Virology in Schoolbooks

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The researchers have analysed all recent Austrian biology schoolbooks for secondary school with respect to virus-related topics. They found that many books cover many aspects, but books even for the same grade differ greatly in content and detail. Most important, there is a severe lack in clear differentiation between viruses and bacteria, in emphasizing that viruses cannot be destroyed by antibiotics, and in presenting pictures of viruses to show and discuss their structure.

Keywords: virology ; schoolbook ; biology ; antibiotics ; vaccination

1. Introduction

The last few years have drastically shown that deadly viral diseases are not gruesome stories from the past, related to specific behaviour, or restricted to specific regions. On the contrary, the COVID-19 pandemic has probably had physical, mental, economical, and/or social impacts on most people worldwide. The causal agent of viral diseases—viruses—are non-living particles very distinct from living organisms and even bacteria, although they are often misleadingly placed under the heading “micro-organisms” and understood by many as a kind of unicellular living being [1][2]. Viruses display a wide variety of structures, with some viruses even making use of host cell membrane components; for replication, they depend on host cells, which can be any living organism, though individual viruses may be very host-specific [2]. The wide occurrence of viruses, their significance as pathogens, and their very special organization make them an interesting and important topic at school. Therefore, the time has come to examine the place virology finds in schoolbooks, since such books are an essential source of information for a large part of the population in many countries.

This is even more important as what the researchers learn about viruses at school may help them to:

- Understand what viruses really are, e.g., non-living particles, which is biological knowledge that is valuable on its own, but also highly relevant for everyday situations (see next points).

- Counter fake news, e.g., the belief that viruses causing measles or COVID-19 do not exist but are an invention of politicians and the pharmaceutical industry; that they are harmless, and their danger is exaggerated by governments and industries; and that they may be killed off by antibiotics [1][2][3][4][5][6][7][8][9][10].

- Realise how they can protect ourselves and others against viral infections, which is an important issue both for individual well-being and public health. Therefore, students should become familiar with the transmission routes of the (regionally) most important viruses and learn how to protect themselves against an infection.

- Raise awareness for and develop new therapies against viral (e.g., antiretroviral medication against HIV) as well as bacterial diseases (e.g., phage therapy). In this respect, it is important that students learn about the essential steps of viral replication, at least basically, to be able to understand why and where antiviral medication can target this process and thereby prevent the further production of viral particles.

Naturally, the knowledge presented and discussed in schoolbooks must not contain content or wording/phrasing-related mistakes, as both may create misconceptions and/or lead to the memorisation of wrong ‘facts’ (e.g., naming viruses as micro-organisms or incorrectly labelling structures shown in illustrations).

However, there are only very few studies analysing in depth what students know about viruses [1][11][12][13]. Yet Dumais and Hasni (2009) rightly stated that “understanding the conceptions that young people have about viruses […] may be important for the development of effective school health education programs” ([11] p. 62). In this respect, schoolbooks as a knowledge source seem to have been overlooked completely when it comes to virology.

2. Virology in the Austrian Curriculum

The Austrian school system is broadly divided into primary school (grade 1–4), lower secondary school (grade 5–8; either middle school or high school), and upper secondary school leading to A-levels (grade 9–12/13, depending on the type of high school). The counting scheme begins anew after primary school. Thus, students in grade 5 start secondary school with class 1 again, which is reflected in schoolbook labelling.

In Austrian lower secondary school, virus-related topics may be discussed in class within the thematic field “Mankind and health”, mainly in grades 6 and 8. Virology is only once referred to specifically in the curriculum, namely in grade 8, where AIDS (acquired immune deficiency syndrome) is explicitly mentioned as a disease to be discussed. In upper secondary school, viruses may be integrated in topics such as “differences between pro- and eukaryotes” in grade 9 (if teachers want to deliver such knowledge), “immunology and diseases” in grade 10 (again, AIDS is explicitly mentioned here), “pathogens” and “infectious diseases” (with an explicit naming of viruses) in grade 11 (however, only few schools teach biology in grade 11; thus, these topics are either omitted or dealt with in grade 10 or 12 in a condensed version), and “biotechnology” in grade 12 (often, gene therapy is included here) [14][15]. There is no reference to virology in primary school, neither in the curriculum nor in schoolbooks for these grades. Therefore, the researchers restricted their analyses to books for secondary school.

To summarize, viruses are rarely mentioned in the curriculum, which offers little stimulation for schoolbook authors to deal with them in detail in their books. On the other hand, there are several thematic fields that would allow the inclusion of virology.

3. The Impact of Schoolbooks on Knowledge and Attitude of Students

Besides speech and graphical representations, written texts are probably among the most important and most traditional tools to convey knowledge, starting from ancient papyrus scrolls to modern books, nowadays supplemented or replaced by e-books, online material, or other electronic texts. Yet, as Heynemann (2006) stated, “textbooks (…) will remain an instrument of extraordinary power. They may (…) be the most effective of educational technologies yet invented, and there is no reason to imagine a modern educational system where textbooks do not play a central role.” (p. 36 [16]).

