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THE PEDAGOGICAL SAILBOAT PROJECT

Intellectual Output 2
Deliverable 3.2

How to read and understand a scientific paper at secondary school (16+)

Three Basic Skills

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Introduction

This pedagogical module has been developed as part of the Pedagogical Sailboat project, funded by Erasmus+ and led by Ayam Sailing Europe (BE). The objective here is to provide a practical approach on how to apprehend a scientific paper[1] for secondary school students (16+).

The European Commission recommends fostering partnerships between education and stakeholders in science-related fields because it might introduce, in an exciting way, real-life challenges to the students while also aiding problem-solving skills (European Commission, 2015). However, the collaboration between schools and research centres, when it exists, is part of isolated initiatives and is rarely developed in a long-term collaboration.

The Pedagogical Sailboat project was set up to develop a framework that eases the development of partnerships between scientific research, education and sailing sectors in the frame of the protection of the marine environment[2].

The definition of the research question is the first phase of a scientific project and it is normally carried out by the scientists. It can, however, be carried out in consultation with other involved actors who can be public authorities, NGO's, students/teachers, and so on. This specific type of project is referred as a "co-created citizen science project".

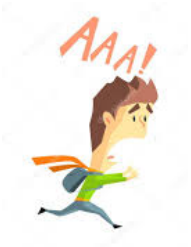
The actors should provide scientific arguments to support the research question and justify the development of the science project. This is generally done through a review of the scientific literature. The information in secondary sources as textbooks, encyclopaedia and other media in which authors did not participate in the work, is not sufficient. The primary articles (scientific publications) are the basis upon which the scientists build their argumentation.

Being able to read a scientific publication is, therefore, a key competence that the student must acquire to participate in a co-created citizen science project.

[1] The translation of the article or collaboration with the English teacher might be necessary for non-native English speakers.

[2] Note that when scientific knowledge is gained through the participation of individuals who do not work professionally in the relevant scientific field, the approach is called "citizen science".

Can a secondary school student read a scientific publication?



Nowadays, an increasing number of academic research papers are open access. However, reading a scientific publication is a difficult task for the student, and for the teacher in a lesser degree, who has not been exposed to this type of literature before (Fankhauser & Lije, 2016). This type of articles, compared to a scientific textbook or encyclopaedia, intimidates at first sight because it is often dense and includes specific technical words. However, several studies have shown that reading a scientific article by secondary school students is not only possible (Koeneman, Goedhart, & Ossevoort, 2013) but also recommendable (Brill & Yarden, 2003) (Hoskins, Lopatto, & Stevens, 2011).

Reading a scientific paper allows students to have a more accurate view of current scientific research compared to reading any other textbook or encyclopaedia. It is also an opportunity for secondary school students to learn how scientists, exploit existing knowledge and present their results to justify their arguments (Ossevoort, Koeneman, & Goedhart, Exploring scientific research articles in the classroom, 2012)

Implementation of the pedagogical module in secondary schools curriculum

The approach to develop a lesson on "*How to read and understand a scientific paper*" is based on the development of the following three sub-competences :

- to be able to identify the type of scientific publication;
- to be able to determine if an article is relevant;
- to be able to recognise and adequately read the important parts of a scientific article

This lesson will be implemented within the Wallonie-Brussels curriculum (Belgium) in the frame of the course "scientific education : Environment" which objective is to develop the following competences :

- identify and explain the impact of a human activity on the ecosystem;
- develop a scientific argument to criticize this activity.

Sub-competence 1. To be able to identify the type of scientific publication

Before reading a scientific paper, the student should be able to identify the type of publication.

There are, in general, two categories of scientific publications:

> The research article presents original results or introduces a scientific methodology by presenting data. The research article is organized in a standardised way (see below). The research article usually includes several pages unless when the researcher want to announce an important discovery before submitting a more detailed research article. This kind of research article is called a research note (two or three pages).
>
> The review article does not present original results but analyses the state of scientific knowledge in a field (Pochet, 2015). It is usually a critical study that includes the author's point of view and recommendations.

In a research article. The central part (or body) of a scientific publication is most often structured as follows:

- Abstract
- Introduction (why do we do this research)
- Methodology (procedures and materials used)
- Results (what we found)
- Discussions (conclusions, new questions)

The acronym for this structure is AIMRAD: **A**bstract, **I**ntroduction, **M**ethod, **R**esults, **A**nd **D**iscussion

This part is preceded by the title and the list of authors and is completed by the references.

The references are an important part of the research paper as they refer to the sources of information and the related research work. The references are presented according to a standardised format called "citation style". Within this document the APA style is used and most of the references ends by a persistent link to its location on the Internet which always start as follow : https://doi.org/10.

