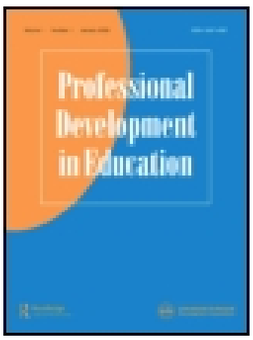

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A one-year teacher professional development programme towards context-based science education using a concerns-based approach

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ABSTRACT

Professional development programmes for teachers that aim at context-based science education are usually lengthy and less effective than intended. In this study, a one-year professional development programme was designed and evaluated that consistently started from the teachers' concerns regarding context-based education. The teachers reported a positive shift in concerns, from self-as-teacher concerns towards student-learning concerns. They also reported that they came to grips with what context-based science education means in teaching practice. Although the number of participants was small (n = 5), this study uncovers that focusing on teachers' concerns throughout the professional development programme is a potentially effective approach to teacher learning. The shifts in their concerns is an important condition for long-lasting change.

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KEYWORDS
Context-based education; concerns-based model; teacher professional development; designing curriculum materials

Introduction

A context-based teaching approach is increasingly adopted in science education around the world (e.g. Pilot and Bulte 2006, Potvin and Hasni 2014). Context-based science education can be defined as an educational approach in which contexts that are meaningful to students are used as a starting point for learning scientific concepts (Gilbert 2006, Bennett *et al.* 2007). Context-based education is becoming more and more effective and popular, as seen from a review study into context-based chemistry education, where over 50 studies where found dating from the last two decades (Ültay and Çalık 2012). In the Netherlands, an effort was made to involve teachers in the design and use of context-based teaching materials, following the example of Salters' chemistry in the UK and Chemie im Kontext (CHiK) in Germany (cf. Bennett *et al.* 2005, Stolk *et al.* 2009). Teams of teachers are expected to focus on creating context-based resources for their own and other teachers' classrooms, under the premise they would learn what context-based teaching entails whilst doing so.

In one of our previous studies, it became apparent that several factors hindered the professional development of these teachers towards the context-based innovation (De Putter-Smits *et al.* 2012). Hindering factors were: the non-voluntary nature of the design team work for some teachers and the time investment needed to (1) do the design work; (2) come to grips with writing context-based curriculum materials; (3) for the own classroom trials; (4) understand the shift from teacher-centred to more student-centred learning (De Putter-Smits *et al.* 2012).

In this paper we report on a modified programme of teacher professional development towards context-based science education through designing curriculum materials. This approach intends to

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solve issues identified in our previous study, by focusing on teachers' concerns in dealing with the context-based innovation in their own classroom in a shorter time frame. We chose to use Fuller's concerns based adoption model (1969) as used in Conway and Clark (2003) as a framework to address teacher concerns about the pending innovation during the professional development programme. We explore whether such a modified programme empowers teachers to design their own context-based classroom material.

Theory

Context-based science education

We define a context-based science education as an educational approach in which contexts that are meaningful to students are used as a starting point for learning scientific concepts (Gilbert 2006, Bennett *et al.* 2007). Context-based science education was introduced in many countries, to counter the falling interest of students in studying the sciences in higher education (Lyons 2006, Potvin and Hasni 2014). Initiatives that could be counted under context-based science education are the Science Technology, and Society movement in the United States, Salters' chemistry and Nuffield physics in the United Kingdom, and the Chemie im Kontext and Physik im Kontext curricula in Germany (Bennett *et al.* 2007). In context-based education, concepts are learned from a knowledge development in science or science, technology, and society perspective, rather than a fundamental science, abstract perspective, providing the students with information on 'why they need to know' from the off-set. If and when appropriate this includes interactions with other science subjects or outside-school organisations and activities (De Putter-Smits *et al.* 2012). A key element of such an approach is that the students are responsible for their own learning, causing the necessity to adapt their environment to their needs, assisted by the teachers (Parchmann *et al.* 2006).

To be able to create such a context-based learning environment teachers show a need for professional development (Mikelskis-Seifert *et al.* 2007, Ottevanger *et al.* 2016).

Effective professional development for context-based science education

Review studies into components that ensure effective professional development of teachers agree on four essential elements (e.g. Wilson and Berne 1999, Garet *et al.* 2001, Van Veen *et al.* 2010):

(1) Teachers should be allowed to construct their own learning in an active setting;
(2) Teachers should be viewed as professionals and supported to gain ownership;
(3) The programme content should focus on teachers' classroom practice; and
(4) The programme's teaching approach should model the approach to be learned (teach as you preach).

Comparing typical context-based professional development programmes (including CHiK, Salters' and so on) with these four elements leads to the following insights.

Regarding the first element, these programmes focus on the design of classroom materials in a team, preferably with teachers from different schools aided by university and context experts (e.g. Parchmann *et al.* 2006). The guided design of context-based classroom materials can be viewed as active learning in an active setting.

Regarding the second element, the classroom materials designed by teachers during the programme are not judged externally, but the design team members provide each other with feedback, including piloting the materials in other schools to see if they are usable in other settings (De Putter-Smits *et al.* 2012). These features seem to provide the 'viewed as professionals' prerequisite to successful professional development. Moreover, the teachers in the design teams are supported by

experts, to provide an interactive learning environment for teachers, to gain ownership on the contexts and pedagogy they want to use.