Text and information in schoolbooks are compiled and designed by the authors and editors with the intention that students encounter the knowledge deemed essential for their future life, with such knowledge often being listed in national or regional curricula. Thus, schoolbooks are typically written to assist students in learning what a particular school authority believes to be crucial for the general population to possess. This is especially true for countries such as Austria, where all schoolbooks are acquired by schools through a fund of the ministry of education and have been reviewed and approved of by schoolbook commissions specifically staffed with subject-specific experts according to national curricula. (Approved schoolbooks are free of charge in Austria.)

On the other hand, schoolbook texts may also influence attitude formation in those reading them. Political influence may have the consequence that the same schoolbook may be published in different versions—even within the same country—if commissions of certain states differ in what they want their students to read. A prominent example comes from a New York Times analysis comparing U.S. history schoolbooks with special editions for California and Texas [17].

Depending on such authorities’ level of independency, schoolbooks may thus contain subliminal or openly declared attitudes and prejudices concerning specific topics, countries, groups of people, etc. One may think that such attempts to steer readers towards a certain political direction may particularly relate to history, geography, politics, or religion/ethics. For example, many early U.S. history textbooks have conferred anti-British feelings [18]. A more recent example comes from the analysis of schoolbooks for religion, ethics, history, Arabian, and social studies in Afghanistan, Iran, Egypt, Palestine, and Turkey [19]. In these books, the author found conspiracy theories and antisemitism, the control of religious thinking and behaviour, nationalism, and the streamlining of national histories.

However, examples for trying to imprint a certain political (or religious) agenda can also be discovered in the natural sciences and mathematics. For example, creationism found its way into many former biology schoolbooks in the U.S., even though more recent books seem to have mostly expelled this religious concept from biology teaching [20]. Another example comes from a math book from the former German Democratic Republic: “36 German, 25 Soviet and 15 Polish pioneers take part in the friendship meeting. How many pioneers are celebrating together?” [21]. On the surface level, this is a simple calculation task. Yet there are several political messages transported, too: First, this task relates to pioneers, which were members of a scout-like organization training pupils according to the respective socialist government’s political views and making them contribute to society in social projects. When embedded in a math task, pioneering is

transported as something normal. Second, young readers learn that there are pioneers in other socialist countries, which had been political allies of former East Germany. Thus, political bonding may be formed between students from these countries.

Apart from hidden or openly conferred political, moral, or religious messages, the kind of knowledge presented in a schoolbook is also important, as well as the degree of detail. For instance, the way students understand inheritance and genetics may well be influenced by how strongly a textbook emphasizes genetic determinism and how the interrelation between genotypes and phenotypes is discussed [22].

Although there are apparently very few studies that have analysed the impact of schoolbooks on students' knowledge formation, there is some indication that schoolbooks are not only widely and consistently used in the classroom, but that they may additionally function as a source for information both for students and parents at home [23][24][25][26], although some authors have found that schoolbooks are only used inside school [27]. For biology, the importance of schoolbooks as a source of knowledge and interest is demonstrated in a pilot study by Aufdermauer and Hesse (2007), in which 44% of the participating middle school students stated that they would make use of their biology textbook even in their leisure time, while more than a third had tried out experiments described in the book at home [28]. For math, some authors have found that the specific schoolbook chosen by teachers may influence both the content and methodology of teaching [29]. One must concede, though, that on the individual level the influence and use of schoolbooks may very much depend on students' training in self-learning, on their teachers' background and skills in information presentation and discussion (and, if needed, in scaffolding according to individual students' needs), the attitude and background of parents, and the use and opinion of a specific book by peers.

4. Schoolbooks, Virology, and the DARAHM Model

As explained above, schoolbooks and the knowledge presented therein may influence students' and parents' knowledge about a particular topic and their attitude towards that topic. This may also hold true for teachers relying on schoolbooks as the main or only knowledge/attitude source for their subject. Furthermore, one's predisposition and preconceptions may play important roles here. For example, the acceptance of factual knowledge about specific diseases, their causal agents, and preventive measures such as vaccination presented in schoolbooks may come into conflict with conspiracy theories, esoteric beliefs, certain religious views, general fears concerning specific technologies (e.g., genetic engineering), or general scepticism against science. Thus, students may hear from their parents that certain diseases are, in fact, an invention by certain groups and/or that their causal pathogen does not exist in reality (see above). Here are three examples: (i) Kindergarten children in the U.S. have been found to be less likely to have received vaccination against measles, mumps, and rubella (MMR) and diphtheria, tetanus, and pertussis (DTaP) in states allowing exemption due to religious or philosophical reasons [30]; (ii) Some anti-COVID-19-vaccination campaigners used the court case of a German 'biologist' denying the existence of the measles virus for implicitly arguing against vaccination against COVID-19 (discussed in [2]); (iii) in a small-scale pilot study in the German state Baden-Wurttemberg, three of the seven interviewed biology teachers said that many parents were against vaccination [31]. It may be a coincidence, but this state is the centre of the anthroposophical movement in Germany, and there is some indication that belief in non-evidence-based treatments (such as homeopathy) and the refusal of COVID-19 vaccines are significantly correlated [32].

