

The Use of Context in Science Education

Writing assignment

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Laymen's summary

Science subjects are an important and exciting part of secondary education, but often they are experienced as difficult, irrelevant or even boring. In order to make science more attractive, improve learning results and increase the motivation, interest and attitude of students towards the study of science, contexts are introduced in science education. But what is a context and how do you have to deal with it? There are various interpretations of contexts and consequently also a lot of opinions on the way how these contexts should be used in the teaching and learning of science. In this review article an overview is given of definitions ascribed to the word context and to the approaches which use contexts as a starting point in the education of science. The meaning of these definitions are illustrated with the different attributes of context which are distinguished by researchers to design new science courses. These various aspects and types of context make clear which possibilities there are to make science more attractive and meaningful to students, to show them some reasons why the science subjects should be learned and to provide options which can make this learning process more effective. Researchers also described some models to develop innovative science projects by making use of the different attributes of context which have been recognized. It was demonstrated that the order of presentation and the function of contexts influence the realization of context-based approaches. The use of all these divergent visions of context has led to the initiation of a broad range of projects, which are all covered by the term context-based education. These projects have been performed in several countries since the 1970s and vary in scope from particular lessons to entire curricula. Despite the fact that these programs can consequently be rather different, they all share a couple of common aspects: a recognizable context is taken as the starting point to introduce an issue and trigger the curiosity of students, this context makes the learner aware of the demanded concepts which are needed to understand the issue and active involvement of students in this process is generally required. The amount of research on the impact of context-based education on the learning of science is increased over the last years. Although the outcomes of these studies are sometimes contrasting, some general conclusions can be drawn. Compared to traditional programs, students' understanding of scientific concepts obtained from context-based programs is at least as good, while the interest, motivation and attitude towards science is usually improved. There is still little empirical evidence on the effects of the use of context on the development of attributes like critical thinking, argumentation and decision-making abilities. The role and behaviour of teachers are both influenced by the implementation of contexts in science education. It is important to study this effect, because teachers can have a major impact on the improvement of learning results and the development of a positive attitude towards science.

Contents

<i>Introduction</i>	4
<i>Definition of context in science education</i>	5
<i>Attributes of context</i>	6
<i>Models of context</i>	8
<i>Examples of context-based projects</i>	9
<i>Impact of context-based science education</i>	11
<i>Discussion</i>	13
<i>References</i>	15

Introduction

In the past decades contexts were introduced in secondary science education. These contexts were used as a starting point for the design of innovative curricula, with the intention to tackle a couple of problems perceived in conventional science education (Gilbert, 2006): Science curricula are overloaded with content, they contain a large amount of isolated facts and concepts which lack the transfer among science classes and the world the students live in and they lack the relevance to trigger the interest of students. Furthermore, the reasons why science subjects should be learned are often not clear by school students (Roberts, 1982). The introduction of context in science education attempts to bridge the gap between abstract concepts and everyday life, in order to show students the relevance of science for their own lives and interests and to improve their motivation for learning about scientific content. Besides the focus of this approach on enhancing the interest and attitude towards science education, the use of context also has the purpose to have an effect on the improvement of learning outcomes and an increased understanding of science by students.

In traditional curricula the starting point of science education consists of basic concepts, facts and theories, which are taught in a logical order and structure. In this approach the interests and thoughts of students and the knowledge they already possess are not really taken into account, which could lead to forced concept development and misconceptions (Lijnse, 1995). An ideal learning process should therefore also be guided by the motives, skills and pre-knowledge of students. In addition, science subjects are often perceived as difficult and irrelevant and the attitude of secondary school students towards science generally declines during the progression through their schooltime (Barmby, 2008). This observation can be related to the inability of students to make a connection between science taught at school and everyday life.

Several projects have been performed in many countries using contexts as the starting point of science education. These projects range from short individual enrichment tasks to longer series of lessons, whole courses and complete curricula. In the Netherlands, for example, new secondary science curricula were designed recently to cover modern science concepts, create coherence between science subjects, attract more students to choose for science in further studies and relieve the overload of content (De Putter-Smits *et al.* 2012). The committees which were assigned to develop these curricula decided to use a context-based approach for all of the science subjects. The conception of context-based education as well as the approach of the implementation of these projects differed between the committees of the individual subjects, however.

The aim of this article is to give an overview of the use of context in secondary science education. The science subjects discussed here include biology, chemistry, physics and some general science courses. The use of context will be reviewed by giving some insight into the interpretations of the definition of context and context-based education and by describing the attributes, aspects and types of context which are designated by different researchers as well as the models of context which are used for the development and implementation of context-based curricula. These different applications of context will subsequently be linked to several examples of

context-based projects that have been performed around the world. Finally, the impact of these context-based programs on the learning of science by students in secondary education will be reviewed.

