Science in School
The European journal for science teachers

ISSUE 55 | 03/11/2021

Topics Biology | Chemistry | Engineering | General science
Health | Science and society | Careers in STEM

What is it good for? Basic versus applied research

Martin McHugh, Marcus Baumann, Sarah Hayes, F. Jerry Reen, Laurie Ryan, Davide Tiana, Jessica Whelan

Basic research is often misunderstood by the public and misconstrued by the media. Try this role play to learn how research is funded and how basic research advances and protects society.

In 2019, an international research group published a paper examining the effect of the song Scary Monsters and Nice Sprites by Skrillex on the breeding behaviours of mosquitos. [1] The paper became a viral news story, with many media outlets using the 'obscure' research story to generate clicks. However, the research concluded that, when mosquitos were exposed to the song, they bit less and refrained from mating. The paper generated equal amounts of praise and criticism but highlights the potential of basic research and creative thinking in science. Indeed, the historical problem with basic research is the lack of immediate commercial objectives. To non-scientists, basic research can seem like a waste of money, whereas applied research, designed to solve practical problems with obvious scientific and societal benefits, seems like a better use of resources.

The following activity will bring the debate into the classroom and allow students to explore the pros and cons of basic and applied research. Using an argumentation framework, students will discuss the merits of a variety of research projects, with updates to show how some of them later turned out to be important for vaccine development for COVID-19.

What kinds of research should be funded?

In this activity, students will be divided into groups of funders and scientists. Using the materials provided, the scientists will pitch their research proposals to the funders, who will have €100 000 at their disposal. The activity will also provide cues to promote argumentation among students to develop critical thinking, reasoning, communication, and scientific literacy skills.[2]

Learning objectives and context

After the activity, students should understand
- how scientific research is funded and that this involves difficult decisions;
- the difference between basic and applied research;
- how applied research relies on basic research findings, and that it is difficult to predict what might become useful.

To set the scene, students should be asked who they think funds scientific research. Students will generate multiple answers, from the government to universities and industry. Truthfully, funding can come from a variety of sources and can be public, private, national, or international.

Scientists using a modern chromatography instrument
Kinga Lubowiecka/EMBL/Photolab, Copyright: EMBL 2019

The next question is how do funding bodies select what research should be funded. Scientific research is often broadly divided into two types: basic research (also called fundamental research) and applied research.

- Basic research is about pushing the boundaries of our understanding and generating new knowledge. An example is researching how a physiological process works at the molecular level.
- Applied research involves applying existing knowledge to create solutions to specific problems. An example is developing a treatment for a disease.

However, many research projects have elements of both basic and applied research. Research scientists from around the world must compete and push the merits of their work to get funding.

The following role-play activity will put students in the shoes of both the funding bodies and scientists. In groups, students will be asked to pitch their project proposal to the funders, who will ultimately decide how to allocate €100 000 to a variety of projects.

A key element of this lesson is to encourage debate and argumentation. Students acting as scientists should try to convince funders with their words. They should be encouraged to make claims, rebuttals, and back up their statements with data, if possible. Each scientist will have an individual text that will give them the information to argue effectively. To support debate, funders are given a list of key questions, along with more probing questions. This activity can also be extended over multiple lessons to allow students time to debate.

Materials

- Funder information sheet
- Project proposal cards
- Discussion cards

Procedure

1. For this role-play activity, divide students into groups of five or six. Each group requires four scientists and at least one funder.
2. Hand out the project proposal cards to the four scientists in each group. There are four project proposals and each scientist should get a different one. One of these proposals is highly applied, while the others are more basic. All funders receive the same information sheet and can allocate €100 000. If there are two funders in a single group, then they must come to a consensus.

3. Give students 10 minutes to read over their documents. Funders need to be aware of the key questions (on the information sheet) they can use to assess the proposals. Scientists need to be aware of the key arguments they need to make to receive funding (on the proposal cards).
4. Each scientist then gets 2 minutes uninterrupted to make their 'pitch' for funding. Once complete, funders need to ask key questions and all scientists are allowed argue their positions against each other. This should take around 15 minutes.
5. At the end of the activity, funders are asked to fill in the funding-allocation table at the bottom of their information sheet. This is to be kept private.
6. In turn, ask the funders from each group to the front of the class. The table on their sheets can be copied onto the board and funders can fill this out. Once complete, they need to give a brief justification to the class for their decision.
7. Throughout this process, ask the students if they are seeing any patterns emerging in the funding between groups.
8. Ask whether the students think each project is more basic or applied.
9. Next, hand out the discussion cards to each group. Project 3 is purely applied and has a clear link to vaccines, but these cards describe how proposals 1, 2, and 4 turned out to be fundamental to the development of the COVID-19 vaccine in unexpected ways.
10. Get the class to discuss whether this new information would have changed their funding decisions.
11. Discuss whether the applications envisioned by the researchers were necessarily those that turned out to be important.