The third element is addressed in that the classroom materials teachers design are intended for their own and other teachers' classrooms, which is also promising to gain ownership (second element) of the context-based teaching principles. A direct product of the professional development programme are evaluated context-based curriculum materials, thus the focus on classroom practice is provided for.

Finally when considering the fourth element, the professional development programmes typically offer context experts to be available to the design team, for instance a molecular biologist for a scientific context or an expert on energy streams for a durable earth context. This can be viewed from the 'teach as you preach' requirement for context-based science education: teachers learn the scientific concepts specific to this field from the experts in their workplace, providing the teacher with the authentic context to learn in.

Summing up, to a certain extent all four design requirements are taken into account in the existing professional development programmes for context-based science education mentioned in literature.

Context-based education requires the teacher to change from a teacher-centred towards a student-centred teaching perspective (Avargil *et al.* 2012). Change in teacher behaviour is notoriously difficult to achieve (Fullan 2007). A study on the professional development of teachers who participated in such a typical context-based education professional development programme reported that teachers who gained these design experiences were better able to create context-based learning environments in their classes than those using of-the-shelve material (De Putter-Smits *et al.* 2012). The study thus confirmed the effectiveness of the professional development effort. However, the authors also report that changes in classroom practice only occurred after three years of design team work. Similarly, Parchmann et al. report that teachers designing for Chemie im Kontext in Germany required at least three years for any change towards context-based teaching was visible in the classroom (Grasel *et al.* 2006, Parchmann *et al.* 2006). This means that teachers require a long-term view when embarking on this type of professional development programme. For Dutch science teachers, a three-year professional development programme is not feasible. Teachers in the Netherlands are required to teach more hours per fulltime job compared to other countries (De Putter-Smits and Van Driel 2016), and feel pressed for time to prepare their regular classes, let alone prepare for a context-based innovation.

The same study also revealed that teachers in the programme who did not use the designed classroom materials in their own classes, did not progress in creating a context-based learning environment (De Putter-Smits *et al.* 2012). The main reason for not using the materials, was that these teachers felt obliged to join the design team as part of their teaching job, without being interested in adopting a context-based teaching approach.

The study also showed that the participating teachers who used off-the-shelve context-based science materials did not progress in creating a context-based learning environment either. The teachers were hindered in their progress due to their lack of understanding on an active level of the intentions underlying the materials, such as a student-centred approach, the emphasis change (from fundamental science towards knowledge development in science and science, technology, and society), and the connections to the contexts (world outside school). Reading about the intentions on paper was apparently not sufficient to recreate them in the classroom (De Putter-Smits *et al.* 2012).

Present-day context-based professional development programmes thus seem to take into account the four essential elements of effective teacher professional development. However, they are time-intensive, whilst teachers in the Netherlands have a notorious lack of time to prepare their lessons. In addition, the programme is only effective in achieving context-based learning environments in the classrooms for teachers who are interested in learning to teach context-based science and are involved in creating the materials.

When an effort is made for improving the existing professional development programme, foremost the time issue should be addressed: according to the teachers a one-year programme should be feasible. The interest issue should be addressed in that a revised version of the professional development programme should start from the teachers' concerns when designing and using context-based science materials. To be able to use context-based materials, the teachers must first consider themselves owners of the context-based innovation, to be self-regulating as Davis *et al.* (2016) put it. Therefore the professional development programme should focus on teachers attaining a high stage of concern on this topic.

Paying attention to teachers' concerns on context-based science education could speed-up the process of gaining ownership of the innovation and provide teachers with the security they need to teach context-based science. Teachers' concerns about teaching are 'expressions of felt need which probably possess motivation for relevant learning' (Fuller *et al.* 1974, p. 2). A model regarding teachers' concerns was first designed to describe the stages of concern pre-service teachers go through before they feel equipped to teach (Fuller (1969) as described in Both 2010). In subsequent studies, this model has been adapted to describe stages of concern for in-service teachers who are faced with an innovation (e.g. Van Den Berg and Ros 1999, Conway and Clark 2003). When individuals are confronted with an innovation, the stages of concern can be described as concerns about the self, concerns about the task, and concerns about others, and these concerns are not stable throughout an innovation (Van Den Berg and Ros 1999, Conway and Clark 2003). For instance, Van den Berg and Ros found that primary school teachers shifted to a different stage of concern after two years involvement in an innovation in their school curriculum (Van Den Berg and Ros 1999). Subcategories are sometimes added when studying teachers more closely with this concerns lens (e.g. Loucks-Horsley 1996). Addressing these concerns towards context-based science education in professional development programmes could show the effectiveness of the change in concerns on the ownership element more clearly. Teachers feeling the need to learn the context-based science innovation could voice their personal needs while learning provided that more attention is given to these concerns during the programme.

Research question

Our main research question addressed in this paper is: What is the effectiveness of a one-year professional development programme that takes teachers' stages of concern into account when preparing teachers for context-based science education? Two research questions have been distinguished:

(1) What change in stages of concern towards context-based science education do teachers show in such a programme?
(2) To what extent are these teachers able to create a context-based learning environment after following the programme?

