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The role of socioscientific issues in biology teaching: from the perspective of teachers

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ABSTRACT
Previous research has documented that students who engage with socioscientific issues can acquire some of the complex competences and skills typically related to scientific literacy. But an emerging field of research on science teachers' understanding and use of socioscientific issues, has documented that a range of challenges hinders the uptake of socioscientific issues. In this study, we investigated the interpretation and implementation of socioscientific issues among Danish biology teachers. We conducted five in-depth group interviews and validated the emergent themes from the teachers' talk-in-interaction by distributing a questionnaire. Our findings suggest that the participating teachers generally harbour a content-centred interpretation of socioscientific issues which manifests itself in at least three separate ways. First, the teachers generally use socioscientific issues as a vehicle to teach factual biological content. Second, the teachers emphasised mastery of factual content in their assessment. Third, the teachers tended to reduce socioscientific issues to specific biological contents in a way may preclude students from engaging with the real socioscientific issue. Our findings are particularly significant for science educators, policy-makers and curriculum designers, as we argue that key aspects of this content-centred interpretation may be a coping strategy used to navigate a divided curriculum.

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Introduction and background

A number of scholars have documented that teaching socioscientific issues can have positive effects on student motivation and interest – both to learn science content in school and to pursue science careers (Dori, Tal, & Tsaushu, 2003; Harris & Ratcliffe, 2005; Parchmann et al., 2006; Sadler, 2009). Various studies indicate that teaching socioscientific issues contributes to student learning outcomes: such teaching can foster critical thinking skills, decision-making, argumentation, reflective judgment and moral development (Dawson, 2011; Eastwood, Schlegel, & Cook, 2011; Sadler, 2004, 2009; Zeidler, Applebaum, & Sadler, 2011; Zohar & Nemet, 2002). In addition, teaching socioscientific issues may contribute to developing students' scientific literacy (Zeidler, Sadler, Simmons, & Howes, 2005).

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Clearly, teachers play a vital role in how socioscientific issues are taught in school science (e.g. Forbes & Davis, 2008; Lee, Abd-El-Khalick, & Choi, 2006). For example, Lazarowitz and Bloch (2005) cast teachers as 'the link between the world of science and society since they have an important role in educating their students to function as citizens' (pp. 437–438). In this paper, we report on an investigation of Danish biology teachers' interpretations of, or beliefs about, (i) socioscientific issues and (ii) the role and function of socioscientific teaching activities for upper secondary school biology teaching.

Throughout the paper we will use the term 'socioscientific issues' to denote the issues, problems, questions, dilemmas that students can be engaged with – for example, 'Should we ban genetically modified foods?'. Such issues are typically defined as issues that on the one hand have a conceptual basis in science, and on the other hand arise as issues within the ethical, political and economical realm of society (e.g. Sadler & Zeidler, 2003). In contrast, we will use the slightly awkward term 'socioscientific teaching activities' to denote the teaching situations or activities in which one or more specific socioscientific issues are thematised – for example, an activity in which students are engaged with the issue about whether or not to ban genetically modified foods.

Challenges to the uptake of socioscientific issues

While research into how teachers design and implement socioscientific teaching activities is still an emerging area, trends in the research indicate that teachers' uptake of socioscientific issues is challenged. It seems that many teachers have a low awareness of potential socioscientific issues for teaching and that many teachers simply do not include such issues in their teaching (Lazarowitz & Bloch, 2005). Beyond this Lee et al. (2006) found that while many teachers believe that students benefit from socioscientific teaching activities, teachers tend to teach socioscientific issues in a 'short-lived and rather superficial' fashion, in 'which (what participants considered to be) SSI were addressed instructionally' (p. 108). In fact, previous research has uncovered a range of challenges to the uptake of teaching socioscientific issues.

First, there seems to be a lack of resources for implementing socioscientific teaching activities – this includes a lack of appropriate teaching materials, and time to prepare (Cross & Price, 1996; Millar & Osborne, 1998; Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006; Saunders & Rennie, 2013). These challenges can drive teachers to focus on the objective and factual aspects of science (see, e.g. Day & Bryce, 2011). According to Lee and Witz (2009), most science teachers feel that their most important task is to teach the principles of science, and any substantive pedagogical changes represent a burden. And while some teachers may find the social and ethical dimensions of science important, 'the rigidity of the science curriculum and associated syllabuses militate against this' (Levinson & Turner, 2001, p. 14).

Second, many teachers express concerns about their capacities to respond to student ideas in the context of socioscientific teaching activities, and are worried that their insufficient knowledge of science subject matter will serve to disadvantage them and their students (Forbes & Davis, 2008; Lee et al., 2006; Sadler et al., 2006). It seems that when teachers do implement socioscientific teaching activities, such activities tend to be teacher-centred, where students' views do not figure prominently, with the risk that students 'gain knowledge rather than a deep conceptual understanding of how knowledge fits

into a given context' (Day & Bryce, 2011, p. 1697), and may hinder the students' critical engagement with science, which is a key part of scientific literacy (Ryder, 2001).

