Fact-value discourses in 19 analyses of genetics in biology textbooks: A critical review

Abstract
This study analyses research reports on textbooks in genetics education regarding the fact-value distinction. From the perspective of four possible fact-value-related discourses, I have conducted a content analysis of 19 research reports on genetics in textbooks after 2002 (articles, book chapters, and one paper based on a conference presentation.) The general background for this review is an underlying interest in combining and integrating academic achievements and value(s) education in the context of science education in the field of genetics and human beings, by, at the same time realizing the challenges in practicing the principle of interdisciplinarity. This “interest” has been illustrated both in the science education literature and in general educational theory during the last decades. Our study falls into two parts. First, we conducted a qualitative interpretative content analysis. Second, we used a quantitative approach by counting value-related words. We identified the discourses on a continuum, from single-academic-discipline-oriented discourse (based on the natural sciences) to interdisciplinary value-oriented discourse involving the social sciences and/or the humanities with their related concepts and debates. Based on our study we can recommend future researchers on textbooks to be aware of the discourses we have exemplified and therefore explicitly delimitate their study accordingly. In this context one research field could be to study what textbooks say about how to discuss value questions in the context of science and science education.

INTRODUCTION
Parallel to an increased focus on genetics in research during recent decades, the same tendency can be seen in science education literature, with studies of scientific correctness in textbooks, students’ and teachers’ conceptual understanding in the field, genetics in curriculum documents and socio-scientific aspects of the topic (e.g., Donovan, Semmens, Keck, Brimhall, Busch, et.al., 2019; Kampourakis, Reydon & Patrinos, 2014). The review by Stern and Kampourakis (2017) gave an important overview. The textbook is still a key factor, which can significantly influence the teaching and learning process. Therefore, textbook development and research are crucial, in combination with research into the use of curriculum materials (Davis, Janssen & Van Driel, 2016; Pingel, 2010).
In this paper, I present a critical review of textbook studies analysed from a particular perspective. With other words, this study distinguishes between research on textbooks, the textbooks themselves and our perspectives and findings. Therefore, there is no direct consequences of this piece of research understood as implications for practice and textbook writers. However, at the end of this article I briefly sketch, from my perspective some challenges not only for research but also for practitioners and textbook writers in this field. Obviously, in the discussion of practice a wider context must be taken into consideration, for instance the aim and curriculum guidelines of science education.

The present study falls into the area of science education concerned with values, socio-scientific, social and ethical issues and research on such issues (e.g., Roberts & Bybee, 2014; Pedretti & Nazir, 2011; Mansfield & Reiss, 2020; Zeidler, 2014). The debate on a balanced view about the aim of science education is a good entry into this broad field (Roberts & Bybee, 2014). Should science education primarily focus on “mastering what is needed to study more advanced science in the future,” or should school science begin “by looking outside science to build curriculum that illuminates how science permeates and interacts with many areas of human endeavour and life situations”? This latter, broader approach called Vision II usually includes “political, economic and ethical considerations” (Roberts & Bybee, 2014, p. 546). In two open-access articles, one of them presenting a model for analysing genetics and values in biology textbooks (Sæther, Reindal, Skrunes, & Toft, 2018a) and the other on genetics and ethics (Toft, Reindal, Skrunes, & Sæther, 2018), we have given more of references to the vast literature on values in science education and modern genetics. Of particular interest is the discussion of how to deal with controversial issues in science education (Sæther, 2019).

My focus is on the ethical and moral aspects of values, which, in the case of our sources, are sometimes explicitly in focus and sometimes implicitly interwoven with other issues. In this “messy landscape”, our focus is on fact-value discourses, about which Crisp (1998) has argued: “According to proponents of the fact/value distinction, no states of affairs in the world can be said to be values, and evaluative judgments are best understood not to be pure statements of fact.” Accepting this very general principle, I presuppose, with reference to Afdal (2004) and Føllesdal (2005), that interdisciplinarity is an important principle in dealing with fact-value problems generally, and in education. In the end of this paper, I briefly comment on some of the context factors without taking the discussion further how to deal with the fact-value issue in practice. See for example Weyringer, Patry, Pnevmatikos and Borhaug (2022) for examples about a combined focus on academic knowledge and values in education.

The general background for this review is this underlying interest in combining and integrating academic achievements and value(s) education in the context of science education in the field of genetics and human beings. My interest in this field and my conception of various discourses (see below for details) is rooted in (a) the literature on fact-value/socio-scientific issues in science education (e.g. Roberts & Bybee, 2014; Mansfield & Reiss, 2020; Pedretti & Nazir, 2011; Zeidler, 2014); (b) educational theory/didactical literature on methodology in the context of a combined focus on academic learning and values (e.g. Weyringer, Patry, Pnevmatikos & Borhaug, 2022), and (c) our own suggestions for terminology (Sæther, Reindal, Skrunes, & Toft, 2018b). The discourses I talk about (see details below) are rooted in this literature and do not represent any ground-breaking new ideas. However, they do summarize in a new way thinking in the fact-value field in an educational context and suggest categories for analysing texts (and practices).