Set-up of the programme

In this section we describe the professional development programme that was conducted and the design principles on which it was based. The goals for the programme were to make the participating teachers aware of the details of context-based science education and to encourage them to design and trial their own curriculum materials. The idea was to specifically address the teachers' concerns about context-based science education during the programme. The teachers were expected to develop from a self-as-a-teacher concern: 'Do I know what context-based science education entails?' to task-concerns: 'Am I able to create a context-based science learning environment?' and 'Am I able to teach context-based science classes?'

The one-year professional development programme was scheduled to take place one year prior to the official introduction of context-based science curricula in the Netherlands (for biology, chemistry, and physics) and was geared to upper secondary education teachers.

The four essential design criteria for effective teacher professional development were operationalised in the programme set-up. A fifth criterion, the teachers' stages of concern, was added because of the focus of the study.

Teachers construct their own learning in an active setting

The programme required the participants to learn actively: most importantly the context-based curriculum material the participants designed and created was tried out in their classes (cf. Garet *et al.* 2001). Moreover, they were expected to comment on each other's work and visit each other's classrooms during the execution of the study module designed. Meetings contained brainstorming sessions, discussions, reflection, and feedback on ideas, materials and classes taught. All participants had the intention to design their own context-based curriculum material, considering that the use of materials made by others is not effective (Coenders *et al.* 2010).

Teachers should be viewed as professionals and supported to gain ownership

The teachers subscribing to the programme did so on a voluntary basis in order to provide a solid base for ownership. The participants' expectations were clear before the start of the programme, so that the content could be adapted to their needs (Garet *et al.* 2001). During the programme meetings (university) experts (Borko *et al.* 2010) on context-based education, instructional design models, and writing curriculum materials were asked to provide their expertise. These experts were be available to the participants and offered feedback throughout the programme.

The content must focus on classroom practice

Inherent to the programme was the focus on content knowledge (Van Veen *et al.* 2010): teachers were given the opportunity to design context-based material for their own classroom under the supervision and guidance of experts. The programme aimed at awareness and development of context-based teaching competences. These were made explicit through showing the different activities by an expert on context-based education during the programme meetings. Examples on paper and on video of the differences between the standard science teaching approach and the context-based approach aided participants to experience the context-based teaching practice they designed for. During the programme attention was paid to the materials, the talks and the discussion to 'students' ways of learning' and the student perspective of the material the teachers were designing (Borko *et al.* 2010).

Teach as you preach

The programme was built on the principles of context-based education. According to De Putter-Smits *et al.* (2013), context-based learning environments can be characterised by a more student-centred learning approach, using contexts students' recognise and identify with, and taking a knowledge development in science or science, technology and society emphasis when explaining concepts. For the programme the context was the pending innovation, the student-centred learning approach was the desire of the participants to design their own context-based classroom material and the emphasis was cared for by showing examples and learning routes towards context-based teaching from other (expert) teachers.

Focus on the teachers' stages of concern

The teachers' concerns were enquired about and the mentioned needs and 'worries' were followed up on in the consecutive meeting. The concern about the 'self and the innovation' were enquired about prior to the start of the programme and the content of these concerns can be taken into account in the first meeting. Feedback was provided on ideas the teachers generate during a brainstorm phase, on the materials the teachers made, and on the classes they taught, to help address teachers' concerns about the task (cf. Norcini 2010). The concerns about others was enquired about and addressed in a meeting after the designed materials were tried out in class.

The general outline of the meetings is depicted in Figure 1. The topic of the first meeting was 'what is a context-based science approach and what do context-based curriculum materials look like'. An expert teacher provided general information, showed teaching materials and videoed classroom practices of the context based science approach. She also chaired the discussion on what context-based education is, to help the teachers gain confidence. The next expert explained a model for curriculum design, that was previously used to create context-based educational materials (Prins 2010). The final expert in the first meeting discussed the problems and pitfalls when writing curriculum materials in general. During the first meeting the participants were asked to brainstorm together on the possibilities of using a context-based approach for their own science classrooms. Their homework for the second meeting was to provide a first draft of context-based teaching materials for their own teaching practice.

The topic of the second meeting was 'discussing and improving the own context-based teaching materials'. The first author and the expert teacher discussed the homework assignment before the meeting and made a list of suggestions for improvement, taking care to keep these in line with the own ideas of a context-based approach the teacher had chosen for his or her classroom. The second meeting started off with a short recapitulation of what the context-based science approach could entail. The remainder of the session was spend providing feedback per teacher, asking the input of the other participants first, before giving the previously agreed recommendations. Homework this time consisted of transforming the own ideas for context-based science teaching into actual curriculum materials, and trying these materials out in the own teaching practice. Participants were asked to visit each other's classrooms (pairwise) at least once during the context-based science lessons. One or more of these lessons were videoed by the first author. The video was given to the teacher for self-evaluation.

