Research in Science & Technological Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/crst20

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To cite this article: Karolina Broman, Sascha Bernholt & Camilla Christensson (2022) Relevant or interesting according to upper secondary students? Affective aspects of context-based chemistry problems, Research in Science & Technological Education, 40:4, 478-498, DOI: 10.1080/02635143.2020.1824177

To link to this article: https://doi.org/10.1080/02635143.2020.1824177

RESEARCH IN SCIENCE & TECHNOLOGICAL EDUCATION
2022, VOL. 40, NO. 4, 478–498
https://doi.org/10.1080/02635143.2020.1824177

Relevant or interesting according to upper secondary students? Affective aspects of context-based chemistry problems

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ABSTRACT

Background: To make students more interested and engaged in science, new teaching approaches have been developed aiming at higher order thinking. Context-based learning approaches emanate from an idea that science content knowledge should be presented in a relevant context for students to improve their learning outcomes as well as making them more engaged in science. Previous research on context-based learning approaches has shown positive results; however, researchers and teachers need to explicitly consider which aspects of the contextual settings young students perceive as interesting and relevant to improve chemistry education.

Purpose: In this paper, the constructs of 'interest' and 'relevance' are explored to analyse which aspects of open-ended chemistry problems engage students.

Sample and Design: Both qualitative interview data and quantitative survey data are elaborated on in three subsequent studies with Swedish upper secondary chemistry students. Students' statements when discussing contextualisation of chemistry problems are analysed in relation to analytical frameworks to explore students' perceived interest and relevance.

Results: The results highlight the importance of connections to personal dimensions in chemistry to make students more engaged and interested in chemistry. The language of the context-based problems is also found essential as the students indicate trigger-words in the tasks influencing perceived interest and relevance. This in combination with students' distinction between high interest as a positive feeling, and high relevance as something important or worthwhile, are important results from this study.

Conclusion: From the results, conclusions are drawn to help researchers and teachers develop chemistry problems aiming for higher order thinking, but at the same time are found interesting and relevant for the students.

KEYWORDS
Interest; relevance; context-based learning; chemistry education

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Introduction

Context-based learning (CBL) approaches have influenced curriculum development and teaching in many countries and different science subjects (Nentwig and Waddington 2005; Pilot and Bulte 2006b; Sevian, Dori, and Parchmann 2018). Context-based learning is often implemented as a means to improve students' affective responses as well as to develop their cognitive learning outcomes (Habig et al. 2018; Prins, Bulte, and Pilot 2016). To elaborate CBL approaches further, Pilot and Bulte (2006a) together with Bellocchi, King, and Ritchie (2016) emphasise the need to identify contexts that are appreciated by students but also can be related to the learning of chemical concepts in order to develop chemistry education towards higher-order thinking, i.e., beyond recall of factual knowledge.

Previous research highlights the need for the contexts to be perceived interesting and relevant to the students (Fechner et al. 2015; Savelsbergh et al. 2016). The affective constructs of interest and relevance in science education have been explored by Stuckey et al. (2013) and will be elaborated further in this paper emanating from their statement that relevance is a notion inadequately conceptualised. If teachers want to engage students in chemistry, we have to know more about if and how students find contexts more or less interesting, or more or less relevant. In a book discussing relevant chemistry education, Eilks and Hofstein (2015) explore the relationships between chemistry as a less popular school subject, especially at secondary level, with the idea that chemistry in schools is perceived irrelevant.

In Sweden, where this study was undertaken, no context-based approach is explicitly stated in the upper secondary curricula. Instead, knowledge and understanding of chemistry concepts are emphasised together with ability to do and think in a scientific way. However, depending on how the chemistry syllabus is interpreted by the teacher, interesting and relevant contexts could, or perhaps, should be applied. In the current syllabus when considering the aims of chemistry, there are statements which seem to address contexts that are interesting and relevant; 'Teaching should take advantage of current research and students' experiences, curiosity and creativity' (Swedish National Agency for Education 2011, 1). Swedish teachers are free to decide how to teach and how to assess student learning. In chemistry, there are no national tests at upper secondary level.

This paper aims to investigate CBL through the application of open-ended chemistry problems to explicitly study the different affective aspects of the tasks' contexts and elaborate on relevance and interest. The research questions are: Which aspects of open-ended context-based chemistry problems are found more or less interesting and relevant to students and why? How do students differentiate between interest and relevance when meeting these problems?

Background

Context-based learning approaches and higher order thinking

One of the fundamental ideas with context-based learning (CBL) approaches is to use a contextual setting for the content with an aim to increase students' perceived interest and relevance to the subject, in this case chemistry. Through the contexts and the open-ended problems, the focus is to shift from lower order thinking with rote learning and memorization of factual knowledge, into higher order thinking and problem solving of open-ended tasks (Zohar 2004; Zohar and Dori 2003). A complicating factor when developing context-based problems is that the notion of context is sometimes referred to in different ways. In some studies, the contextual setting is discussed in terms of 'modules' (e.g., Graeber and Lindner 2008; Walan and McEwen 2017) while others use the notion of 'themes' (e.g., Christensson and Sjöström 2014; Nentwig et al. 2007), and the definition of the different aspects has not always been explicit. Since context often is broadly defined, van Oers (1998) has argued that it should be regarded as a general theoretical concept, stating that 'context is seen here not merely as a synonym for a concrete external situation, but it can assume the character of a mental framework as well' (van Oers 1998, 474). In this paper, the notion 'context' is used as an explanatory variable that helps students to discern the role of chemistry in real world situations. We will also argue that there is a content-related context, which we name 'topic', and a setting-related context, which we name 'context'.