Tip for the students :
The research article has a standardized structure, which is not the case of an article of synthesis. To differentiate them, it is enough to identify the structure of the article.

Exercise :
To which type of publication belongs each of the following articles?

Publication 1

Kay, P., Hiscoe, R., Moberley, I., Bajic, L., & McKenna, N. (2018). Wastewater treatment plants as a source of microplastics in river catchments. Environmental Science and Pollution Research, 25(20), 20264–20267. https://doi.org/10.1007/s11356-018-2070-7

Publication 2

Hartmann, NB; Hüffer, T; Thompson, RC; Hassellöv, M; Verschoor, A; Daugaard, AE; Rist, S; Karlsson, T; Brennholt, N; Cole, MJ; Herrling, MP; Hess, MC; Ivleva, NP; Lusher, AL; Wagner, M. (2019). Are We Speaking the Same Language? Recommendations for a Definition and Categorization Framework for Plastic Debris. Environmental Science & Technology, 53 (3). 1039-1047. https://doi.org/10.1021/acs.est.8b05297

Publication 3

Viršek, Manca & Palatinus, Andreja & Koren, Špela & Peterlin, Monika & Horvat, Petra & Kržan, Andrej. (2016). Protocol for Microplastics Sampling on the Sea Surface and Sample Analysis. Journal of Visualized Experiments https://doi.org/10.3791/55161

Publication 4

Kooi, Merel & Reisser, Julia & Slat, Boyan & Ferrari, Francesco & Schmid, Moritz & Cunsolo, Serena & Brambini, Roberto & Noble, Kimberly & Sirks, Lys-Anne & Linders, Theo & Schöneich-Argent, Rosanna & Koelmans, Albert. (2016). The effect of particle properties on the depth profile of buoyant plastics in the ocean. Scientific Reports. 6. 1-10. https://doi.org/10.1038/srep33882

Publication 5

Hidalgo-Ruz, Valeria & Gutow, Lars & C Thompson, Richard & Thiel, Martin. (2012). Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification. Environmental science & technology. 46. 3060-75. https://doi.org/10.1021/es2031505

Sub-competence 2. To be able to determine if an article is relevant

Before starting an in-depth reading of a scientific paper, it is essential to know if the article is relevant. The student should answer the question: What do I want to know?

For that, he should :
- describe the issue or the questions that arise,
- describe the information he is looking for and,
- make a list of keywords.

The student should then read the title and skim the summary/abstract (Hudson-Barr, 2004), (Subramanyam, 2013).

Tip for the students : If the content of the summary is too complicated look for the information in the introduction.

By performing this task, the student should obtain a minimum of information, allowing him to decide if he should go further in reading the article.

Exercise

1. Which of the publications listed below allows knowing the origin of microplastics that end up in the oceans?
2. Identify the publications that provide with relevant information needed to carry out microplastic sampling aboard a sailboat?

Publication 1

Brown, DM & Cheng, Lanna. (1981). New Net for Sampling the Ocean Surface. Marine Ecology-progress Series – Mar. Ecol. Progr Ser. 5. 225-227. http://dx.doi.org/10.3354/meps005225

Publication 2

Kooi, Merel & Reisser, Julia & Slat, Boyan & Ferrari, Francesco & Schmid, Moritz & Cunsolo, Serena & Brambini, Roberto & Noble, Kimberly & Sirks, Lys-Anne & Linders, Theo & Schöneich-Argent, Rosanna & Koelmans, Albert. (2016). The effect of particle properties on the depth profile of buoyant plastics in the ocean. Scientific Reports. 6. 1-10. https://doi.org/10.1038/srep33882

Publication 3

Viršek, Manca & Palatinus, Andreja & Koren, Špela & Peterlin, Monika & Horvat, Petra & Kržan, Andrej. (2016). Protocol for Microplastics Sampling on the Sea Surface and Sample Analysis. Journal of Visualized Experiments https://doi.org/10.3791/55161

Publication 4

Lenz, Robin & Labrenz, Matthias. (2018). Small microplastic sampling in water: development of an encapsulated filtration device Water, 10. 1055. https://doi.org/10.3390/w10081055

Publication 5

Kay, P., Hiscoe, R., Moberley, I., Bajic, L., & McKenna, N. (2018). Wastewater treatment plants as a source of microplastics in river catchments. *Environmental Science and Pollution Research, 25*(20), 20264–20267. https://doi.org/10.1007/s11356-018-2070-7

Sub-competence 3. To be able to recognise and adequately read the important parts of a scientific article.

If the article is relevant (previous chapter), the student can start with the reading.

Research articles are more interesting to read for a student than a review article because they include information that pushes the frontiers of scientific knowledge further.

