Science Extension – Critical Analysis of Scientific Articles

UTS Mentor Science+ Science Extension Program: https://www.uts.edu.au/mentor-science-plus-science-extension

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Introduction

This article outlines strategies to teach students how to conduct "Critical Analysis" of scientific articles for the HSC Science Extension course, based on a recent article titled: Embedding Scaffolded Reading Practices into the First-Year University Science Curriculum (Griffiths and Davila 2022). Strategies outlined in this article were modified for Year 12 Science Extension students.

There is some discussion over how early students should be taught the skill of reading and critically analysing scientific literature. It is known that early exposure to academic literature is great for introducing students to scientific reasoning (Muench 2000) and to aid in the development of their scientific process skills (Brownwell, Price, and Steinman 2013). Learning how to conduct "Critical Analysis" of a scientific article is a required skill in the current Year 11/12 science curriculum. All first year science students at The University of Technology Sydney (UTS) enrol in the subject Scientific Perspectives for Global Issues, which introduces students to the approaches to scientific knowledge production. Critical reading of scientific texts is a key practice in science. As such, it is recommended to "embed these activities into the core curriculum in the first semester of the first year, so that students can develop their strategies and use them in assignments across multiple subjects" (Griffiths and Davila 2022). The Year 12 HSC subject Science Extension has an assessment component where students need to write a scientific research report based on their research, making Science Extension an ideal subject in which to start learning the skills of reading and analysing scientific literature.

Science Extension students are required to perform an in-depth literature review both in forming a scientific research question and in writing a scientific research report, so "Critical Analysis" of the literature is "critical". Science Extension students are required to read, evaluate and cite literature relevant to their scientific research question in their scientific research report. In other words, students are required to "learn to read like a scientist". It is therefore important to teach these skills at the beginning of the Science Extension course, not simply when students start to write their scientific research report.

Background:

Why do students have difficulty in effectively reading scientific literature?

- complexity of academic literature
- unfamiliarity with key scientific terms and reading conventions

- lack of confidence
- students are often overwhelmed by the number of published articles in their chosen area and do not know where to start
- students often feel overwhelmed and underprepared for the reading and interpretation of texts that is required
- students need to understand that reading a scientific article is not the same as simply reading pages of a science textbook linearly to acquire knowledge - reading a scientific article is “a process of investigation, analysis and discovery rather than simply a list of facts to be memorised “(Levine 2001)

Teaching the skill of reading and interpreting scientific literature should be an explicit approach (Harper and Vered 2017). One suggestion is to use an embedded, scaffolded series of learning activities that teach students how to read and select relevant, reliable scientific literature. “Students’ uncertainty about how to read in their disciplines is a growing concern for educators as university curriculum design needs to cater to an increasingly linguistic, culturally, and socially diverse student cohort” (Griffiths and Davila 2022).

In the first year of their science degree UTS students learn how to read scientific literature through an interactive and collaborative workshop using a recently published journal article. A three year evaluation (Griffiths and Davila 2022) of student learning after completion of the workshop found the following:

- more than 55% of students agreed the workshop helped them develop active reading practices
- 73% of students used the strategies provided in the workshop when reading articles for their scientific research reports
- 82% of students found unpacking the structure of an article component of the workshop helpful when writing their reports
- 89% of students reported they would use the reading practices they had learnt in the future

(Griffiths and Davila 2022)

The key skills that students took away from the workshop included:

- being more efficient at reading articles through scanning and making a list of questions as they read through the article
- being more familiar with the structure and sections of scientific articles and understanding what was in each section before attempting to write their own report
- having the confidence to openly discuss other’s opinions of an article to find things about the article they hadn’t noticed
- knowing how to read and analyse scientific articles and how to apply this skill to their own scientific writing
- increased confidence in being able to read scientific articles post workshop
- increased confidence in finding relevant articles for their research report

(Griffiths and Davila 2022)

Introducing scaffolded ideas for critical analysis of research articles early in the Science Extension course could be a way of improving reading skills, not just for students in Science Extension, but for students undertaking science courses in the future.

Workshop

UTS recently held a student-centred face-to-face workshop for Year 12 Science Extension students on how to perform a literature review and how to conduct critical analysis of scientific literature, led by UTS Librarian Sarah Su, Associate Head of School (Teaching and Learning) Dr Scott Chadwick, Senior Lecturer (Faculty of Science) Dr Yvonne Davila, Associate Head of School (Education and Students) A/Prof Irina Kabakova and Lead Teacher – Science Dr Lisa Cabral.