Whitelegg and Parry (1999) discuss both broader and narrower definitions of 'context' and build on the work of Vygotsky by stating that 'a learning context requires relating learning to an *application* in the real world' (Whitelegg and Parry 1999, 68). In their narrower definition, contexts are applications of a theory to illuminate and reinforce science. However, they note that merely introducing an application after teaching using conventional methods is unlikely to be very effective. Sevian and Talanquer (2014) stress the importance of not neglecting content knowledge or losing sight of the need to convey chemical ideas and practices when concentrating on the context. The student-centred emphasis commonly applied within CBL approaches might also slow students' learning progressions by making it difficult to see the chemical concepts in the context (Parchmann et al. 2006; Wickman 2014). Furthermore, Marks and colleagues emphasise that the contextualisation of tasks might make them more superficial (Marks, Bertram, and Eilks 2008; Marks and Eilks 2010). When developing context-based tasks, it is important to consider the progression in learning, and focus on explicit chemistry topics/content areas, still relating the contextual settings to areas interesting and relevant for the students.

A key goal of this study was therefore to identify appropriate interesting and relevant topics and contexts for context-based problems, where content concerns have been addressed by maintaining a clear focus on chemistry within the context-based tasks students met.

Affective domain of learning – interest and relevance

With regard to educational research, the affective domain of learning is explained through several constructs, for example interest, motivation, and attitudes; however, the relationship between them are not always explicit. Koballa and Glynn (2007) state two main constructs; attitudes and motivation, where motivational constructs such as arousal, anxiety, interest and curiosity are mentioned to play important roles. The concept of attitudes is discussed by Reid (2011) claiming the clear relation to favour or disfavour of something. A unifying conclusion from previous reviews on students' attitudes towards science in general and chemistry in particular is that attitudes towards science are positive among young children but older students' attitudes become more negative with age

(Gardner 1975; Osborne, Simon, and Collins 2003). According to Koballa and Glynn (2007), studies on attitudes have become less common and there has been a growing emphasis on other constructs, e.g. interest.

The evident close relationship between attitudes and interest together with motivation, makes it crucial to consider them together when analysing students' affective responses (Potvin and Hasni 2014). While Fortus (2014) notes that a person might hold a positive attitude about something without being interested in it, it is generally the case that people have positive attitudes about things that interest them. To further complicate the position, Tytler (2014) discusses the notion of attitudes as an umbrella term; 'attitudes such as interest, motivation, enjoyment, curiosity, and confidence [...], they are interrelated' (p. 85), whereas Reid (2011) has summarised key findings derived by treating attitude as a construct in its own right, on the basis of research in social psychology. This ambiguity of the definition of the attitudinal construct contributed to the decision to avoid its use in this study. The use of 'interest' rather than 'attitude' was largely due to pragmatic considerations; questions about interest were assumed to be more explicit and easily interpreted by upper secondary school students and their teachers than equivalent terms based on the notion of attitude. This might depend on translation; the Swedish word for interest [intresse] was considered to be more precise and straightforward than any alternatives. The word 'attitude' was also avoided because it often has negative connotations in everyday usage. Nevertheless, Fortus (2014) argues that 'without motivation, interest, positive attitudes and self-efficacy, there can be only limited and curtailed engagement, and without engagement, learning is partial at best' (822).

The choice to further explore interest in relation to relevance, was due to results from discussions with both students and teachers, when investigating how students solve context-based problems (Broman and Parchmann 2014). To engage students into learning science, we benefit from finding triggers to emphasise personal relevance and interest (Renninger and Bachrach 2015). Therefore, students' voices when discussing interest and relevance from different perspectives are presented in this paper.

Interest

Interest is an affective construct that is sometimes taken to be almost a synonym of attitudes and sometimes treated as a construct in its own right (Krapp and Prenzel 2011). Interest has been investigated for a long time, and various interest frameworks have been developed (e.g. Häussler et al. 1998; Krapp and Prenzel 2011). Interest is primarily conceptualised as having an intrinsic character, with an explicit relationship between an individual and a topic, object or activity; in other words, it is content-specific (Häussler et al. 1998). Therefore, the perceived interest is analysed in direct connection to the chemistry problems of this study.

When exploring the meaning of interest, Krapp and Prenzel (2011) stress that 'interest cannot be equated with "enjoyment while learning". Enjoyment can occur for many reasons, and interest is only one of these' (30). Three forms of interest are commonly distinguished; a momentary psychological state, situational interest, and individual interest (Dierks, Höffler, and Parchmann 2014; Hidi and Reeninger 2006). Gräber (2011) argues that interest has dual functions in education, first as a requirement for meaningful learning, and second as a teaching goal that promotes life-long open-mindedness.