Second, the acceptance of measures for treatment of viral diseases and the prevention of their transmission may also be influenced by parental views, role models, and other influential voices such as state representatives; whether or not a disease is taken seriously and whether sensible measures are followed may strongly depend on public statements of politicians and their coherence, as could be seen during the current COVID-19 pandemic, where some state leaders publicly denounced vaccination or even the existence of the virus, recommended the use of antibiotics or ivermectin, or declared vaccines produced in countries of other political systems to be inefficient without any scientific proof.

Third, electronic media probably play an important role in knowledge acquisition and attitude formation. As polls from the U.S. have shown, most people with access to the internet, especially younger users, would try to find information on a specific scientific topic on the internet first [33].

All this shows that school is but one of the many factors students are exposed to. These factors (or settings) are part of the DARAHM model recently introduced into health education [34]. This model focuses on the empowerment of students to act according to their (perceived) best interests in health-related situations. The model is built upon inner and outer concepts, which are closely intertwined: the centre of the model is the individual "self", which includes how one sees oneself in relation to one's health and in general, the ability to reflect about one's own attitudes, intentions and behaviour, and one's own impression of self-efficacy; here, three aspects should be heeded, namely, cognition (e.g., acquired

knowledge), motivation/affection (e.g., personal interest and beliefs), and performance (e.g., knowledge put into practice). Yet every individual experience is influenced by its surroundings. This is mirrored in the model in that the centre (the “self”) is surrounded by two “settings”: “school” (as the setting of particular interest for educators this model is made for) and “other settings”. The latter refers to family, friends, role models, media, local or other communities, etc. The DARAHM model is not meant as something static. On the contrary, both the self, school, and the other settings are in constant exchange and influence each other [34].

In relation to the way schoolbooks are used as a source for knowledge and attitude formation, the DARAHM model can be understood in a way that such a usage can be influenced by several players, as discussed above. For example, teachers must select and use specific books, and these books may deliver different or differently detailed content and, implicitly or explicitly, different attitudes, which in turn may depend upon individual authors and/or school authorities. On the other hand, parents may have explicit attitudes to certain content dealt with in such books and/or may use such books for their own knowledge building. Students, being influenced by their family, peer groups, role models and others, may or may not accept scientific facts and recommendations presented in their schoolbooks. However, well-written and designed books and the well-prepared usage of them by teachers may not only foster learning but lead to conceptual changes in case of conflicting concepts (e.g., parental refusal of vaccination vs. positive representation of vaccination in a schoolbook).

Thus, the “other settings” mentioned in the DARAHM model [34] may have a positive, negative, or neutral effect on the reception of information gathered at school and from schoolbooks. However, individual teachers play a very important role here, both in the way schoolbook (and other) knowledge is selected, structured, and prepared for a possibly heterogeneous group of learners and in the way both teachers and, presumably, books are perceived as subject authorities by their students [35]. Nevertheless, to allow students to acquire, evaluate, and apply knowledge on their own by reading a textbook, decisive facts concerning a given topic should be presented in a comprehensible manner that is detailed and appealing enough to facilitate understanding and not just knowledge reproduction. Consequently, schoolbook authors should:

- Provide up-to-date scientific knowledge (e.g., what a virus is, how it is different from living organisms, how a virus is replicated and transmitted, and how vaccination and medication may interfere with viral replication by the priming of the immune system or by blocking receptors or enzymatic steps in the replication process);

- Make suggestions for implementation in real life (e.g., preventive measures and treatment);

- Deliver clear-cut arguments against myths (such as “viruses are killed by antibiotics”) by making use of scientific facts (e.g., viruses have no metabolism with which antibiotics could interfere with);

- Aid understanding by multiple but interconnected representations (e.g., visual representation of the replication process);

- Make suggestions for exercises to facilitate both long-term knowledge storage and knowledge transfer (theoretical tasks) and behavioural routines (e.g., handwashing, boiling water for the preparation of meals, avoiding contact with blood from other persons, and so on).

This, in turn, may allow students to develop knowledge and, subsequently, knowledge-based behaviour that is in accordance with the present scientific view.

Yet, the COVID-19 pandemic has drastically shown that many people have lost trust in science due to contradicting views by experts. For example, even leading virologists in German-speaking countries disagreed about when to implement certain measures and how strictly these measures were to be followed. Here, it is important to discuss with students that the formation of knowledge in science is no clear-cut and streamlined process. Instead, it is highly discursive and includes comparing new insights, testing and discussing new results, and, possibly, overthrowing hypotheses and theories held true until a given contemporary period. Teaching about the nature of science, including its process of knowledge discovery, may help students to better come to terms with the complexity of science in later life [36]. In schoolbooks, this could be reflected in the presentation and discussion of different perspectives on the same topic, or the delineation of how a certain scientific discovery was made, including discoveries that were originally not believed in even by experts of the field (e.g., that human papilloma viruses are the main cause for cervical cancer). However, this latter approach would require a different and more argumentation-based schoolbook analysis and has therefore not been included here.

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