My research question is on reviewing research: With a focus on the period after 2002, what do recent analyses of genetics in textbooks express about fact-value discourses? Our focus is on analysing the research reports, i.e., the texts produced by the researchers. In this context it is important to be aware that the meaning of a text may exist independently of the author’s intention with respect to the text. This principle is a common-sense insight; what one intends to express might be interpreted differently from a new perspective, i.e., from an outsider’s point of view. Therefore, our focus on fact-value discourses does not imply that we are making any claims as to having said that these discourses represent the actual intentions of the researchers. Against this background, I do not wish to criticize the delimitations always necessary in research. However, the reason why I focus on more or less hidden discourses is that research in this area I focus on have not said enough about these delimitations, i.e.,
Jostein Sæther

in particular when it comes to value aspects in genetics. On this background I also hope that this paper could contribute to more of explicit focus on value related issues in future research on genetics in textbooks (see the conclusion part), and in the end also challenge textbook writers.

In this paper I use “I” and “we” interchangeably. In cases where I explicitly base my work on papers co-authored with others I use “we”/“our”; when referring to my own single-authored publications I use “I”/“my”.

MATERIALS AND METHODS
Materials analysed
Our selected papers cover a broad field of textbook research with a focus on overlapping issues such as the following:

1. Conceptual variation with a focus on various gene concepts or models (Aivelo & Uitto, 2015; Albuquerque, de Almeida & El-Hani, 2008; Christidou & Papadopoulou, 2020; dos Santos, Joaquim & El-Hani, 2012; Flodin, 2009; Gericke & Hagberg, 2010a; Martinez-Gracia, Gil-Quílez & Osada, 2006; Wahlberg & Gericke, 2018).
2. One special topic is that of genetic determinism (hereditarianism vs. epigenetics). Several articles address this field to a greater or lesser extent (Aivelo & Uitto, 2015; Castéra, Bruguière & Clément, 2008; Castéra, Clément, Abrougui, Nisiforou, Valanides, Turcinavičienė et al., 2008; Christidou & Papadopoulou, 2020; deJong-Lambert, 2009; dos Santos, 2012; Forissier & Clément, 2003; Gericke & Hagberg, 2010a, 2010b; Puig & Jiménez-Aleixandre, 2011).
3. Textbooks sometimes conflate storytelling about nature with nature itself, by using models, analogies, theories, concepts and metaphors (Gericke & Hagberg, 2010a, 2010b).
4. Varying ontologies emerge by describing genetics, for example, idealistic vs. naturalistic thinking and realism vs. instrumentalism (dos Santos et al., 2012; Flodin, 2009; Gericke & Hagberg, 2010a, 2010b).
5. Ethics, moral aspects, politics, ideologies, world views, and interdisciplinarity not only between the natural sciences but also, in various degree including the social sciences and the humanities: Traditionally, science has not focused on value terms. However, when combined with technology and politics, the dimension of values comes clearly to the fore (Hott, Huether, McInerney, Christianson & Fowler et al., 2002). Often, the social practice of conducting research and teaching science has implicit value-related implications for our understanding of human beings and social life (Aivelo & Uitto, 2015; Calado et al., 2018; Castéra, Bruguière et al., 2008; Castéra, Clément et al., 2008; deJong-Lambert, 2009; Forissier & Clément, 2003; Martinez-Gracia et al., 2003; Morris, 2014).

In this article, the latter issue is the focus of attention (i.e., ethics, moral aspects, politics, ideologies, world views and interdisciplinarity understood as including the social sciences and the humanities and their connected debates). In Table 1, I present a summary of the sources used in this research project.