Interest in different chemistry content areas has in a previous study been investigated at upper secondary level in Sweden (Broman, Ekborg, and Johnels 2011). Some areas, e.g. biochemistry and organic chemistry, were perceived more interesting than others, low interest was stated on areas like energy and enthalpy. From this, the open-ended context-based chemistry problems used for this study were designed using topics both from more and less interesting content areas (medical drugs related to organic and biochemistry, and fuels related to energy and enthalpy). In the context-based problems, students need to make fluid transitions (King and Ritchie 2013) moving back and forth between content and context when solving the tasks. These fluid transitions could therefore influence students' perceived interest and relevance.

Relevance

The meaning of 'relevance' has been questioned in the same way as other affective constructs, and Stuckey et al (2013) state that the notion is inadequately conceptualised. By discussing relevance and its alignment with interest, meaningfulness and worth, they highlight five meanings of relevance; (1) as a synonym for student interest, (2) as students' perception of meaningfulness, (3) as a synonym for importance, usefulness or needs-matching, (4) as a real-life effect for the individual and the society, and (5) as a combination of the above four (pp. 12–13). These different meanings have been used as a starting point for the student interviews when they were unable to put words to their ideas about relevance. From the five different meanings of relevance, Stuckey and colleagues have suggested a three-dimension model which Eilks and Hofstein (2015) have elaborated further. Relevance is in the elaborated model distinguished on three neither dichotomous nor hierarchical levels; the individual dimension, the societal dimension, and the vocational dimension. These three levels can be related to the three different contextualisations applied for the chemistry problems in this study, i.e., the personal, societal and professional context. Emanating from their framework, Stuckey and Eilks (2014, 2015) have developed a teaching sequence on tattoos as a participatory action research project together with chemistry teachers. Through the lesson plan applied on secondary students, the results show that students can become highly motivated and interested in chemistry when related to relevant everyday life areas such as tattoos.

Relevance has been discussed in science education for more than 100 years, largely because of educational reforms that have sought to make learning in school 'relevant' to students' lives and futures. The perceived importance of relevance is readily evident from its appearance in different curricula, and relevance is a watchword in many CBL approaches (King 2012; Smith 2011; van Aalsvoort 2004). Another similar notion that is often taken to be synonymous with relevance is 'meaningful'; CBL approaches have been implemented in several western countries with the aim of making chemistry relevant and meaningful (King and Ritchie 2012). Therefore, a study combining context-based problems with perceived relevance is worthwhile. Besides the apparent relationship between relevance and CBL, Belova et al. (2017) have studied how cross-curricular goals (i.e., generally accepted demands across all school subjects and levels) for example, education for sustainability and critical media literacy, influence teaching and learning. These cross-curricular goals are multidisciplinary and will be discussed in relation to students' perceived interest and relevance towards the context-based open-ended chemistry problems.

Relevance is clearly aligned with interest; some researchers take them to mean the same thing while others separate them, unfortunately often without clearly defining their differences (Stuckey et al. 2013). For example, the name of the widely cited, and by Swedish teachers rather well-known, Relevance of Science Education (ROSE) project (e.g. Jenkins and Nelson 2005; Sjøberg and Schreiner 2012) indicates a focus on relevance but its results are often framed in terms of interest. When defining relevance in the context of their project, Schreiner and Sjøberg (2004) state that they use it as a broad concept but could equally well have used the terms meaningful, motivating, interesting, engaging or important. Similarly, when reviewing research on relevance in science education, Stuckey et al. (2013) assert that the ROSE project is actually investigating student interest. One conclusion of their review is that 'relevance in science education is mainly related to the question of whether science education content accurately matches the students' real or perceived interests [...] good reasons to consider "relevance" and "interest" as consisting of overlapping but non-identical ideas' (Stuckey et al. 2013, 9). Regardless of whether the ROSE project (Sjøberg and Schreiner 2012) explores relevance, interest or some other affective construct, it has produced a substantial and important body of data that is discussed together with the analysed empirical data presented herein. Within the context of the ROSE project, 15-year-olds from almost 40 countries have, 16–17 years ago, completed a questionnaire featuring items on areas students want to learn more about, e.g. 'stars, planets and the Universe', 'cloning of animals' or 'atoms and molecules'. The Swedish ROSE study has explored student interest profiles and connected these profiles to students' upper secondary educational choices, particularly their decisions relating to post-compulsory chemistry studies (Oskarsson and Karlsson 2011). Results from the ROSE project have been applied when developing the context-based problems analysed in this study.

The connection between how students find contexts interesting and relevant or not, will be explored further to be able to design and develop context-based teaching material meaningful for students to learn chemistry more in-depth.

Method

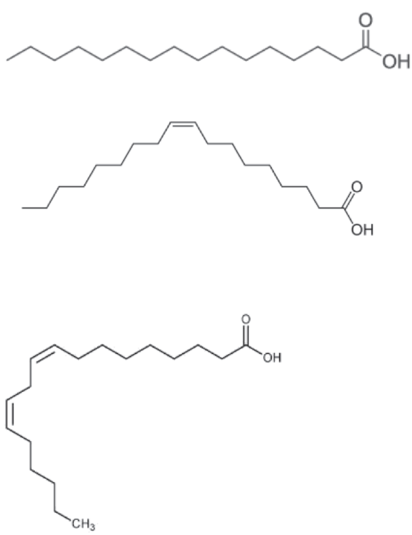
To explore if Swedish upper secondary chemistry students perceive contextual settings interesting and relevant or not, this study emanates from previous studies where 15 context-based chemistry problems have been investigated regarding students' application of chemistry content and problem-solving approaches (cf. Broman, Bernholt, and Parchmann 2018; Broman and Parchmann 2014). In Sweden, students choose one of 18 national programmes for upper secondary level (grade 10–12) where one is the Natural Science Programme (NSP), i.e., the programme investigated here. Students at NSP take courses in chemistry, biology, and physics that prepare them for higher education within science, technology, engineering, and mathematics (STEM).