Definition of context in science education

Various definitions and attributes of context are used by researchers to describe this term in connection with science education. To get a clear picture of the function and impact of context, it is important to elucidate the meaning of the word. In this section an overview of the interpretations of the term context and context-based science education will be given. There is no intention to give a perfect definition of context, since Duranti and Goodwin concluded:

“It does not seem possible at the present time to give a single, precise, technical definition of context, and eventually we might have to accept that such a definition may not be possible.” (Duranti *et al.* 1992; p. 2)

The word context takes on various meanings in everyday language and is mainly used as in verbal context or social context. Dictionaries commonly describe context with phrases like the setting for an event, circumstances, the local environment, a group of conditions or a surrounding situation. The word is derived from the Latin verb ‘contexere’ which means ‘to weave together’. This implicates that there also has to be an interaction between the context and that which it surrounds. In science education this interaction takes place between the context and the learning of a student, which shape each other (Finkelstein, 2005). Gilbert describes the function of context in education as the circumstances that give a coherent meaning to a new situation set within a broader point of view (Gilbert, 2006).

In accordance to the various interpretations of the term context, there are also different approaches of introducing context to science education with associated definitions. These differences are induced by the use of particular aspects and types of context. The introduction of contexts in science education can be classified in two global approaches: the science-technology-society (STS) approach and the context-based approach. The term STS is mainly used in North America, while the context based approach is preferred in European countries (Bennett *et al.* 2007). A definition of the science-technology-society approach is provided by Aikenhead:

“STS approaches [are] those that emphasise links between science, technology and society by means of emphasising one or more of the following: a technological artefact, process or expertise; the interactions between technology and society; a societal issue related to science or technology; social science content that sheds light on a societal issue related to science and technology; a philosophical, historical, or social issue within the scientific or technological community.” (Aikenhead, 1994; p. 52–53)

A definition of the context-based approach, which shares some common characteristics compared to the STS approach, is obtained from Bennett:

Context-based approaches are approaches adopted in science teaching where contexts and applications of science are used as the starting point for the development of scientific ideas. This contrasts with more traditional approaches that cover scientific ideas first, before looking at applications. (Bennett et al. 2007; p. 348).

Both the context-based approach and the STS approach are broadly used terms comprising a variety of motives to include contexts in science education. In the remaining of this article the term context-based will be used for all these approaches. Although it seems impossible to define the exquisite meaning of context-based science education, all approaches generally aim to improve the interest, attitude and motivation of students by making the learning of scientific concepts more relevant through the use of meaningful contexts (King *et al.* 2012). This relevance is obtained by the transfer of scientific concepts to the real world, which is most effective using a need-to-know principle. This principle starts with the teaching of a recognizable context, which will make the learner aware of the knowledge about concepts which is demanded to understand the particular issue (Bulte *et al.* 2006).

Attributes of context

As mentioned in the previous section, there are different interpretations of context-based science education due to the use of varying definitions for context. Because of their complexity, these definitions are quite general. It would be helpful to describe the use of context in its different appearances more accurately. In this section the various attributes, aspects and types of context that are designated in the various interpretations of context-based science education will be reviewed.

Four domains were defined by de Jong as the origin of contexts: the personal domain, the social and societal domain, the professional practice domain and the scientific and technological domain (De Jong, 2008). These domains are distinguished to clarify in which presence contexts give meaning. In the personal domain contexts make a connection between science and the personal life of the learner. Personal health care is given as a useful example of an everyday life issue. In the social and societal domain contexts refer to the role of the student in a community and in social issues. As examples for this domain the context of climate changes and the effect of acid rain are provided. In the professional practice domain contexts are related to the prospective career of the student. The practices of chemical engineers can be used as a context for several processes and topics. In the scientific and technological domain the context is shaped by scientific innovations and discoveries. The paradigm shift in an historical model or theory could be used for example as a context in this domain.

Finkelstein identified three frames of context that form the conditions for effective learning: task, situation and idioculture (Finkelstein, 2005). Context as the form of a particular problem that has to be solved is called the task. The activity in which the task takes place is called the situation. This could be for example a group of three students working together to solve the problem. The circumstances of the situation are formed by a larger context, for instance the chemistry class, which is called

idioculture. During the solving of this particular problem all three frames of context interact and influence each other.