It should be noted that in Table 1, the article entitled “Conceptual variation or incoherence? Textbook discourse on genes in six countries” (Gericke, Hagberg, dos Santos, Joaquim & El-Hani, 2014) was not included since it was based on two previous studies already among our sources (dos Santos et al., 2012; Gericke & Hagberg, 2010a). The analysis of Mendelian genetics by Campanile, Lederman and Kampourakis (2015) was not included because it primarily analysed textbook presentations of what science and scientific inquiry is, and it did not focus on genetics.
Table 1. Analyses of genetics in textbooks 2002–2020 (Sæther et al., 2018b – adapted and extended)

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Methodological emphasis of the study</th>
<th>Age group focused on</th>
<th>N (textbooks)</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aivelo &amp; Uitto, 2015</td>
<td>Content analysis, combining qualitative and quantitative aspects</td>
<td>Upper secondary</td>
<td>4</td>
<td>Finland</td>
</tr>
<tr>
<td>Albuquerque, de Almeida &amp; El-Hani, 2008</td>
<td>Content analysis</td>
<td>College level</td>
<td>3</td>
<td>Used internationally; no specific country focused on</td>
</tr>
<tr>
<td>Calado et al., 2018</td>
<td>Qualitative content analysis &amp; quantitative frequency analysis (p. 274)</td>
<td>9th and 11th–12th grades</td>
<td>8</td>
<td>Germany and Portugal</td>
</tr>
<tr>
<td>Castéra, Clément et al., 2008i</td>
<td>Content analysis</td>
<td>12–19</td>
<td>50</td>
<td>12 from Europe + Tunisia, Morocco, Senegal and Lebanon</td>
</tr>
<tr>
<td>Castéra, Bruguière et al., 2008</td>
<td>Quantitative content analysis</td>
<td>15–18</td>
<td>18</td>
<td>France</td>
</tr>
<tr>
<td>Christidou &amp; Papadopoulou, 2020</td>
<td>Quantitative content analysis</td>
<td>12-18</td>
<td>6 (+1?)</td>
<td>Greece</td>
</tr>
<tr>
<td>deJong-Lambert, 2009</td>
<td>Content analysis / interpretative methodology</td>
<td>High school, higher education</td>
<td>?</td>
<td>Poland</td>
</tr>
<tr>
<td>dos Santos et al., 2012</td>
<td>Categorical content analysis/ aspects of discourse analysis/ qualitative study (p. 553)</td>
<td>High school (14–18)</td>
<td>18</td>
<td>Brazil</td>
</tr>
<tr>
<td>Forissier &amp; Clément, 2003</td>
<td>Content analysis</td>
<td>16–17</td>
<td>3</td>
<td>France</td>
</tr>
<tr>
<td>Flodin, 2009</td>
<td>“inspired by the phenomenographic method”</td>
<td>College level</td>
<td>1</td>
<td>USA (textbook analysed is used worldwide)</td>
</tr>
<tr>
<td>Gericke &amp; Hagberg, 2010bii</td>
<td>Content analysis/holistic perspectives</td>
<td>Upper secondary</td>
<td>13 +7</td>
<td>Sweden (with 7 textbooks from English-speaking countries)</td>
</tr>
<tr>
<td>Gericke &amp; Hagberg, 2010aiv</td>
<td>Concept mapping / content analysis/holistic</td>
<td>Upper secondary</td>
<td>8 +7</td>
<td>Sweden (with 7 textbooks from English-speaking countries)</td>
</tr>
<tr>
<td>Hicks et al., 2014</td>
<td>Quantitative content analysis</td>
<td>High school</td>
<td>11</td>
<td>USA</td>
</tr>
<tr>
<td>Hott et al., 2002</td>
<td>Analysed for six content areas</td>
<td>Graduate</td>
<td>5</td>
<td>USA (textbook is used internationally)</td>
</tr>
<tr>
<td>Martinez-Gracia et al., 2003i</td>
<td>Content analysis</td>
<td>High school, grades 10–12</td>
<td>34</td>
<td>Spain</td>
</tr>
<tr>
<td>Martinez-Gracia et al., 2006ii</td>
<td>Content analysis</td>
<td>Grades 10–12</td>
<td>34</td>
<td>Spain</td>
</tr>
<tr>
<td>Morris, 2014</td>
<td>[Qualitative and quantitative]</td>
<td>Ages 14–16</td>
<td>1</td>
<td>England, UK</td>
</tr>
<tr>
<td>Puig &amp; Jiménez-Aleixandre, 2011, pp. 201–204, 210–212vi</td>
<td>“contents...analysed”</td>
<td>10th grade</td>
<td>5 +3</td>
<td>Spain</td>
</tr>
<tr>
<td>Wahlberg &amp; Gericke, 2018</td>
<td>“a content analysis approach inspired by text summarization and text mining techniques”</td>
<td>Upper secondary</td>
<td>7</td>
<td>Sweden</td>
</tr>
</tbody>
</table>