Third, it seems that many teachers lack confidence in handling discussion (Bryce & Gray, 2004; Simonneaux, 2014), as they may find it challenging to express their own values, ethics (Sadler et al., 2006) and their own opinions (Cross & Price, 1996). Perhaps one of the most persistent findings is that many teachers do not feel a responsibility to facilitate the exploration of ethics, or even agree that socioscientific teaching activities should be a part of science education, and that their professional responsibilities entail the presentation of scientific facts and data, and not necessarily the ethical and emotional ramifications (Forbes & Davis, 2008; Levinson & Turner, 2001; Sadler et al., 2006; Saunders & Rennie, 2013).

Fourth, student assessment may be a key challenge to the uptake of socioscientific teaching activities. According to Millar and Osborne (1998), 'assessment is based on exercises and tasks that rely heavily on memorisation and recall, and are quite unlike those contexts in which learners might wish to use science knowledge or skills later in life' (p. 9). Levinson and Turner (2001) argued that not only do teachers generally lack effective criteria for assessing the skills at play in socioscientific teaching activities; teachers also find that 'while knowledge of substantive science concepts can be weighed in assessment it is more problematic to assess the ways in which students interpret social and ethical implications in the context of a specific issue' (p. 60). Thus, it is likely that many teachers refrain from socioscientific teaching activities due to the challenge of assessing the complex skills at play.

We believe that the previous research provides a relatively full description of the types of challenges teachers will face, and that future empirical research in the area will primarily incorporate one or more of these four types of challenges. But in order to inform future steps towards increasing the uptake of high-quality socioscientific teaching (e.g. in the form of professional development or more systemic interventions), we believe that more knowledge is needed about teachers' beliefs vis-à-vis socioscientific issues in general – a vista explored by for example, Barrett and Nieswandt (2010). In particular, we need to accumulate knowledge about how teachers from a variety of educational contexts interpret socioscientific issues and operationalise such issues in socioscientific teaching.

The Danish upper secondary school curriculum for Biology provides a highly relevant context for such an endeavour.[1] Since 2005, socioscientific themes are woven deeply into the fabric of the curriculum. Notably, Biology is defined as a discipline with the ultimate goal of providing students with a

> […] basis for the development of responsibility, decision-making and action with respect to present societal issues with a biological content. (Ministry of Education, 2013)

Indeed, some of the key assessment criteria – against which students' performance is measured – include students' ability to 'assess extensive biological issues and their effect on the local and global level', to 'have the disciplinary background for decision-making and action in connection with own and societal issues with a biological content', and to 'include ethical/value-laden aspects' when thematising 'disciplinary biological subjects' (Ministry of Education, 2013). Finally, it is stipulated that in Biology, 'the teaching is

thematic and takes its point of departure in biological issues that have a personal or societal relevance' (Ministry of Education, 2013).

So for more than 10 years now, the Biology curriculum in the Danish upper secondary school has been heavily laden with socioscientific themes. But to date, no study has tasked to investigate how teachers who operate in this socioscientifically focused curriculum interpret socioscientific issues and operationalise such issues in practice. Thus, the research question for the study reported here is the following: How do Danish upper secondary biology teachers interpret and implement socioscientific issues in their teaching? While this question is on purpose formulated as focusing on Danish teachers, the question is formulated in a way that affords extrapolations about practice on an international level.

Research design and methods

In order to elucidate the research question, we designed a qualitative investigation that involved group interviews and a questionnaire consisting of open-ended items. This enabled us to triangulate the research object – namely biology teachers' interpretation of socioscientific issues and socioscientific teaching. In total, we conducted five group interviews (11 teachers) and solicited 100 responses to the open-ended questionnaire.

As can be seen in Figure 1, the research design was linear in the sense that we first conducted group interviews, the analysis of which led to the identification of emergent themes (see below), and those themes, in turn, created the backdrop for the construction of items in the questionnaire. This linear design enabled us to validate the emergent themes of the group interviews in the context of a wider sample of biology teachers.

Group interviews

The group interviews were conducted in five different schools (sub-urban as well as urban) in the Capital Region of Denmark. The teachers were mostly experienced biology teachers – 7 teachers had 20 or more years of experience while 4 teachers had 10 or fewer years of experience. All five interviews were semi-structured (Kvale, 2008) and thus allowed us to focus on predetermined issues of interest, while retaining the possibility to pursue pertinent tangents in the individual interviews. We elected to interview teachers in pairs or trios rather than individually since such a setting usually provides the researcher with 'the opportunity to study the ways in which individuals collectively make sense of a phenomenon and construct meanings around it' (Bryman, 2012, p. 504).

Each interview began with a reflective exercise, in which the teachers recalled examples of socioscientific issues that they had included in previous teaching. This led to a phase of

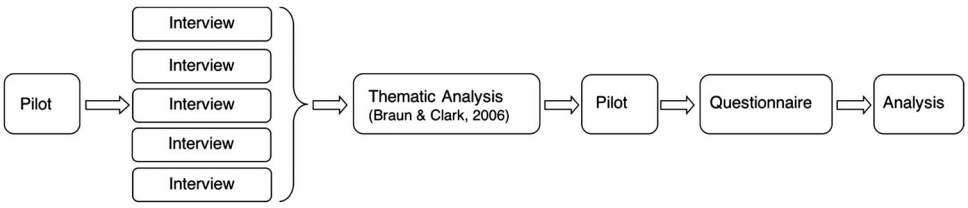

Figure 1. Schematic overview of the research design.

dialogue about the teaching context of these issues as well as about how they had implemented these issues. The purpose of this exercise was to provide us with an overall sense of the teachers' understanding of the place and role of socioscientific issues in biology teaching. The rest of the focal points in the interviews corresponded to the trends in previous research (see above). Thus, we elected to allocate a portion of the interview to a discussion about (a) the role of values and ethics in biology teaching, (b) the perception and frequency of student-centred discussion activities, (c) assessment practices when teaching socioscientific issues, and (d) the teachers' attitudes towards including controversial socioscientific issues in biology teaching.