The third meeting consisted of evaluative discussions on the lessons taught, using the video's as support. Both the first author and the expert, and the teachers themselves chose moments from the video to discuss their progress in teaching context-based science lessons. Each participant thus took

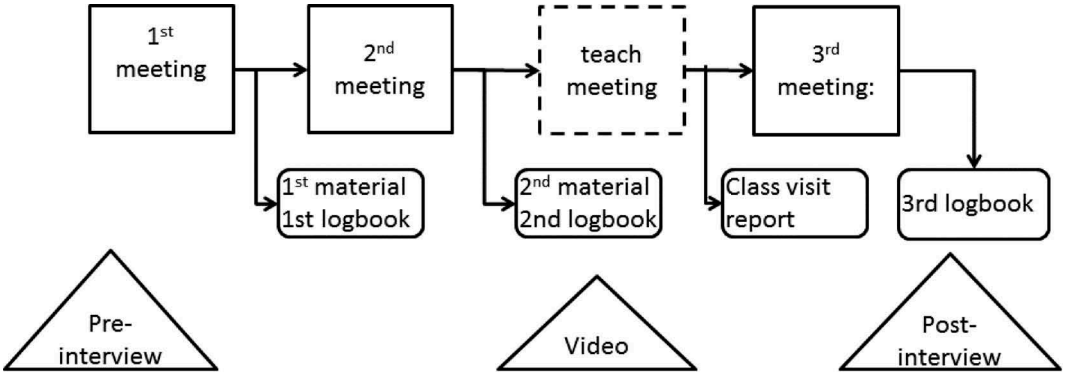

Figure 1. Overview of the programme and the instruments used.

feedback away for the next schoolyear, to improve on the context-based materials and their teaching.

The researchers prepared not only the content and the feedback as planned for each meeting, but also adjusted the content and feedback to address the concerns the teachers voiced during the previous meeting, during the interviews or in the logbooks. For instance, from the pre-programme interview it became apparent that three teachers had read as much of the official information on context-based science education as they could, and were mainly concerned how they could put it into their teaching practice. The others were mainly waiting for more information or the new textbooks to come out to acquaint themselves with context-based science teaching. Their concerns were more towards themselves as a teacher in a future of context-based science teaching. To provide attention to this difference in concerns we instructed the context-based expert to ask as much input from the group as she could on what they already knew about context-based science education, and to use her expertise to focus on how it could then be used in teaching, and what the teaching practice resulted in.

Design of the study

Participants

An advertisement for the programme was placed on the website of a teacher education institute and in the magazine for science teachers in the Netherlands (NVOX). The six teachers that applied for the programme on context-based science education were aged between 23 and 56. An overview is given in Table 1. For privacy reasons the names have been altered. Four teachers that applied together were from a school that professes a strong student-centred learning philosophy (Lisa, Mary, Gina, and John). One teacher was from a school that focusses on academic learning (pre-university education only – Jacky). One teacher was from a school where the learning philosophy was left to the individual teacher (Wilma). Gina dropped out of the programme after the first meeting, to work at a school on the other side of the country.

Instruments

Fuller's model on teacher concerns (Fuller 1969) has been applied to describe the actions, motivation, and change of teachers getting to grips with innovations. Although this model is used frequently in monitoring or analysing teacher change, a reliable questionnaire to measure changes in teacher concerns towards an innovation was never developed (Linnell 1994, Shotsberger and Crawford 1996). To be able to evaluate the teachers' change in concerns towards context-based science teaching (research question 1) and their change in creating a context-based learning environment (research question 2) we used a qualitative approach, as used by Conway and Clark (2003) for concerns and by De Putter-Smits *et al.* (2013) for context-based learning environments.

The teachers were interviewed before the start of the programme using a semi-structured interview on their pre-existing knowledge of context-based education, their knowledge on designing teaching materials, and their expectations of the professional development course. A similar, but evaluative interview on these three topics was conducted after the completion of the programme to

Table 1. Participants, years of experience and subject taught.

	Teaching experience (yrs)	Subject
Lisa	1	Physics
Mary	19	Biology
Gina	10	Chemistry
John	32	Science
Jacky	20	Biology/Science
Wilma	5	Chemistry

Table 2. Overview of data collected per teacher.

	Interview Pre/post	Logbooks	Class visit report
Lisa	y/y	1, 2, 3	y
Mary	y/y	1, 2	y
Gina	y/n	-	
John	y/y	1, 2, 3	y
Jacky	y/y	1, 2	
Wilma	y/y	1, 2	

illicit what they learned regarding context-based education and teaching context-based science, and designing context-based teaching materials for their own classrooms. The third topic of the interview was the programme itself, to evaluate the operationalisation of the five design criteria. The teachers were asked to keep a logbook (self-report) after each meeting, to record what meant most to them after thinking back on the meeting.

Analysis

As Table 2 shows, there are some missing data. Mary did not manage to try-out the material she made, due to changing teaching schedules. Her participation attitude changed from active to passive, causing her not to join activities related to teaching context-based science classes (third logbook). On strong request from her colleague, she did visit the colleague's lesson and wrote a class visit report to use as a feedback tool, helping her colleague. Gina left the programme early, so no more data were collected. Jacky did not manage to video any of her lessons. Due to the travelling distance and time constraints Wilma and Jacky did not visit each other's lessons. Hence the class-visit reports are missing. Jacky said she really had nothing to add to the post-programme interview, which is why she did not complete the 3rd logbook. Wilma indicated she simply had no more time to fill in another form, and also indicated that the final interview was sufficient for her to report on what she learned, and what she thought of the programme.

Interviews and logbooks (self-report) were used to explore the participants' change in concerns (timeline also depicted in Figure 1 above).