i Also presented in Clément & Castéra, 2014.
ii Two studies by Gericke and Hagberg used overlapping samples of textbooks: Gericke and Hagberg (2010b) used more recent editions, compared with a previous study (2010a).
iii Two studies by Martinez-Gracia et al. (Martinez-Gracia et al., 2003, 2006) used the same textbooks as sources but studied them from different perspectives.
iv Textbook analysis is just one part of this book chapter. The introduction to the book chapter is included.
More about the selection of materials
We focused on studies published after 2002, i.e., 17 research articles from journals and two book chapter (one of them based on a conference presentation)—all of them on genetics in textbooks. The conference paper deserves a comment. It is not a peer-reviewed journal article, but a selected paper based on a presentation at the XIIth conference of European Researchers in Didactics of Biology (ERIDOB) in 2018. This well-established organization/conference is supposed to give enough of guarantee for the quality of this paper. We identified material using our general knowledge in the field, by recommendations from the reviewers of a previous version of this article, and by searching for peer-reviewed articles in databases available on online browsing platforms such as EBSCO, ERIC and ISI, using terms such as *genetic* (i.e., including *genetics*, *genetical* and *genetically*) and *textbook* (i.e., including *textbooks*) (see Table 1). Only studies of introductory textbooks were included (not specialized textbooks), i.e., studies with a broad approach. Therefore, reports not included were on specific issues, such as “symbol systems of alleles in textbooks” (Livni-Alcasid, Haskel-Ittah & Yarden, 2019) and content analysis of an anti-genetic conception in one historic(al) textbook (Caroli, 2019). 13 of these analyses were presented in an earlier study (Sæther et al., 2018b), and reference is made in this paper to our previous material, findings, conclusions, and theoretical background (Sæther et al., 2018a, 2018b; Toft et al., 2018). In one of these articles (Sæther et al., 2018b) some more details are presented about the procedure how to select relevant material. However, now, a new quantitative methodology has since been applied and five new studies analysed (Aivelo & Uitto, 2015; Calado, Scharfenberg & Bogner, 2018; Christidou & Papadopoulou, 2020; Hicks, Cline & Trepanier, 2014; Wahlberg & Gericke, 2018). To limit our project, we could have excluded studies on higher level textbooks. But we have not because such studies include textbooks that can be used in teacher education. See also a few more details about the selection of sources in the footnotes to Table 1.

Methods: Analytical Perspectives – How to Analyse
The first part of this study can be categorized as qualitative and interpretative research. We also carried out a quantitative content analysis of word frequencies to strengthen the validity of our qualitative analysis (see Part II for details about the methodology). The qualitative methodology, which represents our first step, required that each report be presented in enough detail to provide sufficient arguments for our classification.

Hammersley (2004) has summarized key criteria when conducting a literary review, as we have done. The focus should be on relevance, validity and “making sense of the findings of different studies to construct a holistic picture of the field, a picture that may well reflect the particular interests and sensibilities of the reviewer” (p. 578). This intention to construct a holistic picture of the fact-value issue in the field of “genetics and human beings” in textbook studies (cf. Sæther et al., 2018a, 2018b) is of course too ambitious if we see “holistic” as something covering all issues in this field. My “holistic” picture is of course influenced and limited by our analytical perspectives. By applying other perspectives of course more could be said.

(1) Focus (or lack thereof) on values or value aspects, and examples of topics and perspectives illustrating these aspects. In this context, ethical and moral aspects are of decisive importance but also ideological, political and world-view issues if these may be connected to ethical and moral issues.
(2) Topics particularly related to human genetics.
(3) Explicit emphasis on interdisciplinarity understood as involving the social sciences and/or the humanities with their related concepts and debates.

Figure 1 Three categories for analysing textbook analyses in genetics-related fields (adapted from Sæther et al., 2018a, p. 64)
Previously, I have linked the concept of value to ideologies (Sæther, 2003). Ideologies can be “tacit rather than explicit” and therefore need to be analysed, detected and perhaps criticized. Ideologies in education can be “located on a continuum from the most obvious, public and articulate statement of purpose, content and rationale to the most subtle, private, and latent view” (Eisner, 1992, p. 305). Combining the criteria in Figure 1 with a model originally called “Four strategies for how to handle value-related, ideological, and/or interdisciplinary questions in teaching and learning processes” (Sæther et al., 2018a, p. 50), we focused on four possible underlying discourses situated on a continuum, from a fact-oriented discourse based on the natural sciences to an interdisciplinary value-oriented discourse influenced also by the social sciences and the humanities and their related concepts and debates:

1. Discourse that does not include questions about values: If the study gave no (or an insignificant) presentation of value aspects and/or corresponding needs for interdisciplinarity, it was classified as Discourse 1-oriented.
2. Handover discourse: This applied to studies that mentioned such aspects but without ascribing any weight to these and without any concretization or elaboration in subject matter terms. Discourse 2-oriented studies were characterized by accepting or raising value-related questions but (implicitly) handing these over, to be dealt with in other contexts or by other disciplines.
3. If value aspects were emphasized but still not to any significant extent in subject matter terms or with respect to emphasizing interdisciplinarity, the study was classified as Discourse 3-oriented, i.e., emphasizing value-related questions without systematically involving other disciplines or subjects.
4. If a study treated these aspects in subject matter terms from interdisciplinary perspectives (including the social sciences and/or the humanities and related concepts and debates), the study was classified as Discourse 4-oriented, i.e., encouraging value-related questions by systematically collaborating with other disciplines or subjects.