In this paper, three subsequent studies are presented with a starting point from the 15 context-based chemistry problems. To understand more in-depth how students interpret the contextualisation of the tasks, both regarding interest and relevance, we have collected qualitative interview data together with quantitative survey data. The design with three studies was chosen to be able to adapt the methodology and to learn from the results that have emerged over time.

The problems are related to five different topics (i.e., medical drugs, soaps and detergents, fuels, energy drinks, and fat) and are presented in three different contextualised settings (i.e., personal, societal, and professional context). The reasons for the choice of topics are related partly to the ROSE project, e.g., where students claim that soaps and detergents is a topic of low interest and the conclusion is therefore drawn that students do not find everyday-life connections interesting (Sjøberg and Schreiner 2012). The reason for the choice of the contextual settings is related to studies presenting how the settings can fit into chemistry education (de Jong 2008; de Jong and Taber 2014). The three contexts, i.e., the personal, societal, and professional context of our study, are moreover connected to the relevance model developed by Eilks and Hofstein (2015) and their three dimensions; individual, societal and vocational.

Important in all problems was the explicit connection to the chemistry content, thereby hopefully avoiding the tasks being superficial (cf. Marks and Eilks 2010). Therefore, all problems had molecular structures embedded in the task; the importance to emphasise the chemistry content through a structural formula was a result we found in one of the previous studies (Broman, Bernholt, and Parchmann 2015). To avoid reading-

Trans fats are a group of fats discussed in the media, found in for instance industrially baked cakes. Trans fats are found naturally in for instance meat but can also be produced industrially by hydrogenating unsaturated fats. In this hydrogenation, hydrogen (H_2) is added to a fatty acid and becomes saturated. How would the chemical properties of the fatty acid change because of this hydrogenation reaction?



palmitic acid, T_m 63°C

oleic acid, T_m 13°C

linoleic acid, T_m appr -10°C

Figure 1. One exemplary context-based problem from the topic of fats and the professional/vocational context. For more exemplary problems, cf. Broman, Bernholt, and Parchmann (2018); Broman and Parchmann (2014).

difficulties, the tasks were written in everyday language in Swedish and the length of the task was short (in Swedish 50–60 words, approximately 5 sentences). In Figure 1, one exemplary task is presented (here translated into English), in the topic of fats and put into the professional/vocational context.

The problems were used in three subsequent studies with slightly different foci. In all three studies, NSP students were asked to work through (all or a selected subset of; cf. description below) these problems, but also to evaluate and comment on specific features of these problems. As stated above, students' application of chemical concepts as well as their problem-solving process when actually working on these problems are presented in previous studies (cf. Broman, Bernholt, and Parchmann 2018; Broman and Parchmann 2014), whereas students' perception of the problems' interestingness and relevance as indicated by both qualitative and quantitative methods is evaluated here.

In the first study, 20 upper secondary chemistry students read and evaluated all 15 problems regarding how relevant and interesting the tasks were perceived. Through semi-structured interviews, the students qualitatively discussed the similarities and differences between interest and relevance in relation to the specific tasks from their personal perspective. The interviewer prompted students to further elaborate on their understanding of both terms (i.e., interest and relevance) and to rate the different problems with regard to their perceived interest and relevance. Thereafter, they solved six of the tasks, that is, two topics in all three contextualisations (for more information about the methodology and results on the cognitive aspects of the tasks, cf., Broman and Parchmann 2014).

In the second study, 175 students from the same school level, but from another part of the country, responded to the same affective questions. The reason was to explore if the results from the 20 students could be generalised to a larger cohort. In this study, the problems and the rating questions were presented in the form of a survey and students' responses were collected in written format. The rating questions asked students to rate their perceived interest and relevance of both the topic and the context of each problem on a four-point Likert-scale, ranging from 1 (not interesting at all or not relevant at all, respectively) to 4 (very interesting or very relevant, respectively). The students also solved one task from every topic in written format, however, these results are only published in Swedish.

Finally, a third study aimed at getting more in-depth insights into the perceptions and interpretations of the concepts of interest and relevance by students in the second study. Here, 25 interviews were conducted with a new group of upper secondary chemistry students to explore the constructs of interest and relevance further. These interviews were based on the quantitative results from study 2 (as presented below). The 25 students were asked to discuss and elaborate on the quantitative results from study 2 in order for us to get a more thorough explanation about the larger group of students' ideas (n = 175). The 25 students in this final group only read the problems through and were not asked to solve them, the only focus was the constructs of perceived interest and relevance. Throughout the interviews, the interviewer (i.e., first author) had the opportunity to go more in-depth into the previous empirical data. For example, questions were given on the potential demarcation between interest and relevance, where the students were asked to explain their perception of the concepts, and thereafter, comment on the synonyms given in the second study.

