



About the Potential of Adapted Scientific Literature for Science Education

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Abstract

Science education should be more than teaching science contents. An additional goal is to provide an understanding of the social practices of science. To this end, we propose to make the process of scientific publication transparent and to present authentic scientific literature to non-scientists. Authentic scientific literature is an important part of the culture of science and is underrepresented in formal education. After describing the main characteristics of research and review articles, textbooks, and the new genre of Adapted Scientific Literature, we compare their pedagogical potential and plead for including authentic literature in formal education.

Keywords: *scientific literacy, adapted primary literature, scientific literature, social practices of science*

1 Introduction

“There is more to teach about science than the content of science itself” [1, p. 248]. This statement from Osborne and Pimentel summarizes one of their main arguments why science education needs to facilitate more than just scientific core concepts. The authors argue that formal science education is incapable of enabling individuals to evaluate all the scientific claims they are confronted with in their lives. Since not all the necessary knowledge that is currently relevant or will become relevant in the future can be taught, individuals must be educated with an understanding of science that allows them to judge which sources and scientific arguments are trustworthy, regardless of its content. Instead, the authors propose to make them “competent outsiders”, which requires an understanding of basically three concepts [1]:

- (1) An understanding of the social practices of the scientific community that lead to the production of reliable knowledge.
- (2) The ability to evaluate scientific expertise.
- (3) Basic digital media literacy.

One of the possible contributions to achieve this goal is the development of new curricular materials [1]. For this, we propose to introduce the text genre of Adapted Scientific Literature, e.g., in the form of Adapted Primary Literature based on Yarden, Norris and Phillips [2], to non-scientists. We want to argue why we are convinced that making authentic scientific communication transparent could make the social processes in the scientific community more understandable. For this purpose, we will compare authentic scientific literature, Adapted Scientific Literature and textbooks and analyze their didactical potential.

2 Written science communication

Science communication fulfills different roles or functions for different groups in society and by that consequently changes in form and rhetoric depending on the receiver [3]. It addresses the different needs and characteristics of the recipients, e.g., different prior knowledge. Focusing on written forms, science communication can be distinguished in three sociocultural roles: *communication among scientists*, *popularization for the general public* and *formal education*. Fig. 1 displays the involved stakeholders and the most common used communication methods.

Research articles in scientific journals are the most important way to communicate for scientist. With these articles new results and theories are brought to other scientist in an argumentative way and by time a scientific consensus is formed [3, 4]. Textbooks on the other hand are the most common used text genre for formal education while Adapted Scientific Literature is a new hybrid text form in between. In the following, we briefly present the characteristics of the text types.

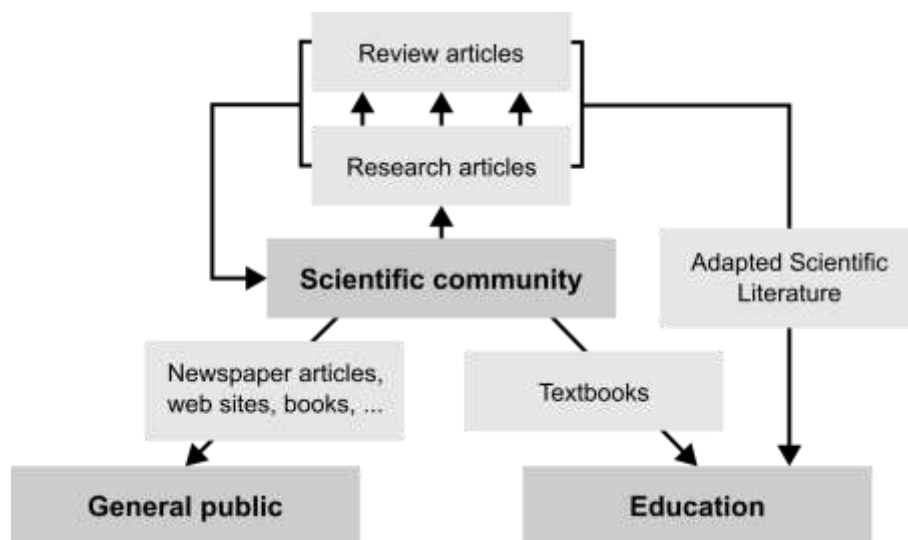


Fig. 1. Overview of written science communication processes and its stakeholders, supplemented by the new genre called Adapted Scientific Literature. Illustration based on [2, 3, 5].

2.1 Research and review articles

Scientific literature can be very heterogeneous and discussing all properties adequately would go beyond the scope of this paper. Therefore, only selected features can be presented here. Furthermore, we limit this analysis to the two main types of articles, the research article and the review article.

One of the most prominent features of a research article is the IMRaD structure (Introduction, Methods, Results and Discussion), which has been established since the 1940s [6]. Each section serves a specific function: justifying the research question, describing the research methods used, presenting the results, and analyzing and interpreting those same results [3, 4, 7]. Because of the heterogeneity of review articles [8], this structure cannot usually be found in these, even if some sections pursue similar goals.