In the first (introductory) stage, we summarized the articles using the three categories presented in Figure 1. Based on the outcomes of this first analysis (Table 2), the next step was to present a summary in Figure 2. The core of our interpretative strategy was to consider in what sense and to what degree the researchers brought into their discussion aspects of values and interdisciplinarity pertaining to genetics and human beings.

We found few explicit references to other disciplines, but we identified many references to societal, political, ethical, value-related or ideological aspects. Therefore, the approach we adopted when drawing our conclusions was to focus on these aspects as indicators of a move from Discourse 1 towards a Discourse 4 orientation. This qualitative and interpretative approach requires a relatively detailed presentation of the arguments for classification of each article. In this paper, reference is made to the arguments and conclusions in a previous article (Sæther et al., 2018b), along with five new reports that were added to the list of sources (Aivelo & Uitto, 2015; Calado et al., 2018; Christidou & Papadopoulou, 2020; Hicks et al., 2014; Wahlberg & Gericke, 2018). In this paper I therefore introduce these five reports in some detail. I also demonstrate how a quantitative approach support our conclusions from Part 1. This was done by simply counting particularly relevant words to identify the degree of value focus. For details about the methodology, see introduction to Results Part 2. Based on the results from the first part (applying qualitative methodology) and the second part (applying quantitative methodology), we managed to find two independent rank orders. Finally, we compared these ranks and found the rank order coefficient.

RESULTS PART 1

Examples of classification into fact-value discourses

In this section, examples are given from the five articles not reported in Sæther et al. (2018b). However, I refer also to one example from this previously published study (Sæther et al., 2018b). For more examples, see this open-access paper.
Hicks et al. (2014) focused on gene-environment interactions, but they did not clarify “the benefits and limitations of new genetic tests or screening” (pp. 382–383) from any value-related or interdisciplinary perspective. Their paper was therefore classified as Discourse 1-oriented.

Wahlberg & Gericke’s article (2018) “Conceptual demography in upper secondary chemistry and biology textbooks’ descriptions of protein synthesis: A matter of context?” is also classified as an example of Discourse 1. It focuses on interdisciplinarity; however, this means only an analysis of connections and lack of connections between the natural sciences (biology and chemistry). Seen from the perspective in this paper a general issue or challenge could be highlighted: When students study the same subject matter (genetics) in two similar but different contexts (discussed by Wahlberg & Gericke as biology and biochemistry) this represents a possible threat of compartmentalizing, i.e., lack of focus on integrative understanding and meaning, in this case without emphasis on connections between a mechanistic (chemistry) and conceptual approach (biology). Wahlberg & Gericke’s contextual approach is a reminder of the importance of the broader setting that textbooks (and teaching) should take into account.

Aivelo and Uitto’s study of Finnish upper secondary school textbooks (2015) focused on historical gene models and definitions of genes. They found hybrid models to be pervasive and encountered many examples of strong genetic determinism with no modern models. Their focus was on scientific correctness, though by referring to Häyry, they opened up the possibility of a broader discussion:

The genetic determinism dispute is mostly about how much genes determine and how the understanding of the role of genes is best learnt. This debate shows how important genetics is for both understanding what being human means and how many connections it has to social and cultural issues. Many different concepts from eugenics and immortality to stem cells and gene therapies are linked to the promises and pitfalls of advances in genetics. (p. 140)

Furthermore, by referring to Keverne, they introduced the importance of human “lifestyle choices” as a contextual factor:

Downplaying of the environmental effects can in our view lead to weak genetic deterministic views... Understanding the developmental basis of phenotype could make it easier to understand for example the effect of lifestyle choices on the health and the effect of upbringing and education on the well-being. (p. 149)

This extension to areas outside biology (e.g., “socially and ethically controversial issues” and “the effect of lifestyle choices”), but without more concretization, represents the justification for classifying their report as Discourse 2-oriented.

Christidou & Papadopoulou (2020) also exemplify Discourse 2. Their focus is on gene models. However, they also mention a broader context: bioethics, and that knowledge in the field “could provide the future citizens with knowing how to thoroughly understand and manage the constantly emerging biotechnological issues along with their political and socio-economic effects” (p. 235).