All students in the three studies were in their final year of upper secondary schooling (i.e., 18–19 years old) and had studied almost all areas of the chemistry courses demanded before entering university education. Therefore, the three samples of students have studied the amount of chemistry required before entering higher education within chemistry. The empirical data in the three studies were collected through convenience sampling where teachers were willing to participate with their students. The student groups were from different parts of Sweden, thereby avoiding individual teacher effects on students' perceptions of affective aspects of chemistry. From an ethical point of view, a checklist with ground rules for social research presented by Denscombe (2010) guided the study, and all students were informed about the study and had the possibility to opt out whenever they wanted to. Since individual students' responses would be very difficult to discern in the broad empirical data, there were no concerns about any risk of violating students' anonymity. Moreover, since the participating students were at the end of their upper secondary education and 18–19 years old, they were treated as adults, and their parents' written consent was not requested.

Analysis

The qualitative data from studies 1 and 3 has been analysed using content analysis (Cohen, Manion, and Morrison 2017). By applying the three-dimensional framework of relevance (Eilks and Hofstein 2015; Stuckey et al. 2013), the different levels of contextualisation have been explored and been used as categories to analyse the data. The framework (cf. Figure 1 in Eilks and Hofstein 2015) consists of three dimensions; individual, societal, and vocational, clearly associated to our levels of contextualisation (i.e., personal, societal, and professional). Within each dimension, there are both a time aspect moving from present to future, and an intrinsic/extrinsic aspect. The interviews were transcribed and categorised using these dimensions and aspects, an exemplary analysis is presented in Figure 2. Students' responses were connected to the individual, the society, and the profession, moreover, the described interest and relevance often had a time aspect where the problems were related to students' present chemistry courses or more related to their future life.

Students' ratings in the survey in study 2 were coded in accordance with the four-point Likert-scales, i.e. by assigning values from 1 to 4. These quantitative data have then been summarised and presented through inferential statistics using SPSS24 and R3.5.3.

Results and discussion

The results will be presented in three steps related to the three studies. First, students' interpretation of the concepts interest and relevance and their evaluation of the different context-based problems with regard to these concepts are discussed. Second, aggregated results from a larger cohort of students with regard to their rating of the perceived interest and relevance of these problems are presented. Thirdly, these findings are then discussed based on students' evaluation of these results.

Interviewer: What makes a chemistry task interesting?
Student: For me, it's important that the chemistry is related to myself, that I can understand the things I learn in everyday life, now or in the future *(Individual dimension, Present and future, Intrinsic)*
I: And what makes a chemistry task relevant?
S: What do you mean by something being interesting **or** relevant, isn't that the same?
I: Do you think it's the same?
S: Well, when I think about it, relevant chemistry might be things I should know, things that are important and meaningful to learn, like to understand how headache drugs work in the body. But for me, that task is interesting as well, since I want to become a medical doctor in the future *(Vocational dimension, Present and future, Intrinsic)*. If I compare with the tasks about energy drinks, these are more interesting than relevant, I mean, I don't **have** to understand it, but it's something I can talk about with friends outside my chemistry group as well, since almost all my friends drink Nocco and Red Bull *(Individual and Societal dimension, Present, Intrinsic).*
I: Do you find any of the topics in the tasks more or less interesting and why?
S: As I said, headache drugs are most interesting to me since I'm interested in the human body, and therefore it's also interesting with different fats. These things make me curious to know more about, both for myself but also for my future job, I hope. *(Individual and Vocational dimension, Present and future, Intrinsic).* I don't think that soaps and fuels are as interesting, but of course, it's relevant, it's chemistry things I should know about. But for me, as a person, topics related to myself is most interesting. When it comes to fuels, it's of course important for society, we need to have sustainable fuels for the future *(Societal dimension, Future, Extrinsic)*…

Figure 2. Analysis of interview transcript applying the Eilks and Hofstein (2015) framework.

Study 1: interest vs. relevance

The interviewed students (n = 20) at first did not differentiate between the notions relevance and interest, a result also highlighted by Stuckey et al (2013). One exemplary quote was a student asking: *What do you mean by something being interesting **or** relevant, isn't that the same?* After elaborating the notions further, almost all students expressed that something is perceived relevant when being important and worthwhile, something meaningful, whereas other areas could be interesting just in itself but with no specific use. Thereby, interesting aspects were not always stated as meaningful and worthwhile. Several students expressed that a task was fun, but then the interviewer (i.e., first author) always moved the discussion back to interest or relevance, since enjoyment, according to research, is not a synonym for interest or relevance (Krapp and Prenzel 2011). The students agreed that their use of the word 'fun' was mostly due to carelessly using everyday language, not being explicit in the responses. Different notions or synonyms of interest and relevance stated by the students are presented in Table 1. The most common synonyms to interesting were engaging and fun, and the most common synonyms to relevant were applicable and meaningful. Overall, these associations indicate that, in the perspective of the students, interest seems to be more closely related to feelings (Renninger and Bachrach 2015), while relevance seems to be more closely

Table 1. Students' suggestion of notions/synonyms of the words interesting and relevant, in alphabetic order. The students gave the words in Swedish, translated by first author into English.