The interviews spanned from 59 to 67 minutes. All group interviews were audio-recorded and transcribed verbatim. The transcriptions were subjected to thematic analysis (see below).

Open-ended questionnaire

In total, 100 biology teachers responded to the questionnaire, of which 53 teachers had 0–5 years' experience, 18 teachers had 6–10 years' experience, and 29 had 11 years or more teaching experience. The items concerning socioscientific issues in the questionnaire were open-ended because we hypothesised (on the basis of the interview data; see the analysis section below) that the concept of socioscientific issues by and large is not well defined from the perspective of Danish biology teachers. Indeed, rather than shoehorning the responses into fixed categories we wanted to elicit responses about the respondents' thinking using their own words (Johnson & Christensen, 2013).

The full list of items of the questionnaire is presented in Appendix A. Like in the interviews, the first item concerning socioscientific issues corresponded to the trends in previous research. Here, we adopted an item from Lazarowitz and Bloch (2005): 'If you were asked to include the topic of Cystic Fibrosis in the curriculum, into which subjects would you integrate in it?' (p. 444). The purpose of this item was to provide an overall sense of the teachers' awareness of societal and ethical issues while teaching biological content. The remainder of the items in the questionnaire were formulated on the basis of the emergent themes from the analysis of the group interviews. The items pertained to (a) how the respondents characterise socioscientific issues, (b) how they integrate socioscientific issues in their teaching and (c) which pedagogical or educational aspects they feel it is important to pay special attention to, when implementing socioscientific teaching activities.

The link to the online questionnaire was distributed in a closed Facebook™ group for upper secondary school biology teachers. At that time, the group consisted of more than 600 members. The link along with a brief description was posted 2 times within 11 days. The questionnaire included initial items concerning teaching experience and the level of biology the respondent has taught in order to solicit responses solely from high-level biology teachers in upper secondary school. In total, 100 responses were solicited.

In both the interviews and the questionnaire, we deliberately elected not to formulate ourselves in terms of 'socioscientific issues' since this concept is a technical term mainly used by educational researchers – instead we formulated ourselves in terms from the curriculum (mainly 'societal issues with a biological content') that conspicuously latch onto the main aspects of the socioscientific discourse in the research community.

Analysis procedure

Both the transcribed interviews and the responses to the open-ended items in the questionnaire were analysed using semantic thematic analysis (Braun & Clarke, 2006). The aim of the analysis was to find overarching, consistent, and prominent themes that emerged from the teachers' talk-in-interaction and the responses to the questionnaire. In order to have a rigid analysis process, we strictly followed Braun and Clarke's (2006) six-phased analytical tool for thematic analysis.

First, we carefully read the data. In order to preserve the dialectical context (Nielsen, 2013a) the transcripts of the interviews explicated all talk-turns and interjections in the recordings. Second, we coded singular responses from the questionnaire and sequences of talk-turns from the interviews in accordance to that which was signified in a response or in a talk-turn, respectively. Third, we scrutinised the codes and if possible combined them in order to identify candidate key themes and sub-themes. Fourth, we reviewed, revised and refined the list of candidate key themes in order to secure coherence within each theme and minimise overlap between themes. Fifth, we went through a writing process (Becker, 2007) in which a careful description of the key themes led to an identification of the essence of each theme. Sixth, we wrote an initial report that served as a basis for the results section in this paper.

Analysis and findings

This section presents the results of the thematic analysis of the group interviews and the responses to the questionnaire. In the transcripts of the interviews the teachers are given an individual code in the form of a letter (C, F, U, etc.), in addition, the teachers are identified by school by a number (1 through 5). Thus, the reference 1C denotes teacher 'C' from school 1. The responses to the questionnaire are given an identifier that marks the item – for example, Q4 – and a number for the individual respondent – for example, 199 – so that Q4, 199 marks respondent number 199's response to item number four.

A content-centred interpretation of socioscientific issues

A primary theme that emerged from the teachers' talk-in-interaction during the interviews and from the questionnaire responses pertains to traces of a particular way of parsing socioscientific issues. As we will delineate below, the teachers can be said to entertain a content-centred interpretation of socioscientific issues. In other words, these teachers gave primacy to a specific biological content over a specific societal contextualisation – both in terms of what constitutes a specific issue as a socioscientific issue and in terms of why and how a specific socioscientific issue should be taught.