Regarding research question 1 (changes in teacher concerns), the interviews, logbooks, and the class visit report have been used as data points. Each data point represents the state of mind of the teacher at a certain moment in time. A change in teacher concern can be demonstrated by analysing each data point and determining the main concern or concerns expressed. When comparing these concerns following the timeline they were expressed in, possible changes in concerns towards context-based science teaching can be made visible (Conway and Clark 2003).

The pre and post-interviews, the logbooks, and the class visit report were analysed for expressions of concern towards the topics: context-based science education, including designing and teaching context-based teaching materials (Conway and Clark 2003). Similar to Conway and Clark (2003), three levels were used in the analysis:

- Concerns with self – in this study specified to self as a teacher of a context-based science class;
- Concerns with task/situation – in this study specified to designing and teaching context-based curriculum materials;
- Concerns with teaching/students – in this study specified to student learning of context-based science.

Typical examples of the concerns the teachers expressed were identified. Next, all data points were analysed by coding teacher remarks under one (or more) of the three levels of concern. The coding was compared for one teacher by two researchers who had worked on them independently, and

a codebook was set-up and agreed upon. Next, all data points were coded using the codebook. Then a timeline of (change in) concerns towards context-based science teaching was made per teacher using the coded data points. The timelines were created by two researchers independently, then discussed. Consensus was reached unanimously for each teacher. For one teacher the timeline is provided using his own words, to clarify the coding.

Regarding research question 2 (ability to create context-based teaching materials) the pre and post-interviews, the logbooks, and the class visit report were also analysed for changes in descriptions of what context-based science education entails according to the teacher. These changes were described for each of the elements of a context-based learning environment: context, regulation, emphasis, design, and collaboration.

The data was coded similarly to the procedure described for the concerns and their timeline. Two researchers made descriptions of knowledge and use of context-based learning environment separately for the same teacher. After comparing results, a codebook was set-up and agreed upon, which was then used to analyse the data for the other teachers.

Results

General evaluation of the programme and setup

In Table 2 an overview of all data that were collected per teacher is provided. In the post-programme interviews, the teachers indicated that they appreciated the input from the experts on their work. They also described that they felt safe to make and receive comments and give and receive feedback to and from the other teachers. 'I don't think I would have been able to accept comments from other teachers on my work this easily, as I do here.' In the first logbook the teachers commented on the content of the first meeting. They indicated they did not appreciate the writing tips and the instructional design model. Instead, they indicated to prefer their own style and way of designing and working on texts. The other meetings only attracted positive comments, on content, feedback, and progress.

Changes in teacher concerns (research question 1)

All qualitative data (interviews, the three logbooks, and the class visit report) were analysed per participant to identify their concerns towards context-based science teaching. Since Gina left the programme her data have not been used in the analyses.

Following Conway and Clark (2003), examples of typical expressions the participants made for each of the three concerns categories were selected. Instances of these are:

(1) Self as teacher of a context-based science class: 'Talking to a less experienced colleague, I now realise I have a lot of teaching competence just from doing it all those years' Jacky; 'I am unsure what a didactical innovation means until I have seen it performed' Mary.
(2) Designing and teaching context-based curriculum materials: 'I don't want to guard the exact learning goal by adding thousands of research questions or assignments' Wilma; 'I hope I will be able to teach new chemical content to the students, and that the prescribed curriculum materials and exams will not "kill" this addition to the curriculum' John.
(3) Student learning of context-based science: 'I really should teach my students how to solve [real life] problems, because they need to be able to in the future' Lisa; 'I wonder whether context-based education is a good method for children with autism disorder. They experience the world differently' John.

Per data point per teacher the texts were analysed and the main concerns identified, using the method described. Each data point depicts a moment in time, and thus the concerns expressed at

Table 3. Changes in teacher concern towards context-based science education during the professional development programme (1 = self-as-teacher concerns; 2 = designing and teaching concerns; 3 = student learning concerns).

	Pre-interview	Logbook 1	Logbook 2	Class visit report	Logbook 3	Post-interview
Lisa	1	1 moving towards 2	2	2	2 moving towards 3	2
Mary	1	2	2	-	2 moving towards 3	2
John	2	2 moving towards 3	2 moving towards 3	2	3 versus 1	3
Jacky	2 moving towards 3	3	2 moving towards 3	-	-	1 moving towards 3
Wilma	2 moving towards 3	2	2 moving towards 3	-	-	3

that moment. This results in a time-line of concerns, depicted in Table 3. After the one-year programme all participants show a change in concerns.

The less experienced teachers show a change from self-as-teacher towards designing-and-teaching concerns. An example here is Lisa. *In the first interview she shows a lot of self-as-teacher concerns. She struggles with the differences between the current school and her previous one. She is a dyslectic, and prefers not to write much, it makes her feel unsure. She has no idea what context-based education entails but describes that she as a teacher would like to change towards a teacher that teaches from context or history as a starting point to physics concepts. In the post interview she is dissatisfied with her own performance and feels she should have made more material to try out in different classes. She also says that she should have visited one of the teachers of the other schools, since she already knows how her direct colleagues teach.*

The more experienced teachers show a change from designing-and-teaching towards student learning concerns, as can be shown from the experiences John reports. For John we present the full timeline in his own words.