The delivery of workshops by disciplinary experts, who are accustomed to using critical analysis skills is highly beneficial (Davies 2017). Workshops were therefore run by practicing academics who modelled the skills required for reading and analysing scientific articles, highlighting the importance of reading and critical analysis skills in everyday scientific practice.

Science Extension students are aware from the onset they will need to write a mandatory Scientific Research Report, helping students understand the relevance of learning how to conduct critical analysis of the literature and hence students are more likely to be engaged (Griffiths and Davila 2022).

The workshop targeted the following **Science Extension outcomes**

A student:

SE-3 interrogates relevant and valid peer-reviewed scientific research to develop a scientific research question, hypothesis, proposal and plan

SE-5 analyses and applies the processes used in reliable and valid scientific research to solve complex scientific problems and inform further research

SE-6 analyses and reports on a contemporary issue or an application of science informed by either primary or secondary-sourced data, or both, in relation to relevant publicly available data sets

SE-7 communicates analysis of an argument or conclusion incorporating appropriate scientific language and referencing techniques in a scientific report

Strategies

Step 1: Students were explicitly taught how to choose relevant and reliable literature

- Use of **Semantic Scholar/Google Scholar**
- Use of **Keywords**
- Use of **Keywords** combinations connected via and/or **operators**

Step 2: Students were explicitly taught how to read and unpack the literature through **guided instruction**

- Students were taught how to identify the content and function of each section in a scientific article.
- Students were asked to identify different sections of the article, as they will appear in their own scientific research reports at the end of the course: Title, Scientific Research Question, Scientific Hypothesis, Abstract, Introduction (Literature Review), Methodology, Results, Discussion, Conclusion and Reference List.
- Students were asked to pull apart what the above sections of the article are trying to convey to the reader. Students were instructed to unpack, discuss and record the purpose and key points contained in each section.

- Students were taught skimming and scanning techniques for efficient reading of sections of articles.
- Students were taught to identify possible conflict of interest and assess the scientific quality and credibility of the publisher.

Step 3: Students were explicitly taught **active reading** techniques including asking questions, identifying discipline-specific language and technical terms, recording vocabulary, highlighting and making notes (Griffiths and Davila 2022). Students were taught to ask **WHY** as they critically analysed the text.

Examples of questions included:

- Are there any keywords/key concepts you do not understand? If so, do some research.
- Why did the author/authors carry out the Investigation?
- What is the scientific research question for the investigation?
- What is the hypothesis?
- What are the aims and key findings of the research or study?
- What have authors done well in this study?
- What are the limitations of the study? Could they be addressed?
- How could you incorporate their methods or analysis into your experimental design?

Step 4: Critical evaluation and interpretation of findings, evaluation of authorship, relevance, reliability, currency of different sources

- Students were encouraged to read texts, explore and discuss the meaning of the texts and to form arguments by stating how ideas were supported by scientific evidence. Students were asked to discuss any shortfalls of the scientific method, analysis and interpretations of results. Active discussion in a face-to-face workshop was important for students to practice the skills of breaking down a text and discussing their understanding with peers and instructors. Students were encouraged to communicate their findings through writing a scientific summary of what they had found.

Information slides were provided to students to provide explicit instruction on key concepts and strategies, enabling students to revisit slides for reinforcement and reflection.

Choosing a Scientific Article

A challenge in selecting an article to introduce the skill of reading and analysing scientific literature is that scientific articles which have been published in journals have already undergone extensive peer review by experts in the field and hence it is difficult to expect Year 12 students to critically interrogate the literature further. Therefore, an article was carefully chosen from *The Journal of Science Extension Research* (a collection of Science Extension Scientific Research Reports). Students were able to begin learning a new skill with an article written by a Year 12 student with a scientific writing level similar to their own and following the structure required for their scientific research report. The relative simplicity of the scientific research presented in the article from *The Journal of Science Extension Research*, compared to a published peer reviewed journal article, enabled students to develop the confidence to read, critically analyse and actively discuss their evaluation of the research article.

Examples of Science Extension Research Reports

https://education.nsw.gov.au/teaching-and-learning/curriculum/science/science-curriculum-resources-k-12/science-11-12-curriculum-resources/journal-of-science-extension-research

Conclusion

Science Extension students need to know how to choose a relevant, reliable scientific article, how it is structured, how to efficiently find relevant information and be able to identify and place information in the correct section of their own scientific research reports. The course requires students to interrogate peer-reviewed scientific research articles in development of their research proposal and in the writing of their research report. This workshop, developed with UTS science academics and staff, explicitly teaches students these skills, increasing their confidence in both reading, analysing and writing scientific literature.

References

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