In general, all interviewed teachers agreed that socioscientific issues are characterised by being issues that are relevant to or arise in the societal sphere. For example, a number of teachers mentioned 'pollution' as the paradigmatic socioscientific issue: As one teacher argued, pollution is a socioscientific issue because 'politicians make demands on industry and agriculture' (1F, 24); and another teacher argued that pollution contains economic aspects as 'it has a cost in agriculture if they are not allowed to fertilize using nitrogen' (2B, 36). Other examples that the teachers gave included 'bacteria' – which

was referred to as a socioscientific issue 'because they are used industrially and in food production' (1C, 52–54); 'biochemistry and nutrition' was described as a socioscientific issue because it relates to the students' eating habits and overall lifestyle (1F, 186); 'food chains' was also used as an example because 'it is a societal problem if we ruin the last step of the food chain' (1F, 321), some teachers mentioned 'DNA', because 'everything related to DNA is societal' (1F, 327), while other teachers talked about 'genetics' as a socioscientific issue because it relates to economical and ethical discussions in society (2B, 44).

The important point here is that the interviewed teachers did not really formulate examples of issues that call upon reflection or pose dilemmas for students to make decisions about; rather, they listed a range of core biological contents and argued that these were socioscientific issues because they have potential bearing on societal and ethical deliberation. For example, one of the teachers who mentioned 'pollution' as a socioscientific issue later in the talk-in-interaction explained that she uses pollution as a way to frame her content specific teaching in the sense that she would typically ask her students to …

> investigate a lake in order to see what lives in a lake […] to find out whether the lake was polluted […] we also went to the university to use those new DNA-methods to determine the pollution of a lake […] we looked at nature, right, because we have to make an analysis of nature as one of the [pre-set learning objectives in the curriculum]. (1F, 24–33)

This predominant focus on scientific content was also evident in the questionnaire responses, and resonates with what we call the content-centred interpretation of socioscientific issues that emerged in the interviews. As mentioned, the questionnaire respondents were asked to identify topics they would include when teaching about Cystic Fibrosis (a very viable outset for several socioscientific issues). A total of 270 topics were identified by 93 teachers (see Table 1). These responses could be categorised into 27 overall topic areas of which 26 were purely scientific topics, while one was a societal topic. By far the most of the 270 responses belong to the scientific category. Examples of the 11 (4%) of the identified societal topic were 'ethics', 'ethical considerations' and 'bioethics'.

In the questionnaire, the teachers were also asked to identify two to three characteristics of socioscientific issues. The teachers collectively identified 209 characteristics. The thematic analysis of these responses led us to extrapolate four emergent themes (see Table 2).

First, socioscientific issues were characterised as devices for framing teaching of subject-specific biological contents: the teachers referred to subject-specific biological contents such as pollution (e.g. Q4, 199; 24; 49; 51; 71; 72), environment (e.g. Q4, 82; 134; 158; 164), diseases (Q4, 104; 3; 5; 29) endocrine disruptors (Q4, 147; 90; 153), obesity epidemic (Q4, 160; 167; 170; 182) and ecology (Q4, 4; 29; 69;176). Some teachers wrote that via biology teaching, students become aware of societal issues, for example, 'our planet's ecology' (Q4, 27). This category of characteristics accounted for more than half of the total number of characteristics of socioscientific issues. Second, socioscientific issues were characterised as a specific set of problems – for example, a problem that is of current interest and that is debated in the public sphere. About a quarter of all characteristics belonged in this category. Third, a total of 28 responses out of 209 characterised socioscientific issues as either a dilemma, problem or issue that is debated in class. The difference between this thematic characteristic and the second (a specific set of problems) is that only the former signalled that students can be involved in debating. Fourth, 24

Table 1. Identification of topics.

Scientific topics	Societal topics
Genetics (77)	Ethical subjects (11)
Heredity (26)	
Respiratory physiology (21)	
Cell biology (15)	
Mutations (14)	
Gene technology (11)	
Prenatal diagnosis (10)	
Hereditary diseases (10)	
Proteins (8)	
DNA (8)	
Osmosis (6)	
Immune response (5)	
Protein synthesis (5)	
Nervous system (5)	
Physiology (4)	
Dominant vs. recessive genes (3)	
Antibiotics and resistance problems (3)	
The causes of the disease (3)	
Digestion (3)	
Mendelian Laws (3)	
Biotechnology (2)	
Methods (2)	
Evolution (2)	
DNA sequencing (2)	
Various other topics (11)	
No. of topics	
259 (96%)	11 (4%)

responses characterised socioscientific issues as devices for letting students apply biology on a societal level.

Overall, in the teachers' descriptions of socioscientific teaching there was a conspicuous lack of a controversial issue, dilemma or quasi-ethical challenge. Instead we find a clear focus on teaching biological contents. Indeed, the interviewed teachers generally held that one cannot separate socioscientific issues and biological contents, because biology itself is perceived a part of society. Statements similar to the following appeared regularly: 'biology itself is societal. […] the issues biology engages with are issues which we engage with in society' (4L, 34). So the interpretation of socioscientific issues that these teachers seem to share is one in which every specific biological content is socioscientific, because in the end, but not necessarily in a teaching situation, that topic is contextualised in society.

As described above, a substantial portion of the talk-in-interaction during the interviews revolved around why and how socioscientific issues should be taught. The interviewed teachers generally argued that socioscientific teaching activities are useful for their biology teaching because the inclusion of such issues can put a specific biological content into perspective, can motivate students to engage with a specific biological content, can bring

Table 2. Characterisations of socioscientific issues.