Discussion

As previously stated, the goal of this activity is that students understand how research is funded and the differences between applied and basic research. The activity is designed to highlight how basic research often forms the foundation for applied research. Both types of research are important, but basic research can be perceived negatively in the eyes of the public. It is often impossible to predict how knowledge gained through a basic research project could be vital for an application in the future. Often multiple scientific advances have to be combined for an applied impact. Sometimes, scientists must accept that they may not be able to identify an immediate application for new knowledge generated. However, without new knowledge, we may lack the foundation for future applications that could be years away.

In this example, the three more basic research proposals proved to be vital to the final application. This can be easily illustrated with proposal cards 1 and 3. Proposal card 1 discusses modified mRNA, and this research underpinned the manufacture of the COVID-19 vaccine. The two proposals are so closely linked that you can replace the word 'polynucleotide(s)' with mRNA on proposal card 3 and the document still makes perfect sense.

A group of scientists at work in the lab
Trust *Katsande*/*Unsplash.com*

As a follow up to this activity, ask students to go online and find the most obscure and weird basic scientific research (that has been published in a peer-reviewed journal) they can find. The Ig Nobel Prizes are a good source of inspiration for this. Similar to the mosquito example used in the introduction to this activity, get the students to find practical applications behind the headlines and articles.

References

[1] Dieng H et al. (2019). The electronic song "Scary Monsters and Nice Sprites" reduces host attack and mating success in the dengue vector Aedes aegypti. *Acta tropica* **194**: 93–99. doi: 10.1016/j.actatropica.2019.03.027

[2] Erduran S, Ozdem Y, Park JY (2015). Research trends on argumentation in science education: a journal content analysis from 1998–2014. *International Journal of STEM Education*, **2**: 5. doi: 10.1186/s40594-015-0020-1.

Resources

- Read an article on different techniques to resolve and predict protein structures: Heber S (2021) From gaming to cutting-edge biology: AI and the protein folding problem. *Science in School* **52**.

- Read an article on how modern vaccines work: Paréj K (2021) Vaccines in the spotlight. *Science in School* **53**.
- Discover CRISPR-Cas9 and how it revolutionized gene editing: Chan H (2016) Faster, cheaper, CRISPR: the new gene technology revolution. *Science in School* **38**:18–21.
- Visit the Annals of Improbable Research, which runs the Ig Nobel Prizes, to learn more about research that makes you laugh and then makes you think.
- Read a simple explanation of basic research and its importance from the National Institute of Health.
- Read a short article from Harvard University on the importance of basic research.
- Watch a video on the potential uses of CRISPR outside gene editing.
- Watch a video on how 50 years of fundamental research enabled the rapid development of mRNA vaccines for COVID-19.
- Read an article from *STAT* describing the main steps that – 50 years later – led to COVID-19 mRNA vaccines.
- Watch a video introducing the ESRF and its 41 beamlines.
- Read an article from *Scientific American* that underlines the important issue of research funding and final profits.
- Read an article from *c&en magazine* on synchrotrons and their uses.
- Read an interview with Katalin Karikó in *Scientific American* that discusses her role in developing the mRNA technology

AUTHOR BIOGRAPHY

Dr Martin McHugh is the education and public engagement officer for SSPC, the Science Foundation Ireland (SFI) research centre for pharmaceuticals at the University of Limerick. Formerly a researcher in informal learning and part-time lecturer on science education, he has degrees from NUI Galway and the University of Edinburgh in environmental science and teaching. He is also a qualified secondary school science and biology teacher.

Dr Marcus Baumann is an assistant professor in the School of Chemistry at University College Dublin. He leads a research group aiming to develop new methods for the sustainable generation of drug-like molecules through the use of continuous-flow technologies. These methods are based on using light and enzymes in combination with machines to synthesise biologically active molecules.

Dr Sarah Hayes is the chief operating officer (COO) of SSPC. Sarah's background is in physical chemistry and she received her PhD in Science Education. Sarah has many years of teaching experience as a physics and chemistry teacher. Through her various roles, she has been involved in research, curriculum development, and continuous professional development courses. Her most significant focus has been informal and non-formal learning and engagement.

Dr Jerry Reen is a lecturer in molecular microbial ecology at University College Cork. His research team study polymicrobial biofilm communities to understand molecular communication systems between species in disease and biotechnology. They also apply molecular technologies to harness biocatalytic proteins and bioactive compounds of marine origin.

Laurie Ryan is an assistant lecturer in general science at Athlone Institute of Technology (AIT). She is a former secondary school science teacher and conducts research in the area of STEM education and outreach. She is currently finishing her PhD examining argumentation in non-formal learning environments.

Dr Davide Tiana is a lecturer in inorganic chemistry at University College Cork. His independent group uses computational chemistry to study, understand, and explain chemistry. Their research goals range from developing new models to better explain chemical interactions (e.g., chemical bonding, dispersion forces) to the design of new molecules such as nanodrugs.

Dr Jessica Whelan is a lecturer at the University College Dublin School of Chemical and Bioprocess Engineering. Her research focuses on developing tools and approaches to optimize the production of proteins, vaccines, and cell and gene therapies. The aim is to make medicines available to patients at the highest quality and lowest cost possible.

EIROforum