Pre-interview

In the first interview, John indicated he had read up on context-based chemistry and the new curriculum quite extensively and that he was curious how to put it into practice. He stated he saw himself as a forerunner for all science teachers at his school, in that they would look to him for guidance once the new context-based science curriculum would become practice.

The idea I have is that chemistry is not only situated in a context more, but also a renewal of the content, because the new chemistry in secondary education is lagging behind. There are so many developments in chemistry that are interesting and that make the subject more fascinating and topical, and here we are doing traditional chemistry day in day out. That is fine, cause you have to start at the basics, but in the upper secondary, you have to start working with real life chemistry, electro-polymers, and so on. [. . .]So I am hoping [. . .] that the experimental bit is added to the central exams. Maybe school exams, cause national exams would be difficult. Everyone can design great experiments and then the Ministry (for Education) comes in and says: no way and all our plans are down the drain. His concerns can be categorised as designing and teaching concerns.

Logbook 1

John finds his ideas on making the subject more fascinating by working in contexts confirmed by the first meeting. He decides to design lessons around the topic Astronomy. He expresses his design for an instruction that should activate students. He does not take a student perspective on this.

I am interested in astronomy myself, I have talked and exchanged knowledge about this topic with others. Last year, I tried doing something with the topic in class. I want to improve on that towards more self-regulated learning for students. I found a way to do this: one week introduction and then one week the students work on deepening their knowledge on the subject and then present their findings in a report and a presentation. All of them together will create a broad context, so together they will present a realistic picture [of the subject].

His concerns can be categorised as designing and teaching concerns towards student learning concerns.

Logbook 2

After the second meeting John describes the notion on how students could be approached and led from one task to another, how differentiating could help to have students control their own learning.

I saw how you can present the context carefully to the students through questions and assignments. Built-in steps to differentiate in knowledge level and to build up slowly towards the topic. Activities have to be well suited to the context. The core of the feedback on my design was to adjust the questions from the question-index-box towards the actual product you expect from students and to separate information from the assignment. So I have to screen all the question cards on the amount of information, main information, additional information. I have to add a lot of questions and check whether students know what to actually achieve by doing the assignments.

His concerns can be categorised as designing and teaching concerns towards student learning concerns.

Class visit report

Lisa visited one of John's classes. She reports him walking around the class room answering student questions and trying to organise the learning process. Practically there are a number of hiccups he reflects on after the lesson: 'I was late due to a traffic jam and the tech assistant had started the class. I started by immediately jumping in to address the different groups. I could have done this more systematically by first going round past all the groups. I was however under the impression they were all making progress. Some groups started up much slower than I expected. For the astrovibe section [practical work], Lisa made me aware I could have designed the groups more around a common problem. And I should help my tech assistant with this form of activity. I am aiming to organise the class and the expected assistance in a clear way, but this is detrimental to the inquiry based set-up. I am going to improve on that.'

His concerns can be categorised as designing and teaching concerns.

Logbook 3

After the third meeting his focus is on how the students did, and how different years of students performed differently. He sees the necessity of taking a student perspective when designing classes and how this affects student motivation and student learning. He concedes that after 30 years of teaching he has a blind spot when it comes to letting students control their own learning.

I noticed that with the pre-higher vocational educational track and the pre-university track students there are a number of opportunities to deepen their knowledge. With Lisa, who has a pre-professional educational track that is not generally the case. Students can be considered to have done well if they can perform an assignment on their own. Too openly formulated questions seem inappropriate for them.

After 30 years teaching in a Steiner-Waldorf school using many themes, context-based education is not so far out. […] The skills you need are twofold: first, skills to properly prepare context-based education such that it is lively, content-rich, doable and inquiry based. Second, that you have to guide the learning process by listening, giving suggestions, taking the risk that it does not go to plan, assess [the learning process] appropriately, designed especially so that it involves students.

I asked [course presenter] to help reformulate my question cards towards more challenging questions. I have some blind-spots that prevent me from seeing these options.

I am most proud of my assessment method that involved students in the assessment. They worked even more seriously after I introduced it and were more critical towards their presentations beforehand.

His concerns can be categorised as student learning concerns and concerns about himself as a teacher.

Post-interview

In the final interview we asked the participants what concerns they still had on context-based education. John expresses concern for the amount of content the new curriculum will have, because he would like to spend time on proper context-based projects with practical work assignment. He also expresses concerns on the appropriateness of context-based education for EVERY student.

What I would like [. . .] is to have some insight into what is possible, what are the boundaries? [. . .] I feel some tension, because it is a time investment, this is more general science, right? But it could be chemistry and then you'd have to justify [the time] for the exams. [. . .] You need a certain freedom to play with the content, and then you don't want to suddenly find yourself rushing through content to reach the end in time for final examinations. That is a tension field for me, how they [context-based education] prepare students for the national exams.

How do you tailor context-based education for which grade and which level? What kind of contexts are suitable? How about student with developmental disorders? You have to take their needs into account. People with autism disorder for instance, is context-based education possible? They might be uncomfortable with that, it makes them insecure, it is too open to change. And we need very practices based context-based education for the students with most basic school level. I could not do astronomy with them. You'd have to do that very differently

His concerns can be categorised as student learning concerns.