Category	*N*	Percentage
Framing subject-specific biological content	105	50
A problem with a certain quality	52	25
Dilemma/debate/discussion	28	14
Applying biology on a societal level	24	11
Total	209	100

students to apply a specific biological content, or can act as a scaffold or frame for teaching a specific biological content. For example, one of the teachers who found that socioscientific issues can motivate students would use a real-life issue about polluted drinking water in order to motivate her students to learn about osmosis; she would show the students a movie about a '30-year old woman […] who died from water poisoning' with the effect that the students 'will all of a sudden listen in a completely different way, or they are motivated to also do these very content specific experiments using potatoes to see "'is it really true that water can move in and out […]?'"' (4M, 39). One of the most common reasons for these teachers to implement socioscientific teaching activities seemed to be that socioscientific issues can put their teaching of a specific biological content into perspective. For example, one teacher explained that after teaching how fat is digested, she would follow up by finding papers in a periodical of the Danish pharmaceutical labour union that 'explain how [the digestion of fat] is used in the real world, if one can say so, in relations to the development of medicine' (4M, 26). Indeed, the teachers typically explained that socioscientific issues serve as an application or elaboration of a specific biological content, so that students witness that the biological content they learn in school is relevant to professionals in the world outside schools. These results from the interviews on how the teachers teach socioscientific issues in their biology teaching resonate with the findings from the questionnaire. This became evident in the item, where the respondents were asked to describe the way in which they integrate socioscientific issues in their biology teaching (if relevant). There were 77 responses. The thematic analysis of these responses led us to extrapolate 3 separate categories of responses (see Table 3).

Of the 77 responses, 60 in some way or other signalled that the respondent uses socioscientific issues to frame her teaching of a specific biological content. In some cases, this meant that the teacher would use socioscientific issues as a means to motivate students to learn biological content; in other cases, socioscientific issues were reported as means to show students why the (future) teaching of a specific content is relevant or important – for example, displaying a potential socioscientific issue about human 'nutrition' to show the relevance of teaching the conversion of 'glucose to fructose' and the breakdown of fructose in the body (Q5, 1). Other 12 of the 77 responses signalled that the teachers considered socioscientific issues as being possible points for discussion in class that seem woven into all their teaching of biological topics. As one teacher stated: 'in all topics there is an opportunity for discussion of possibilities and problems' (Q5, 24). Finally, five responses indicted that the teacher considers socioscientific issues as being the main red thread or theme in their biology teaching. For example, one teacher stated that socioscientific issues 'is the centre of rotation in all my themes in the curriculum' (Q5, 26). Also, the 72 responses to the final item in the questionnaire – in which the respondents had to list aspects that one should be mindful of when implementing socioscientific teaching – further emphasised this theme. Of the 72 responses 24 involved a

Table 3. The integration of socioscientific issues in biology teaching.

Category	*N*	Percentage
Issues as a framing device for biology teaching	60	78
Issues are integrated as activities in teaching	12	16
Issues are the overall themes for biology teaching	5	6
Total	77	100

heavy focus on biological content – for example, one stated that there is a 'need to focus on the biological content in the issue. That is our competence. Via subject specific insight, the students gain a better foundation to be able to discuss these issues (for example in other subjects)' (Q6, 3). Besides the 24 responses that clearly focused on biological content, 29 responses focused on 'objectivity' as the primary aspect to be mindful of – as one teacher expressed it – her primary role in teaching socioscientific issues is to 'learn [her] students to be nuanced and objective' (Q6, 56). Only 5 responses were somewhat related to the ethical dimensions of socioscientific issues – mainly in terms of securing that students acquire a critical stance towards biological information.

Now, there were instances in which there were traces of a characterisation of socioscientific issues as more than an instrument. Some teachers mentioned that the role of socioscientific issues is to prepare students to make informed decisions in real-life settings, outside school. However, even in these characterisations, there was a strong focus by the teachers on biological factual knowledge. For example, one teacher argued that …

> when [the students] obtain a lot of biological knowledge, they will also be able to understand and make informed decisions regarding all these things they are exposed to. When they encounter something with endocrine disruptors […], well, then they have something to draw upon. (5D, 226)

Another teacher stated that 'moral reasoning emerges from what one knows, and therefore it [being able to engage in socioscientific discussions] follows naturally' (2U, 261); and another teacher explained: '[…] I will teach them everything about digestion and the biochemical compounds, and then they will have to try to make their own personal decisions […]' (1F, 183).

Notice again, that the societal aspects of socioscientific issues seem to step into the background as potential and distant contextualisations of specific biological contents; indeed, it was the biological contents that had primacy in these teachers' narratives about their teaching. It is unclear that the students in these cases should acquire the more generic competence of using their biological knowledge to make informed decisions simply by for example, obtaining 'a lot of biological knowledge'.

Notably, the reasoning underlying these interpretations seems to be the slightly paradoxical notion that socioscientific issues teaching can comprise teaching of biological content detached from the societal aspects, because every biological content is (*potentially*) a socioscientific issue. This notion will be one of the key discussion points below.