Martinez-Gracia et al. (2003) write about how genetic engineering is addressed in Spanish secondary school textbooks. For a more detailed presentation, see Sæther et al. (2018b) from which I refer. In their conclusion Martinez-Gracia et al. (2003) exemplify more of what is lacking in the textbooks:

Secondary school textbooks should be critically revised with an emphasis on the message that needs to be transmitted to facilitate understanding of relevant scientific literacy items of twenty-first-century citizens:

- Introduction of a logical content sequence including the fundamental steps that lead to the concept of genetic engineering, ...
- The use of genetic engineering terms meaningfully connected with other genetic and basic aspects.

- Applications and repercussions should be also restricted to those that illustrate the comprehension of concepts, encourage learning and have a meaningful connection with maturity and instruction of high school students. (p. 1161f)

It is obvious that these authors’ analysis of science and technology is framed by an awareness of the ethical and political aspects of gene technology (e.g., the human genome project). They say that

one of the major theoretical considerations in the development of the Spanish curriculum has been the issue of social responsibility of science to inform citizens. The citizens should be able to take on the responsibility of problems related to science ... Controversial social topics and their definitions are socially important and need to be summarized and analysed. (2003, p. 1150)

They refer to several ethical, ideological and value-related aspects, for example “ethical, moral, social and health risks issues” of genetic engineering (p. 1,158); ethical and moral issues about using gene therapy in germinal cells, using human embryos as experimental tools, eugenics, the cloning of human beings, the manipulation of living beings and the role of society and bioethical committees (p. 1,159). We can therefore say that Martínez-Gracia et al. (2003) clearly focus on value-related dimensions and questions, but that they do not try to provide perspectives which might point to substantial deliberations in these issues. It seems reasonable, then, to classify their focus as falling under Strategy 2 (although one might add that in practice, such a strong focus on value-related aspects probably would lead to a Strategy 3-orientation).

In the article entitled “Science-Technology-Society-Environment issues in German and Portuguese biology textbooks: Influence of the socio-cultural context?” the authors contextualize their study by referring to the Vision II of science education (originally formulated by D. A. Roberts). In their words, “Vision II is consonant with humanistic perspectives of science education... and seeks opportunities for students to integrate scientific ideas and scientific reasoning with moral reasoning and cultural considerations that underlie decision-making about socio-scientific issues.” (Calado et al., 2018, p. 266) This view involves including “controversial aspects of human genetics and genetic engineering,” personal values, and perspectives from social science in an effort to see the sociocultural context of science (p. 266f). They ask: “How do textbooks from countries with [a] different socio-cultural background regarding STSE issues in genetics and gene technology differ?” (p. 270). They point out: “[I]t is important to state that we did not appraise perspectives or values per se. We rather appraised the opportunity provided to students to discuss the diversity of perspectives and of values involved in STSE issues,” (p. 270) and that “participative citizenship requires awareness of how scientific work is conditioned by the social, historical, moral and spiritual contexts” (p. 271). In their content analysis, they followed up by, for example, focusing on “Interplay between science and technology,” “Science and technology as a means to solve societal problems,” “Risks and impacts of science and technology,” the “Decision making process,” and the “Controversial character of socio-scientific issues” (pp. 275–276).

In their analysis, Calado et al. (2018) clearly expressed an explicit interest in value-related questions, favouring contact with the humanities and social sciences. But this perspective was not elaborated to any great extent in concrete terms. It therefore seems reasonable to classify their approach as somewhere between Discourse 3 and Discourse 4.
RESULTS PART 1: SUMMARY
Table 2 and our conclusions in Figure 2 summarize the results of our analysis.

Focus on values, human genetics and interdisciplinarity

Table 2. 19 analyses of values aspects of genetics in textbooks, 2002–2020 (Sæther et al., 2018b – adapted and extended)