It is best first to read the parts that include the essential information: the Introduction and the discussion which are also the most readable parts. (see Figure 1).

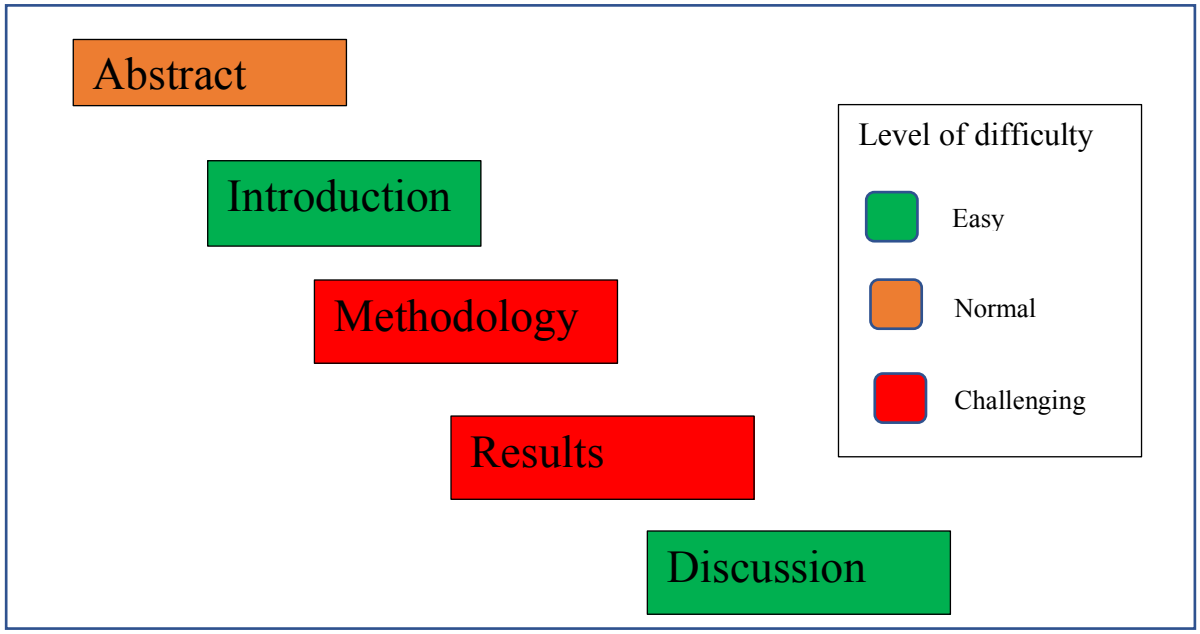


Figure 1 : Levels of difficulty in reading a research article

The introduction and the discussion include all the information needed for an overall understanding of the article.

The introduction includes:

- Studies done on the research topic;
- The considerations that motivated the study, such as gaps in knowledge;
- What the study intends to do to fill these gaps.
- The proposed approach to answer to the research question

The discussion is the most important part of the article because it answers the research question (Subramanyam, 2013). The discussion includes :

- The interpretation of the data
- Similarities and differences with previous studies
- Limitations of the study and suggestions for future research

The most difficult parts to read in a research article is the methodology and the results. For most research articles, the student might not have the background necessary to tackle this part. The reading should be done in collaboration with the teacher who should familiarise the students with the experimental procedures and the technical jargon.

Tip for the students : The word '*Significant*' often comes up in research articles. This word is part of the jargon used in statistics and means that the result is not due to hazard.

We propose hereafter an exercise to be developed in the classroom

Exercise

Most of the microplastics in the oceans come from the continents and are transported by rivers. According to an article on the website of the United Nations Environment Program, a new study concludes that treated wastewater effluents are also key sources of microplastics, which implies that wastewater treatment plants have not the ability to filter them (UNEP, 2018).

Let's verify the accuracy of the information in this article by reading the original scientific publications (Kay, Hiscoe, Moberley, Bajic, & McKenna, 2018).

Note that for this exercise, we have chosen a short article, the scientific protocol is relatively simple and the topic important for society. These points are in line with the recommendations of the pedagogues when exploring a scientific article with students (Ossevoort, Koeneman, & Goedhart, Exploring scientific research articles in the classroom, 2012).

Publication to analyse

Kay, P., Hiscoe, R., Moberley, I., Bajic, L., & McKenna, N. (2018). Wastewater treatment plants as a source of microplastics in river catchments. *Environmental Science and Pollution Research, 25*(20), 20264–20267.
https://doi.org/10.1007/s11356-018-2070-7

Questions

What type of publication is it?
Who did the study? (authors, provenance)
Why ?
What are the new research questions arising from this article?

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