Multifarious challenges to the uptake of socioscientific teaching

The second theme that emerged from the teachers' talk-in-interaction concerns challenges for socioscientific teaching activities in biology. In the interviews, the teachers were asked to discuss the viability of full-fledged socioscientific teaching activities – that is, teaching that involves an explicit engagement with a socioscientific issue (in contrast to teaching activities in which the societal and ethical contextualisation was distant or fully absent in the teaching). These challenges fell into three separate categories.

First, all teachers identified challenges at the system level. All teachers agreed that time constraints are impediments to full-fledged socioscientific teaching activities. According to the teachers, much of the time available is spent on experiments of different kinds, in

laboratories and on administrative tasks. Most teachers mentioned that the curriculum demands cover a lot of subject-specific biological content, and that full-fledged socioscientific teaching would be at the expense of preparing students for exams.

Second, all teachers identified challenges at the level of the teacher. Overall it seems that the teacher's perception of the subject area and his/her interests and beliefs in general affect if and how that teacher chooses to implement socioscientific teaching activities. Some teachers were primarily interested in biological content – for example, one teacher stated that while the societal aspects of the content related to 'endocrine disrupters' are 'fantastic', she held that 'it is a lot more fun to look into what hormones do to us' (1C, 112). Others simply preferred to focus on biological content rather than on societal issues:

> I will rather stick to what I know for sure, also regarding the subject-specific content and so on […] I mean, I prefer to teach them facts and then they will have to make decisions when they feel the need for it […] and they are in a better position to do that if they know how things are (2U, 138).

One teacher even found full-fledged socioscientific teaching 'boring' and thus did not feel 'committed' to it (2B, 356). Further, the teachers generally felt that their lack in background in the social sciences renders them less qualified to teach socioscientific issues, and some teachers argued that socioscientific issues should have their natural home in other disciplines such as social studies or interdisciplinary activities, rather than in biology teaching.

Third, all teachers identified challenges at the level of the students. According to a number of the teachers, many students are not able to engage in socioscientific discussions and/or argumentation. According to these teachers, the majority of students do not possess enough biological content knowledge to properly engage in discussions and/or (biological) argumentation about socioscientific issues, as one teacher for example argued that they 'have to ensure that the students are very good at biological content knowledge before [they] can sit and discuss on a socioscientific level using arguments from biology' (2B, 164).

Formative and summative assessment in socioscientific issues teaching

The third theme that emerged from the teachers' talk-in-interactions related to formative and summative assessment in the context of full-fledged socioscientific teaching.

Interestingly, most of the teachers stated that they perceive their role as different in full-fledged socioscientific teaching compared to 'regular teaching' and hinted that the classroom environment is more open than traditionally, as they for example, 'do not have the same assessor role when we have a socioscientific debate' (1C, 147), and as the students 'are allowed to come up with opinions and discuss' (1F, 149). It seems that most of the teachers' thoughts on assessment of the competences related to socioscientific teaching activities are focused on the exams. The teachers explained that they do not focus on formative assessment or that their focus is mostly on students' abilities to use biological content knowledge in their argumentation due to the fact that that is what the students get credit for at the exams. Apart from that, the teachers' talk on assessment was quite diverse and inconclusive, which could indicate that the teachers are unsure of how to handle the assessment, or that there is no consensus on how to assess the more generic

competences that are at play in socioscientific teaching. This was seen as they discussed that the signs that students achieve some of the competences could for example be when the students make choices as a result of their knowledge: 'action is related to taking care of one's own health, for example […] with the knowledge you possess, you will become aware of what you do. And then, when you do the unhealthy, smoke or drink, or whatever one could do, then eh, then you are in control' (1C&F, 308–315). Other teachers explicitly stated that they do not assess these competences, either because they perceive that the assessment is underlying what they normally teach in class, or because they find it challenging to handle the assessment. For example, some teachers argued that it is challenging to handle students' opinions in practice. The teachers' narratives indicate that students in general have a lot of opinions that are challenging for teachers to handle in practice, and that these are for the most part presented without evidence or (biological) argumentation, but based on personal emotions or experiences. The majority of teachers stated that students' opinions are of no use, because student opinions based on emotions and personal experiences cannot be assessed.

Most teachers argued that student performance in socioscientific teaching activities does play a role in the overall assessment of the student. However, none of the teachers could present a clear strategy as to how to assess the competences that could be the learning objectives of socioscientific teaching activities. Some teachers argued that one cannot assess such competences individually, but the examination is a general assessment in which one assesses 'the whole picture' (1C, 369; 3I&3C, 199–201; 3C, 223), as teachers for example assess students' abilities to choose, structure, present, and engage in a dialogue. Some teachers explained that it is difficult to do the assessment at the oral exams and therefore they focus on the students' knowledge regarding biological content instead, as one teacher for example explained:

> It is easier to see if they do it, I mean, then you are able to see 'she mentioned that and that and that', so in that way it is easier to summarize what they bring in, whereas the extent to which they connect it to the personal and socioscientific becomes a little woolly, so that becomes more difficult […] to measure and assess, in some ways, because it is not completely explicit. (2U, 292)

Discussion

One of the central findings from the interviews that could be validated by the results of the questionnaire study is that the participating teachers entertained what we have called a content-centred interpretation of socioscientific issues – that is, when talking about socioscientific issues, the teachers gave primacy to a specific biological content over a specific societal contextualisation. This content-centred interpretation had three main manifestations, which we will discuss in the following.