On a linguistic level, one of the most important features is hedging. Hedging describes rhetorical figures that limit the truth of a statement, adding uncertainty. This is achieved, for example, by using phrases such as "we believe that", "possibly", or "might" [9]. Hedging allows authors to make claims with caution and modesty, which enables the scientific community to negotiate about the status of such claims [10].

2.2 Textbooks

The main goal of textbooks is to provide well-established facts for non-specialists, e.g., K-12 or university students [2, 3]. The style can be described as expository. School science is presented as static, final, ahistorical and discovered by intelligent and altruistic scientist [11]. This is done through various rhetorical strategies: (a) *concealing the subjects of scientific action*, e.g., by using passive voice; (b) *reinforcing faith in the objective realities of entities and laws of natural science*, e.g., by using present tense; and (c) *emphasizing scientific knowledge as the end product and degrading the scientific process* by using more texts explaining and describing theories and scientific laws and less texts describing experiments and historic information [11].

If present at all, the scientific process is described in a rather anecdotal-pseudohistorical manner, for example Newton's "discovery" of gravity by a falling apple or Fleming's failed experiment that led to penicillin [3].

2.3 Adapted Scientific Literature

Used in the scientific community, original research articles as well as reviews are highly professional, use specialized language and are very detailed. Therefore, they are difficult to read for novice [2, 12]. Facing these problems, Yarden et al. propose to modify research articles and created a new text genre called Adapted Primary Literature (APL) [2]. Adaptation of original articles allows simplifying the texts for easier reading and reducing the cognitive load while maintaining authenticity. This is because the three structural motifs of the *organizational structure*, *goal-directed structure*, and *argumentative*



structure are preserved in the adaptation. The properties of an APL are therefore very similar to an original article [2].

Yarden et al. recommend to use research articles for adaptation, because other types of texts could lack the aforementioned structure motifs and would require an extensive adaption [2]. Nevertheless, we propose the adaptation of review articles. Unlike research articles, review articles usually do not have the established and widespread IMRaD structure, but they have similar structural features. One advantage of reviews is that they are less specific in their subject, making them more accessible in terms of their content. With the term Adapted Scientific Literature we want to combine adaptations of research articles and of review articles under one umbrella term.

3 Pedagogical potential of the text genres

With the described properties in mind, it is noticeable that the presented text types are very different in their goals and thus in their structural and linguistic textual design. This results in both disadvantages and advantages for their use with students in schools.

With reference to the demand to educate individuals to be "competent outsiders", an understanding about the social practices of science is needed [1]. Why not use the authentic literature that reflects the debates in the community for this purpose? The discussion section of a research paper and the summary of research results in an introduction section as well as in a review, is a condensed form of this: citing other researcher groups, balancing different (sometimes contradictory) results and contextualizing the own results and theories [3, 4, 6]. This is done in a language that allows contradiction - by hedging. As described above, textbooks, in contrast, present science in a totally different way: static, final and certain.

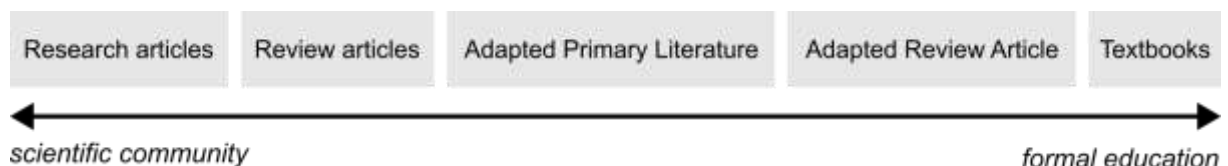


Fig. 2. Schematic arrangement of the text genres according to its usage.

Fig. 2 arranges the text types and Fig. 3 shows some pedagogical potentials for the genres based on their properties. The arrangement (Fig. 2) shows the usage of the texts from the scientific community on the left, to formal education on the right. With this, many different characteristics are associated: from difficult to easy to read; from specialized to general content; from assuming and depending on high prior knowledge to not; from uncertain to certain; from arguing to explaining and so on. Accordingly, possible pedagogical applications (Fig. 3) derive from this, but they are still extremely dependent from the actual content of a text. For example, a textbook could very effectively teach students about social structures if it is actively addressed in a text. This analysis of the potential is to be understood purely qualitatively and is only a first start.



Fig. 3. Pedagogical potential of the text types research article (RSA), Adapted Primary Literature (APL), review article (RVA), Adapted Review Article (ARA) and textbooks (TB). Darker shading of the horizontal bars indicates a higher potential for the respective educational goal.

4 Conclusion

The difference between the texts can be seen from the explanations above. We are convinced that through the inherent characteristics of authentic scientific literature, social practices in science can



become evident. Scientific success is measured especially by the list of publications, but it's hardly a topic in formal education. This could be actively reinforced by additionally talking about the publication process: How does a peer review process work, which interests do which stakeholders have there? This could even be taken as an opportunity to discuss publication pressure of scientist and their funding.

Understanding scientific publications and their publication processes is the first step in understanding consensus building in science, which ultimately determines what is written in a textbook. As Hyland accurately concluded: "Scientific 'truth' is as much a social as an intellectual category" [10, p. 241].

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