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Cat. 1: Focus on values and/or examples of topics and perspectives illustrating these aspects</th>
<th>Cat. 2: Topics related to human genetics</th>
<th>Cat. 3: Focus on interdisciplinarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aivelo &amp; Uitto, 2015</td>
<td>Yes</td>
<td>Yes</td>
<td>To some extent, by showing that the &quot;genetics and human&quot; issue is situated in a broader value context</td>
</tr>
<tr>
<td>Albuquerque et al., 2008</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Calado et al., 2018</td>
<td>Yes</td>
<td>Yes (p. 280)</td>
<td>Yes</td>
</tr>
<tr>
<td>Castéra, Clément et al., 2008</td>
<td>Yes</td>
<td>Yes</td>
<td>To some extent, by focusing explicitly on analysing hereditarianist ideology</td>
</tr>
<tr>
<td>Castéra, Bruguière et al., 2008</td>
<td>Yes</td>
<td>Yes</td>
<td>To some extent, by focusing on a multidimensional concept of health</td>
</tr>
<tr>
<td>Christidou &amp; Papadopoulou, 2020</td>
<td>No (not totally lacking)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>deJong-Lambert, 2009</td>
<td>Yes</td>
<td>Yes</td>
<td>To some extent, by analysing the ideology of Lysenkoism</td>
</tr>
<tr>
<td>dos Santos et al., 2012</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Forissier &amp; Clément, 2003</td>
<td>No (focus on ideologies but not in value terms)</td>
<td>Yes (e.g., “twins”)</td>
<td>To some extent, by referring to Cartesian dualism</td>
</tr>
<tr>
<td>Flodin, 2009</td>
<td>No</td>
<td>Yes</td>
<td>No (but empiricist vs. realist philosophy is mentioned + essential vs. relational views)</td>
</tr>
<tr>
<td>Gericke &amp; Hagberg, 2010b</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Gericke &amp; Hagberg, 2010a</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hicks et al., 2014</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Hott et al., 2002</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Martinez-Gracia et al., 2003</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Martinez-Gracia et al., 2006</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Morris, 2014</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Puig &amp; Jiménez-Aleixandre, 2011, pp. 210–212</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Wahlberg &amp; Gericke, 2018</td>
<td>No</td>
<td>No</td>
<td>No (Yes, if the focus is only on the natural sciences)</td>
</tr>
</tbody>
</table>
Classification of discourses

Seven studies could be classified as oriented towards Discourse 1; one study could be classified as falling somewhere between Discourses 1 and 2; four studies fell into the Discourse 2 category; two studies fell into the Discourse 3 category; four studies could be situated between Discourses 3 and 4; and one was classified as being oriented towards Discourse 4. Although Figure 2 indicates the distances between different studies or between categories, it represents an ordinal scale as seen in quantitative methodology. One interesting detail is that analyses of higher level textbooks have a more discipline-oriented focus than analyses of lower level textbooks.

Figure 2 Fact-value discourses disclosed in 19 textbook analyses of genetics in biology textbooks: rank order based on qualitative content analysis (Sæther et al, 2018b – adapted and extended)

RESULTS PART 2

In the next step, a simple quantitative content analysis of word frequencies was carried out to confirm the validity of our qualitative analysis. The procedure was as follows: (a) we selected concepts from research articles disclosing a focus on the fact-value issue (Table 3). By counting these words, we established quantitative measures to indicate the strength (or weakness) of the focus on Discourses 1–4 in each research report; (b) these measures made it possible to rank the 19 studies on an ordinal scale; (c) based on the results from the first part (applying qualitative methodology) and the second part (applying quantitative methodology), we managed to find two independent rank orders (see Table 3); (d) finally, we compared these rank orders and found the Spearman rank order coefficient to be R=.88 by using the calculator at https://geographyfieldwork.com/SpearmansRankCalculator.html (p = 0.001).

When counting the number of words and making the articles (which were of different length) more comparable, we followed this strategy: When not available in MC Word format each downloaded article was converted into Word (using Acrobat Adobe DC). Reference lists, appendices with references to textbooks, bibliographic details in footnote references, copyright declarations and information, and download information (citing articles, related articles, crossmark data and articles’ view), all this information was deleted before counting number of words. We calculated a value index supposed to
Some possible limitations and critical points should be mentioned. We did not count value related words when picture formats sometimes were part of a Word document. In counting the value-related words the context of the words was not generally considered (see exceptions below); word frequency was not taken to be a direct measure (only an indicator of a value focus); and there were numerous cases of the same rank order (see Table 3). Nevertheless, the rank order correlation strengthened rather than weakened our conclusion from the qualitative analysis.

### Table 3. Fact-value focus: frequency of selected concepts in textbooks on genetics (2002–2020); occurrences in reference lists were not counted; rank order was based on quantitative and qualitative content analyses

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>ethic*</th>
<th>moral*</th>
<th>politic*</th>
<th>religion*</th>
<th>world view*</th>
<th>Article length (Nal)</th>
<th>Value index Nvc/Nal x1000</th>
<th>Rank based on quantitative content analysis</th>
<th>Rank based on qualitative content analysis (Fig. 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aivelo &amp; Uitto, 2015</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.24</td>
<td>30%</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Aleixandre, 2011</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.09</td>
<td>3%</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Martinez, 2011</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.15</td>
<td>5%</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Hicks et al., 2014</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.10</td>
<td>3%</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Forissier &amp; Clément, 2003</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.08</td>
<td>3%</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>dos Santos et al., 2012</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.09</td>
<td>3%</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Castéra, Clément et al., 2008</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.08</td>
<td>3%</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Calado et al., 2018</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.08</td>
<td>3%</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Albuquerqu et al., 2008</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.08</td>
<td>3%</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Handover, 2005</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.08</td>
<td>3%</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