First, it manifested as an instrumental use of socioscientific teaching activities. Clearly, for both the interviewed teachers and the teacher-respondents in the questionnaire, the reasons for including societal contextualisations in their teaching was primarily as an instrument to motivate, frame, or put into perspective the teaching of a given biological content. A few teachers in our study did at times characterise socioscientific issues as more than an instrument – for example, by recognising that including such issues in their teaching may help to prepare students to deal with issues from outside school.

However, also in these characterisations, the teachers tended to focus on biological content knowledge, explaining that simply by obtaining a lot of biological content knowledge, the students will be able to make informed socioscientific decisions. The instrumental way of operationalising socioscientific issues has been quite well documented in science education research – for example, by Barrett and Nieswandt (2010) who found that some teachers' 'purpose of including ethics is to get students interested long enough to teach them the facts and the theories of science or to get them to like science for its own sake' (p. 391).

Second, the content-centred interpretation manifested as a content bias in assessment practice. The interviewed teachers evidently placed much more weight on students' abilities to use biological content knowledge than on the students' ability to navigate, decipher and make decisions on socioscientific issues proper. So similar to previous research (e.g. Lee et al., 2006; Levinson & Turner, 2001; Millar & Osborne, 1998), our findings suggest that current assessment practices seem to impede full-fledged socioscientific teaching activities. Now, previous research indicates that this pattern may be due to science teachers not feeling qualified for monitoring or assessing value-laden discussions (e.g. Bryce & Gray, 2004; Forbes & Davis, 2008; Sadler et al., 2006; Simonneaux, 2014). Indeed, this group of teachers could not identify effective criteria for assessing the skills and competences that are at play in full-fledged socioscientific teaching. But it is unclear whether this is due to their lack of for example, knowledge of, or willingness to arrange, value-laden discussions. There is namely a general tendency that it is fundamentally challenging for Danish science teachers to identify and put to use assessment criteria for competences as compared to knowledge and understanding (Nielsen & Dolin 2016).

Third, the content-centred interpretation manifested as a reductive narrative of what it means to implement socioscientific teaching activities. Recall that the teachers in the interviews initially held that they include socioscientific issues in their teaching. But again and again the teachers' talk-in-interaction contained the following typified reasoning (A) all biological content is potentially related to (or important for) society; therefore (B) teaching biological content is socioscientific teaching. To our knowledge, in contrast to the instrumental operationalisation of socioscientific issues this reductive narrative seems to elaborate existing research. To be sure, the reasoning behind the reductive narrative is unfortunate. If we believe that an issue is socioscientific because it harbours biological content that, in reality, but not necessarily in the actual teaching situation, is contextualised in society; we risk reducing socioscientific teaching to teaching purely biological facts and strip away the dimension in which students are engaged with societal and/or ethical aspects.

The archetypical teaching situations we can extrapolate from this content-centred interpretation are ones in which the societal or ethical contextualisations of biological content are either absent (the reductive narrative) or serve as means for thematising biological content and are thus not necessarily linked with students reflecting about the contextualisations (the instrumental implementation). But without explicit engagement with the societal and ethical contextualisations it is questionable whether such teaching situations support students' acquisition of the complex skills and competences (e.g. socioscientific decision-making and argumentation) typically related to socioscientific teaching. To be sure, according to Sadler (2011), there is not one correct way to include socioscientific issues in science teaching. However, Eilks, Nielsen and Hofstein (2014) suggested the following guidelines or criteria for selecting and thematising socioscientific

issues: The issue should be (1) authentic, (2) relevant, (3) contentious (i.e. undetermined), (4) allow for open discussion, and (5) deal with a problem based on science and technology. These are concrete guidelines to criteria of a genuine socioscientific issue. The teaching situations that can be extrapolated from a content-centred interpretation of socioscientific issues, will arguably not align with all or most of these guidelines. So, if we take at face value this group of teachers' interpretation of what socioscientific issues are, and what role they play in their teaching, we are left with an understanding of socioscientific issues that seems to be quite distant from the core idea of the socioscientific issues movement in science education research, as well as from the aims set by policymakers internationally and in particular in Denmark (as manifested in the curriculum for biology described above).

This study does not enable us to make an exact identification as to what has led to this content-centred interpretation of socioscientific issues among the participating teachers. But there does seem to be some indications – albeit not uniformly – in the teachers' talk-in-interaction. Day and Bryce (2011) argued that the science teachers they studied turned to teacher-centred activities that thematised the purely factual aspects of science as a form of coping strategy in light of the various pedagogical challenges that besets letting students engage with open-ended socioscientific issues. What we have called the reductive narrative (the notion that all biological content is eventually contextualised in society, therefore all teaching of biological content is socioscientific teaching), may very well be a similar form of narrative strategy for this group of teachers to cope with the explicit but possible nominal socioscientific aspects of the curriculum. This connects to the challenges at the system level identified by the teachers in this study. Recall that all teachers expressed that they do not have the appropriate time resources for implementing full-fledged socioscientific teaching; and that most teachers perceive the curriculum to only nominally be focused on socioscientific issues in the sense that the final exams do put an extensive focus on biological content.