Changes in creating a context-based learning environment (Research question 2)

All qualitative data (interviews, the three logbooks, and the class visit report) were analysed per participant to identify any change towards context-based learning environments as described in the design of the study. The change towards each of the five components of context-based education that teachers showed is depicted in Table 4.

All teachers were able to come to a definition of contexts and how to use them, that is meaningful to them. They all described that the contexts have come to life: '*A context is a story around the concepts, to give more coherence between and meaning to the concepts. You can keep the context close to the students, a societal context like cooking. It is not necessary to just stick to scientific concepts [as stated in the formal curriculum].*' Jacky, post-programme interview. John still struggles with the context being meaningful to students. He does recognise that contexts can come from a much broader range of subjects.

All participants have become aware that the students are more in charge of their own learning in a context-based learning environment (regulation). John was well aware of it, but unable to change his classroom behaviour, even though he wanted to. He describes in his logbook that this is his blind

Table 4. Changes in teachers' views on context-based learning environments.

	Context	Regulation	Emphasis	Design	Collaboration
Lisa	Broadened perspective	Unsure in classroom use	Change towards where scientific knowledge comes from	From the context	Desirable, colleagues, time constraints
Mary	Broadened perspective	Cognitive	Cognitive	From the context	Desirable, time constraints
John	Broadened perspective	Cognitive	Change towards where scientific knowledge comes from	from the school's context and with respect to students' needs	time constraints, colleagues and context experts
Jacky	Broadened perspective	Unsure in class use, motivated by result	Change towards fundamental science	From the context, with a close eye on concepts	Desirable, colleagues, time constraints
Wilma	Broadened perspective	Incorporated in class	Change towards where scientific knowledge comes from	From contexts that will motivate students	Desirable, colleagues and context experts

spot, where he will need help from colleagues to change his classroom behaviour. Lisa was surprised by the effect it had on her students, but being a relatively inexperienced teacher, she felt insecure about it. Jacky was surprised by the motivational change in her students, although she admitted she felt unconfident whether this kind of education was possible in her school. Wilma was already working on giving her students their own responsibility, and took the opportunity to reinforce her confidence about this way of teaching. Mary reported to realise what this desired of her, but since she had not taught context-based science she has no experience in the classroom.

Three teachers were happy to teach from the origins of scientific knowledge, either through the eyes of industry, science or societal issues (emphasis). Jacky was tense to try context-based science classes, so she made sure the scientific concepts were very clear within the context by teaching them in an abstract manner first. Only then was she satisfied '*to set the students loose on their project*.'

All teachers agreed that design of context-based learning environments should start from the context. Wilma emphasises her students' motivation when choosing a context to design for '*What I like is usually not what interests them'*. John requires the schools' root ideas (Steiner-Waldorf) to be included in the context, and the specific students' needs to design his classes. Jacky designs with a close eye on the concepts to be learned.

All teachers experienced the feedback sessions on the materials they made and the classroom visits as very useful when designing own context-based materials (collaboration). They did not find the possibility to keep this going, since the time they can spend on lesson preparation is limited. Two teachers would prefer to involve context-experts in their context-based classes, to create a real-life experience for students.

Conclusions and discussion

A one-year professional development programme preparing in-service teachers for context-based science education, taking teachers' stages of concern into account was designed based on a literature analysis and results of previous studies, and was validated in practice with five teachers for upper secondary science education. The professional development programme was designed to overcome the issues identified in earlier research: the time frame to design context-based science classes, to come to grips with context-based science education, to try out the material in class and to understand the shift from teacher-centred to more student-centred learning.

The first research question was 'What change in stages of concern towards context-based science education do teachers show in such a programme?' Based on the results it can be concluded that all participating teachers show a positive change in their stages of concern towards context-based education. In contrast to the research by Conway and Clark (2003), this research did not involve novice teachers, but fully qualified teachers with a number of years of experience. When identifying the concerns of the participants this difference is notable: of the five teachers three expressed their concerns for designing and teaching using a context-based approach, rather than a concern for themselves as a teacher. The less-experienced teachers in the study do express a self-as-teacher concern when it comes to a context-based approach. The change in concerns is similar, both groups of teachers feel more confident and express concerns of a different nature, student learning and designing-and-teaching respectively.

The second research question was 'To what extent are these teachers able to create a context-based learning environment after following the programme?' Considering the changes in how teachers view themselves when teaching context-based science, it can be concluded that the teachers are better aware of what context-based teaching entails.

In teacher professional development programmes that aim at context-based science teaching the initiative and subjects for the context-based lessons comes from the programme's organisers, are based on existing lessons from others, or are suggested by educational researchers (Grasel *et al.* 2006, Coenders *et al.* 2010). The professional development programme reported on here strongly emphasised on using the teachers own ideas to create context-based lessons, creating a sense of

ownership of what context-based science teaching is, judging from the shift in concerns visible in the participants. Trying-out the self-made material in class and receiving feedback on the material was deemed important for the teachers, as is evident from the course's evaluations. Professional development programmes that are set-up as a one-time workshop are notoriously ineffective (e.g. Korthagen 2016). The set-up presented here with its learner-centred, short-feedback loops, and just-in-time information on context-based education design is much more promising. The results achieved within the school year probably need to be consolidated in following years, when comparing this set-up with successful long-term teacher professional development programmes (Mitchell and Mitchell 2005). By creating communities of practice in the teachers' own schools this could be achieved (Nieveen *et al.* 2006).