Interesting	Relevant
Alluring	Applicable
Appealing	Essential
Engaging	Important
Entertaining	Meaningful
Exciting	Significant
Fascinating	Suitable
Fun	Worthwhile
Stimulating	
Thought-provoking	

connected to (utility) values, i.e., the perceived usefulness of an object (such as chemistry) to pursue a specific goal (Jiang, Rosenzweig, and Gaspard 2018; Wigfield and Eccles 2000).

Across the different problems, those problems embedded in a personal context were considered most relevant and interesting, as a student expressed: *When I can connect chemistry to myself and relate it to me, then it's so much more interesting and meaningful than when it's just things we talk about in school*. In contrast, problems embedded in a professional context were considered least interesting, discussed in the following quote: *When the problem relates to a professional context, it's not appealing to me since I want to become a medical doctor. All the professional contexts were connected to a chemist profession. This is not for me*. Both quotes connect to the present and future time aspect; interest and relevance are important today as well as for the future. With regard to the five different topics, only small discrepancies were found. Rather, all topics were considered as interesting by most of the students.

Study 2: interesting and/or relevant?

In the second study, students (n = 175) were rating their perceived interest and relevance in a survey related to both the topics and the contexts of each problem. The results are presented in Tables 2 and 3. Students were asked which problem they found the most interesting when having to choose among the three different contextualisations for the problems within each topic. Here, the personal context is in general found most interesting; however, regarding soaps and detergents, the societal setting is preferred, and

Table 2. Students' (n = 175*) preferred topic and context in relation to interest, i.e. total numbers and percentages (row wise) of responses to the question, which of the contexts the students find most interesting.

Topic	Personal context	Societal context	Professional context
Medical drugs	82 (47%)	37 (21%)	55 (32%)
Fuels	86 (50%)	53 (31%)	34 (20%)
Soaps and detergents	62 (36%)	77 (45%)	31 (18%)
Energy drinks	88 (50%)	63 (36%)	24 (14%)
Fat	50 (30%)	39 (23%)	79 (47%)
IN TOTAL	368 (43%)	269 (31%)	223 (26%)

* Not all 175 students responded to all survey questions, in total per topic 174 (medical drugs), 173 (fuels), 170 (soaps and detergents), 175 (energy drinks), and 168 (fats).

Table 3. Mean values and standard deviations describing students' (n = 175) perceived interest and relevance towards the topics, a high value (maximum 4) indicates high interest/relevance and a low value (minimum 1) indicates low interest/relevance.

Topic	Interest	Relevance
Medical drugs	2.8, SD 0.74	3.7, SD 0.56
Fuels	2.4, SD 0.94	3.5, SD 0.70
Soaps and detergents	1.8, SD 0.81	2.6, SD 0.86
Energy drinks	2.4, SD 0.97	2.3, SD 0.91
Fat	2.3, SD 0.86	2.9, SD 0.81

professional context is favoured in the task concerning fats. In these two cases (soaps and detergents; fats), the personal context is ranked second.

With regard to students' rating of the different topics, all topics besides one show a higher mean value regarding relevance than interest (Table 3). Hence, all topics are perceived more relevant than interesting. The only exception is energy drinks where perceived relevance and interest are almost equal. When comparing the different values for students' perceived interestingness of the different topics, only the rating for medical drugs is above the centre of the scale (2.5), while the ratings for fuels, energy drinks, and fats are close to the centre and the rating for soaps and detergents is substantially lower (cf. Sjøberg and Schreiner 2012).

When further analysing students' ratings of their perceived interest of the five topics, it becomes obvious that these five rating items do not measure the students' general interest towards chemical topics in terms of an overarching personal predisposition (cf. Häussler et al. 1998; Krapp & Prenzel, 2011). The internal consistency of the five ratings of students' interests show only a low reliability (Cronbach's α =.50), which is substantially below common thresholds (Cronbach's α > .70; cf. Field 2013). The same interpretation pertains to the five ratings of students' perceived relevance (Cronbach's α = .52). These values indicate that students do not answer consistently across topics, but that they rate specific topics higher than other topics, without a general tendency towards higher or lower ratings within students. With regard to the theoretical background sketched above, interest is conceptualised as an explicit relationship between an individual and a topic, i.e., as content-specific (Häussler et al. 1998). From this perspective, the low internal consistency of students' ratings across topics matches these theoretical considerations and provides support for conceptualizations of students' interest that differentiate between specific levels of the 'object' of interest (cf. Häussler et al. 1998).

Within both constructs, i.e., students' perceived interest and relevance, correlations between students' ratings of the different topics thus result in rather low intercorrelations (Figure 3). While seven out of ten correlation coefficients indicate significant relations between students' ratings of their perceived interest in different topics (Figure 3(a)), all but one (between fats and soaps and detergents) would be considered to represent small effects (i.e., r < .3; Cohen 1988). With regard to students' perceived relevance of the different topics (Figure 3(b)), again seven out of ten correlation coefficients indicate significant relations between distinct topics, but only two coefficients would be considered to represent medium effects (between fuels and medical drugs and fats,

a) Interest

	Medical Drugs	Fuels	Soaps and Detergents	Energy Drinks
Fuels	0.17			
Soaps and Detergents	0.23	0.18		
Energy Drinks	0.15			
Fats	0.17	0.29	0.3	

b) Relevance

	Medical Drugs	Fuels	Soaps and Detergents	Energy Drinks
Fuels	0.36			
Soaps and Detergents	0.19	0.2		
Energy Drinks				
Fats	0.18	0.31	0.28	0.15

Figure 3. Bivariate correlation coefficients between students' ratings of their perceived interest (a) and relevance (b) of five different topics; only the lower triangle of the symmetric correlation matrix is displayed and correlation coefficients with an associated p-value >.05 (i.e., non-significant) are not displayed.

respectively). Overall, all correlation coefficients indicate only low to medium interrelations between students' ratings of the different topics, providing further support for assuming rather differentiated ratings of the distinct topics' interest and relevance by individual students, instead of a rather general tendency towards higher or lower ratings across topics (cf. Häussler et al. 1998).