Our findings can be related to and elaborate on the findings of Lee et al. (2006) and Levinson and Turner (2001); in both cases, researchers found that teachers (from Korea and England, respectively) were generally positive towards the idea of teaching socioscientific issues, but that the curricular focus on biological content in Korea and England hindered the uptake of high-quality socioscientific teaching. Clearly, a number of the teachers we interviewed did seem to focus on teaching biological content because the examinations seem to focus on mastery of biological content rather than competences related to socioscientific issues. But for a number of the interviewed teachers, the content focus seemed to be driven by a strong personal connection to biological content – what we (in lack of more precise terms) may call their identity as biology teachers (for a slightly similar finidng see Lee & Witz, 2009).

There is an interesting connection between what we have called the reductive narrative (i.e. the reduction without notable remainder of socioscientific teaching activities to activities that revolve around biological content) to the tendency of science education researchers to reduce the analysis or appraisal of socioscientific argumentative discourse to a matter of the presence and quality of science factual content (for an overview see Nielsen, 2013a, 2013b). Indeed, it seems that the widespread focus among researchers and teachers on factual science content is woven so tightly into the fabric of science

education that it effectively precludes a concerted effort to implement full-fledged socioscientific teaching.

Limitations

In this study, we have combined a small-scale but in-depth study of teachers' talk-in-interaction with a larger scale questionnaire study that served the purpose of validating the emergent themes from the interview study. The quasi-explorative nature of the study does not permit us to generalise our findings beyond the particular context (Danish upper secondary level biology teachers). The main limitation of our study concerns sampling. While we have taken care to interview teachers from different demographic areas in the capital Region of Denmark, a larger study would need to include more teachers representing a wider range of variables (experience in teaching biology, experience in teaching other disciplines, etc.) Further, we did not have absolute control of sampling the teachers who responded to the questionnaire. Maybe the teachers who join a discussion group for biology teachers on Facebook™ are biased in some particular way concerning our research object. However, given the, for Danish standards, relatively large amount of elaborate responses to the questionnaire ($N = 100$), as well as the strong saturation of the content of the responses, we do feel secure in stipulating that our findings are representative for this particular context. Further, since our findings resonate well with trends in the literature and since we feel that our findings add a crucial layer to previous research, we feel that this study is highly relevant for international science education research and not just the Danish context.

Conclusions and implications

On the face of it, the biology teachers we studied talked positively about socioscientific teaching activities as an aspect that permeates their teaching practice. Beneath the surface, however, we found strong indication that both the interviewed teachers and the teacher-respondents in our questionnaire study harbour what we have called a content-centred interpretation of socioscientific issues. We have argued that the content-centred interpretation of socioscientific issues is ill-equipped to facilitate teaching and learning situations that would be recognisable as full-fledged socioscientific teaching. Thus, our findings indicate a fundamental un-alignment between teaching practice and the conspicuous intentions behind the Danish upper secondary curriculum for biology. It is important for us to emphasise that this diagnosis should not be interpreted as a critique of the teachers who participated in this study. Rather, our findings merely make visible that while the Danish biology curriculum for the last 10 years has emphasised what we could broadly call socioscientific competences, it has failed to operationalise this emphasis into the final performance assessment of the students. Therefore, our findings imply that curriculum designers and policy-makers need to mend this divided curriculum if they want to support future students' acquisition of complex socioscientific competences.

Two aspects of the content-centred interpretation of socioscientific issues we identified seem to resonate quite well with existing research – namely, on the one hand, an instrumental use of socioscientific issues for the purpose of motivating or framing teaching of biological contents, and, on the other hand, a content bias in terms of what the teachers

put emphasis on when assessing their students. A third, and to our knowledge hitherto undescribed aspect of the content-centred interpretation, was what we have called a reductive narrative – that is, the tendency to reduce socioscientific issues without noteworthy remainder to factual biological content – typified by the notion that all biological content is potentially contextualised in or important for society hence all teaching of biological content is automatically socioscientific teaching. We hypothesise that this narrative manoeuvre may be a part of a coping strategy that enables the teachers to succeed in a Danish curriculum that on the surface is fraught with competences that relate to socioscientific decision-making but essentially still operates as a curriculum that focuses on the mastery of biological content. This hypothesis must be explored in more detail in future studies of teachers' beliefs about socioscientific issues.

It would be standard at this point to propose a range of professional development initiatives that focus on teachers' beliefs about and operationalisation of socioscientific issues. While we do think that such initiatives would be a good investment, it appears to us that this would not properly address the elephant in the room: The divided curriculum. It is our conviction that these teachers merely seem to try to get the best out of a situation in which they have to navigate a curriculum that on paper carries the lofty ambitions of aiming for socioscientific competences, while in practice seems to preclude these ambitions by reiterating an assessment system that emphasises mastery of factual content.

Note

1. A number of national curricular conspicuously reflect socioscientific themes – for example, Homer and Ryder (2014) recently found a strong emphasis on socioscientific issues in GSCE science course in England and Wales; and Eijkelhof and Kapteijn (2000) described how the curriculum in the Netherlands since the late 1990's focused on teaching science with a focus on e.g. the "socio-economic context" (p. 190).

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