The professional development programme was based on a set of design guidelines. To arrive at practical suggestions for future professional development initiatives on context-based science education, each design guideline is discussed briefly below.

Teachers construct their own learning in an active setting

The participants indicated that the active participation (open discussions, brainstorming on ideas for the classroom, feedback sessions) gave meaning to the context-based education they were learning to use. The participants of the programme would like to visit other schools to observe the innovative teaching. They prefer to work together on the design of materials to ensure their efforts would last in the school. In future programmes this should be a point of careful consideration. The teacher showing the least growth is the one that could not try her materials in class, confirming that using the materials made in class is important for learning.

Teachers should be viewed as professionals and supported to gain ownership

All participants mentioned their willingness and personal interest and motivation in joining the programme, one even travelling three hours by public transport to be able to join. The participants all indicated that the subject of the programme was close to their interest and something they wanted to be involved in more.

The participants would prefer to choose the experts (on writing or contexts) themselves, because the involvement of the expert was important to them. They were appreciative of the expert's feedback, but felt the extent of the expertise to be too narrow. The participants indicated they had a need for an expert per subject or context chosen. They suggested a blog, or Q&A page on the researchers' website to facilitate this.

The instructional design model provided did not appeal to any of the participants when they were designing their curriculum materials. It seems prudent to use a more general instructional design model and coach participants in future programmes to find their own way when designing curriculum materials.

In all the interviews the participants mentioned the atmosphere created during the (peer-) feedback sessions felt very safe, and were deemed a positive influence on the process the participants were in. Most professional development initiatives are based on content, around practical restrictions (Borko *et al.* 2010). Our research suggests that creating a safe (professional) environment with (peer-) feedback on every step in the process fosters a change in participants' concerns, even after one year. In a future programme this will be incorporated as a separate design criterium. Peer-feedback is considered important in other professional development programmes, such as in lesson-study (cf. Brosnan 2014, Thurlings and den Brok 2017), although they are not specifically focused on the concerns teachers have.

The content must focus on classroom practice

The participants were appreciative of the discussions on how to guide and influence student learning. Topics on student learning included: coaching, motivating, formulating assignments, and caring for slow-starters. They were named specifically when answering the programmes' evaluation questions.

The participants would have preferred more feedback sessions and classroom visits, which were now restricted by time and practical issues. The teachers indicated that these activities boosted their ideas and enthusiasm for context-based teaching most. For future professional development initiatives this time consuming but highly appreciated guideline needs careful consideration.

Teach as you preach

The participants did not name this design principle in their evaluation. They indicated they felt safe, that the programme was useful to them and helped them succeed in their goal to design context-based material for their own classes. From their comments on what they needed: their own choice of experts, more feedback and more classroom visits, we can derive that they do show the desired attitude of more student-centred learning and learning from the practice of others as a context for their own learning. Such opportunities should be taken into consideration when starting up a new professional development programme.

Stages of concern

The concerns were addressed by inquiring after them and trying to incorporate needs into the next meeting. Prove for this we feel is the safe environment and the feedback on their ideas and materials all participants mention. The researchers noted that the design and try-out of materials had a positive influence on the participants' attitude during meetings. The participants became more confident in using the context-based approach, using the definition provided to them to give feedback to others and to change their own materials to match the definition. A prerequisite for (the start of) lasting change in teaching is a feeling of ownership or self-efficacy (Tschannen-Moran *et al.* 1998). Such feelings of ownership are fostered by paying close attention to teachers' concerns.

Concluding, we are optimistic that the one-year professional development programme for context-based science education that takes teachers' concerns into account is effective in reaching its goal. To consolidate the teachers' professional growth continued professional development in their own school is preferable. In a group of peers further development of context-based science education can be fostered (Wenger 2000, Nieveen *et al.* 2006, Stolk *et al.* 2009)

Limitations

For this research we have chosen a general qualitative research method, with interviews and teachers' self-reports as data. Perhaps an exploratory case-study design for the research into a pilot professional development programme was better suited considering the scale of the intervention. The research set-up was decided upon before it was clear how many participants would actually join the programme. The number of participants became evident only at the very start of the intervention, making it undesirable to change. In a future study, a case-study set-up is advisable, which could illicit more details on the changes in teacher concerns and the progress in learning to teach context-based science.

Qualitative research benefits from triangulation of data. In our research each data point is only represented by a single source. When the number of participants is large, the data points can be analysed with quantitative methods. With a small number of participants such as in our study it is advisable to have multiple sources for each data point. In future research additional data could be

gathered in the form of classroom observations, stimulated video recall interviews, and peer feedback on personal growth.

Of the five teachers that completed the programme only four designed and enacted context-based lessons. All participants differed in years of teacher experience, age, school type taught, and change in concerns. Yet all teachers reported a positive change in concerns towards context-based education. We believe that the personal feedback and the positive atmosphere created during the (peer-) feedback sessions aided in this change.

The aim of this study was to see whether a change in teacher concerns would occur, when using the approach detailed above. Future research using the advocated case-study approach could illicit what exactly causes the changes in concerns. A future professional development programme would be very effective when based on this knowledge what teachers need to adopt context-based science teaching.

Disclosure statement

No potential conflict of interest was reported by the authors.

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