With regard to the interrelation between students' perceived interest and their perceived relevance, Figure 4 shows the correlation coefficients of students' ratings of all five topics. The coefficients are highest in the diagonal of the matrix, i.e. for correlations between students' perceived interest and relevance of the same topic ($.35 < r < 55$, i.e., medium to large effects; Cohen 1988). Coefficients off the diagonal, i.e., for correlations between students' ratings pertaining to different topics, are substantially smaller ($.15 < r < 25$, i.e. small effects; Cohen 1988).

In a final open question, students were asked to suggest how to, in general, improve chemistry education. In previous studies (Broman, Ekborg, and Johnels 2011; Broman and Simon 2015), the connection to everyday life has been one of the most important aspects to improve the subject of chemistry independent of whether the students responded to an open (Broman, Ekborg, and Johnels 2011) or closed question (Broman and Simon 2015). Of the 175 students responding to the survey, 46% ($n = 80$) responded with suggestions. The most common suggestion was that students emphasised the importance of relevance and interest to make chemistry education more meaningful, for instance by including more of the tasks like the ones in this study. This is illustrated through the following survey response: *It should be so much more tasks like this. If we can get these connections to the practical use of chemistry in everyday life, it would be extremely more interesting to study chemistry. Of course, we have to get into the chemistry content, but not without time and space for applications*. Development of new context-based problems is therefore important to elaborate on further with results from this study.

Interest \ Relevance	Medical Drugs	Fuels	Soaps and Detergents	Energy Drinks	Fats
Medical Drugs	0.35	0.25	0.16		0.15
Fuels		0.48			
Soaps and Detergents			0.41	0.17	0.2
Energy Drinks				0.55	0.16
Fats		0.21	0.15		0.51

Figure 4. Correlation coefficients between students' ratings of their perceived interest (rows) and relevance (columns) of the five different topics; correlation coefficients with an associated p-value >.05 (i.e., non-significant) are not displayed in the figure.

Study 3: relevant, but interesting?

To more explicitly understand if it was the topic or the context the students found interesting and relevant, another cohort of students (n = 25) was interviewed. Again, all students met the three contexts connected to the five topics and in this study, students were also asked for their interpretation of the quantitative findings from study 1 (cf., Broman and Parchmann 2014) and study 2.

After realising a difference between interest and relevance, almost all students highlighted the connection to themselves as being important for both interest and relevance. Therefore, the personal context was the most appreciated one in general (in concordance with studies 1 and 2). The exceptions were soaps and detergents, and fats, where the students in the interviews in study 3 explained this through specific trigger-words. A student expressed: *For example, in the fat-task, trans fats are discussed in media, we've heard that they're bad and that you should avoid them, and since it's something I've heard about outside of the classroom, like in real life, I find it both interesting and relevant*. The reason for fats to be more interesting and relevant in the professional context was therefore due to the trigger-word 'trans fats'. Other trigger-words students stated as interesting and relevant were headache drugs (topic: medical drugs), biofuels and E85 (topic: fuels), and palm oil (topic: fats). All these trigger-words are common in everyday life and the interviewed students emphasised that these trigger-words made the tasks more interesting and relevant since the words relate the subject of chemistry to students' life. However, a few words were explained as trigger-words that decreased the interest, i.e., words that were unknown to the students. An interview excerpt exemplified this: *The problem is when the tasks have new words which I don't know what they mean, then I don't find it as interesting or relevant. Like the one with the method, NMR, I don't really know so much about NMR and then it feels more difficult and not as interesting as the others. But in general, if I compare with tasks from our chemistry book, all these 15 are much more interesting and relevant*. New and difficult chemistry words (e.g., NMR, surface tension, hydrogenation) were perceived as decreasing interest, even though these words were always explained in the task. The awareness of how language influences chemistry education has been explored more and more the last years, for example in a special issue on language on teaching and learning science (cf. Markic and Childs 2016). In these context-based open-ended chemistry problems, specific trigger-words have influenced students' perceived interest and relevance, and language issues like this have to be explored further.

Since all topics besides energy drinks were found more relevant than interesting (cf. Table 3), the interviewed students explained this by claiming that chemistry in general is a relevant subject, meaningful for the students' future life. A topic like energy drinks, however, is not something you actually have to understand for life, it is more of a 'fun topic', thereby interesting; *My friends drink Monster and Red Bull so it was really interesting to learn more about it, especially since it's said to be dangerous and you can't buy it if you're too young. But it's more of a fun task, not something you actually need to understand*. A situational interest can be related to the topic of energy drinks, by being an authentic topic (cf. Anker-Hansen and Andrée 2019).

