There are also areas in the curriculum where additional research could help identify successful ways to teach the subject, for example in the reformed national curriculum for science, evolution and genetics are taught in primary school and at key stage 3. Biology education and in particular genetics education impacts not only students' understanding of biology concepts but also informs their understanding of what it means to be human. We would welcome research which explores these wider implications and which considers how different pedagogies impact on students' developing scientific literacy and enthusiasm for science related careers.

Teacher education (initial and ongoing)
Within the UK and across the world there are a variety of different routes that can be taken to becoming a qualified teacher. The success of these different routes in terms of developing excellent teachers and retention of them within the teaching workforce needs to be evaluated. To sit alongside the recommendations that are being made for core content within initial teacher training (ITT)[18], research could establish how, and how much subject and pedagogic content knowledge is developed during ITT and how this may vary between different types of provider. Additional research may help to identify the professional development needs of teachers early on and in later stages of their career.

Educational Outcomes for Students
With the recommendations that have been proposed to expand selective education places within the government consultation "Schools that work for everyone"[19] we believe there needs to be a better evidence base that evaluates the impact of different types of school (grammar, independent, free school, academy) on broad student outcomes.

[17] Ross, P.M, Taylor, C.E., Hughes, C., Kofod, M., Whitaker, N., Lutze-Mann, L. & Tzioumis, V. (2010). Threshold concepts: challenging the culture of teaching and learning biology. In J.H.F Meyer, R. Land & C. Baillie (Eds.), Threshold Concepts: from theory to practice Rotterdam: Sense Publishers.
[18] Department for Education (2016) A framework of core content for initial teacher training https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536890/Framework_Report_11_July_2016_Final.pdf
[19] Department for Education (2016) Schools that work for everyone https://consult.education.gov.uk/school-frameworks/schools-that-work-for-everyone/supporting_documents/SCHOOLS%20THAT%20WORK%20FOR%20EVERYONE%20%20FINAL.pdf

Appendix 1 – Biology Education Research Group - areas of research interest

The areas listed below are **some** of the research interests of the Biology Education Research Group

1. The impacts of compartmentalisation in schools
2. Teaching and learning about the relevance, power and limitations of science in multidisciplinary contexts
3. Learning about science and religion
4. Scientific and technological literacy
5. Use of arts (drama) to teach science/biology
6. Accessible Science (particular interest - pupils with disadvantage)
7. Assessment
8. Threshold Concepts
9. Teaching and learning about neurons and the brain
10. using technology to increase engagement and retention
11. neuroscience
12. Genomics education
13. Teacher continual professional development
14. Out-of-classroom learning / outdoor education
15. Value of outdoor learning/fieldwork
16. Environmental education curriculum
17. Science teachers beliefs
18. Pre-service science teachers professional development
19. Learning and teaching about socio-scientific issues (health, biodiversity & environmental issues)
20. The pedagogical affordances of new technologies
21. TPACK as a theoretical framework to support teacher CPD relating to the use of educational technology
22. Biological illustration
23. Diversity in teaching school biology
24. The role of school staffrooms
25. Assessment of practical notebooks

26. Genetics education at KS3/KS4
27. Understanding evidence in school and HE - implications for curricula and teaching
28. Transition to higher education
29. Collaborative learning
30. Student autonomy
31. Early years STEM education
32. Impact of Zoos, museums, botanic gardens
33. Inquiry based learning
34. Classroom environment
35. Quantitative and statistical skills teaching for life scientists
36. Analysis of data generated from online educational tools