**Notes:** * stands for ethics, ethicist and ethicism; ** stands for moral and morality; † stands for politic(s), politicians and political; ‡ stands for religion; and †† stands for world view and worldview.
I have exemplified the four different fact-value related research discourses in research reports on genetics and values in textbooks. The classification gives an impression of distinct categories (Figure 2 and 3). However, the research reports were distributed along a continuum, ranging from a minimal to a strong emphasis on value aspects and focus on interdisciplinarity. Our study has demonstrated that analyses of genetics in textbooks address ethical, value-related, political or ideological aspects in various ways and to varying degree, implying a greater or lesser focus on subject-matter integration, ranging from a single-discipline-oriented discourse based on the natural sciences to an interdisciplinary discourse.

The quantitative validity check in which I simply counted selected words supposed to be indicators of an engagement with values (see Table 3) seemed to corroborate our ranking based on an interpretative and qualitative content analysis (Figure 2). Comparing these independent rankings (Table 3) gave the Spearman’s rank order coefficient (R = .88). (p = 0.001). In the quantitative part I focused on counting these words and word combinations: ethics, ethicist, ethical/bioethical; moral, morality; politics, politicians, political, socio-political; value(s), valuable (in ethical, moral and political contexts); ideology, ideologies, ideological (in ethical, moral and political contexts); eugenic(s), eugenicist; religion(s), religious (not counted in the context of genetically influenced religion); world view/worldview.

With other words, my main finding is that this variety of discourses does exist in the research literature on genetics in science education textbooks.

I do not claim to have uncovered the intentions of the researchers who conducted the studies that I/we reviewed. Our focus was strictly on relevant texts and the underlying identifiable research discourses.

Again, this review is about disclosing four different discourses in research ranging from low value focus in the context of the natural sciences to high focus on values in the context of a broader concept of interdisciplinarity in which also the social sciences and the humanities with their related concepts and debates might be included.

My suggestion is to let the continuum from Discourse one to Discourse four represent analytic categories in future textbook research. On this background, my first recommendation for the researchers in this field is very simple, i.e., just to make their delimitations as clear as possible, e.g.: Do they want, or do they don’t want explicitly to include value aspects in their research on textbooks? Second, when the answer is yes, do they want to see these aspects in the context of the social sciences, the humanities, and their related concepts and debates? Which other options exist? For example, are the discourses called Discourse two and Discourse three (see above) seen as relevant alternatives? With other words, what do textbooks on genetics say about how to discuss value questions, which perspectives are brought into this discussion, and which are deliberately omitted?

In this paper I have not systematically discussed what is meant by “the social sciences and the humanities with their concepts and debates”. I have just given examples (For more examples, see Sæther et al., 2018b). In the vast literature on different world-views and philosophies we find alternative analytic categories on nature and the human being (e.g., Bokedal, Reindal, Rise, & Wivestad, 2022; Naess & Rothenberg, 1993).

Again, the reader should be aware, our sources only allow us to talk about discourses in research. Therefore, we do not come up with any conclusion about the textbook themselves or research-based guidelines for practice. However, to avoid misunderstandings, I briefly comment on fact-value challenges in educational practice, Isolated from our study the discourses we are talking about could also represent possible strategies in teaching and approaches for textbook writers. To follow up these issues would claim another approach, and this is not a part of our project. But because my study perhaps might be misunderstood as an implicit argument for a certain normative thinking, I give a short comment without claiming that my discourses represent any research-based implication for practice. See Figure 3, which summarizes possible educational challenges in this area.
Perhaps it might seem that I generally recommend interdisciplinarity and value orientation in science education, involving students in personal engagement and elaboration of the subject matter. However, lack of time, competence, resources and structures for interdisciplinarity might hinder this. And the controversial nature of the genetics and human issue may be an argument for Discourse 2. It is not always realistic and desirable to bring the full complexity of these issues into the curriculum. Therefore, I do not necessarily see Discourse 2, in this context, as a negative approach in textbooks and in teaching. How to deal with fact-value issues in science education must be discussed in the context of aims and curriculum guidelines. A starting point is to contextualize this important discussion in the literature on values in (science) education, e.g., the selected sources we have referred to above, and this article.

REFERENCES


Fact-value discourses in 19 analyses of genetics in biology textbooks