The topic perceived least interesting was soaps and detergents, the same topic stated in the ROSE-study as 'everyday-context, low interest for all' (Sjøberg and Schreiner 2012, 221). This conclusion that everyday contexts are uninteresting for students, might be due to the topic in itself. If the ROSE-study connected topics as medical drugs as being an everyday life context, other conclusions might be drawn.

To summarise, and relate to the research questions, students, in general, perceived the personal aspects of the context-based problems most interesting and relevant, and the everyday life connection of the tasks was highly valued. The distinction between interest and relevance was not fully discernible until the two concepts were requested in combination, however, students then differentiated between them, and the topics presented here were found more relevant than interesting. When describing interest, students related to positive feelings and emotions, whereas relevance had more focus on something being perceived important. Depending on how the tasks were formulated, different words triggered students' interest, whereas other words evoked negative connotations. Therefore, not only the topics and contexts in themselves are important to consider if the aim is to raise students' interest and relevance; how a problem is phrased also influence students' opinions.

Conclusions and implications

Both quantitative and qualitative data highlight that students appreciate context-based open-ended chemistry problems by finding them interesting and relevant, in particular when the tasks are closely related to themselves. Chemistry topics and contexts that have explicit personal connections are perceived both interesting and relevant. Therefore, both topic and contextual aspects can be found interesting and relevant if students find them valuable. The division into content-related topics and setting-related contexts can be one way to more explicitly study which aspects of the tasks that make them more (or less) interesting and relevant. Interest is, as Gräber (2011) claims, required for meaningful learning and a starting point for open-mindedness, moreover, interest is, as Häussler et al. (1998) highlight, content-specific, but also in this study perceived context-specific. With regard to CBL approaches, the connections between the content with its concepts and the contexts have been scrutinized by King and colleagues in terms of 'fluid transitions' in order to explore the need of contextual settings (e.g. Bellocchi, King, and Ritchie 2016; King, Bellocchi, and Ritchie 2008; King and Ritchie 2013). These fluid transitions are one way to explain the movement back and forth regarding content and context when students, for example, solve problems, but might also influence students' perceived interest and relevance, especially with regard to context-based problems. Authenticity was stated to be a vital aspect of a task as well, students emphasised that tasks relating to authentic situations were found both relevant and interesting. The concept of authenticity was not scrutinised in this study; however, students' perception of this concept would be useful to consider further in relation to interest and relevance.

When evaluating perceived interest and relevance, the whole task has to be considered, since language issues also affect interest. Consequently, trigger-words can influence students' interest both in a positive and negative way. Another aspect that was explicitly addressed by students in the interviews was the setup of the problems used in these studies. This type of problem was, in general, found unfamiliar to all interviewed students, exemplified by a student stating: *Tasks like this are better than normal exercises. They give a broader picture of what you know in chemistry and it's rewarding to see that I've learnt a lot of chemistry during upper secondary. But we don't meet them so often during tests, sometimes the teacher discusses things like this in class. It would be great if we could work with problems like this in class*. Accordingly, there were also some students who were less positive than the majority with regard to using this type of problems in class, mainly with the objection that they did not know how to solve the tasks. In their interview responses it became evident that these students often perceive chemistry as a subject where there is always a single correct answer (short, focusing factual knowledge, cf., Broman, Bernholt, and Parchmann 2015; Broman and Parchmann 2014). For instance, one student claimed: *I don't know what you want, I prefer tasks where I know what to respond, related to only one chapter in the textbook. I get distracted from the unimportant, even though interesting, information in the task. I don't want to see things from different perspectives.*

Overall, the apparent difference between interest and relevance in the view of students is that students highlight that things are relevant if they are worthwhile and meaningful, a result in line with Eilks and Hofstein (2015). When teachers create context-based open-ended chemistry problems to enhance students' perceived interest and relevance, these different aspects have to be considered. In a subsequent design-based research project (Broman, 2020), teachers have developed new context-based problems emphasising interest and relevance. Chemistry teachers visiting teacher conferences have, together with a chemistry education researcher (i.e., first author of this paper), developed new context-based problems with an aim to enhance students' perceived interest and relevance. The design process where the teachers gave suggestions on topics and contexts for context-based tasks is presented in an upcoming book chapter and the tasks are now tested on students. Hopefully, these new problems will make upper secondary students more interested in chemistry and enhance their learning.

The tasks discussed in this paper have a multidisciplinary focus, not only focusing on one single chemistry area (e.g., solubility), related to the cross-curricular goals discussed by Belova et al (2017). This might influence students' perceived interest and relevance, still, it also probably makes the tasks more complex to solve. The tasks also ask for responses where not only one single response is correct, instead several responses can be correct, this also making them more complex to solve. One expectation with the context-based problems is to acknowledge the idea that chemistry is a clearly defined subject with restricted responses to every issue, and instead present everyday-life tasks where several correct responses can be given to solve the problems further. In conclusion, after scrutinising open-ended context-based chemistry problems, we have realised that Swedish upper secondary students find individual, personal, authentic aspects both interesting and relevant. Moreover, they have made us understand that chemistry is perceived relevant when found worthwhile, meaningful and important to learn, whereas chemistry can be perceived interesting just for the sake of its own. To emphasise relevant chemistry content and context is therefore a fruitful way to trigger and engage students in chemistry education.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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