Four attributes of an educational context are distinguished by Gilbert: the setting of focal events, behavioural environment, specific language and extra-situational background knowledge (Gilbert *et al.* 2011). These attributes can be used as criteria for the design of courses, which will be further discussed in the section ‘models of context’. In these attributes a context is considered to be a focal event, embedded in a cultural setting. Such a focal event was earlier defined as an event which is put in the spotlight and gets attention (Duranti *et al.* 1992). The setting of a focal event is provided by context-based materials and functions as a framework within which concepts can be mutually related. The setting also has to be related to the everyday life of the student. The behavioural environment is set by learning activities and enables discussion among the learners. This environment has to involve activities that are exemplifications of scientific important concepts, relations, skills and attitudes. The specific language is an attribute of context that enables the development of the correct use of scientific language. Learners also have to understand that this specialist language is created by human activity. The behavioural environment provides coherence of the specific language, associated with a relevant setting of a focal event. The extra-situational background knowledge of learners should be related to focal events. By using these preconceptions, a context is placed in a broader perspective. This attribute is an opportunity to overcome the lack of transfer of knowledge in traditional curricula between science classes and the world the students live in, as mentioned in the introduction. When each of the four attributes of context are elaborated, structural and coherent meaning for students will be provided and the reasons why science subjects should be learned will become clearer (Gilbert, 2006).

Some studies prefer to focus on the interpretation of context as authentic practices, because it provides a more strict meaning of the term context (Kortland, 2007). The use of this aspect of context in education is illustrated by Baker *et al.*:

“The term context has different and somewhat conflicting meanings. Some proponents use context to denote domain specificity. Performance in this context would presumably show deep expertise. On the other hand, context has been used to signal tasks with authenticity for the learner. The adjective authentic is used to denote assessment tasks that contain true-to-life problems or that embed assessed skills in applied contexts.” (Baker *et al.* 1993; p. 1211).

The use of context as authentic practices implies to embed only real situations in teaching as experienced by a homogenous group of professionals in science. In these authentic practices specific practical problems are solved by a characteristic procedure. The most characteristic attribute of this approach of learning, compared to the more general way of context-based learning, lies within this procedure that allows scientific attitudes, knowledge and skills to play a natural role in solving a practical problem (Kortland, 2007).

Models of context

Several models of context are used for the design of curricula and for the implementation of context in these courses, to give meaning to science education. The attributes of context described in the previous section function as criteria for most of these models.

Gilbert identified four models for the development of context-based curricula, where context is used as the direct application of concepts, as reciprocity between concepts and applications, as provided by personal mental activity or as the social circumstances (Gilbert, 2006). When a context is used as the direct application of a concept, it is only presented as an example after an abstract concept has been learned. The contexts in this first model seem to appear only for decorative reasons (Gilbert *et al.* 2011). In the second model context is used as a vehicle to relate a concept to its applications. Applications are not only used as examples, but they do also have influence on the meaning of a concept. During the teaching of these concepts the relation with the context is assumed to be cyclical, which makes this model somewhat more complex compared to the first model. In the third model contexts are provided when scientific concepts are linked to narratives by personal mental activity. This approach requires a certain background knowledge of the learner and works best if the student is learning individual, for instance from a textbook or from an online course. A limitation of this model is that all discussions take place intra-personal and the relevance of the context may not be recognized. In the fourth model which Gilbert describes the social dimension of contexts is also recognized. Learning takes place within the interactions between student and teacher, who work together to solve a real-life problem from the community they live in. In this model the four criteria for the design of context-based courses, as mentioned in the section 'definition of context in science education' are most fully met. A few important concepts and contexts have to be chosen, to avoid content overload of curricula, which shape each other and can be transferred to other situations. The authors state that courses designed using the fourth model most effectively embed contexts in science education, which enables it to tackle the problems mentioned in the introduction of this review (Gilbert *et al.* 2011).

De Jong identified three models for the implementation of context-based materials, where the function of context and the order of presentation of the contexts varies. (De Jong, 2008). These models were described as traditional context-based, more modern context-based and recent context-based teaching approaches. The models are based on the order of presentation of concepts and associated contexts, which influences the function of the context. In the traditional approach teaching starts with a concept, followed by the context. In this model contexts can have two functions. The context is often used to illustrate an abstract concept or it can be used by the student to apply their knowledge of a certain concept. This model shows with the use of context for decorative reasons similarities compared to the first model identified by Gilbert. In the more modern approach teaching starts with a context, followed by related scientific concepts. In this second model the context has an orienting purpose and can also increase the motivation of students to learn new concepts. The recent context-based teaching approach combines all functions of context mentioned before. This approach also starts with a context, but after the related concepts are introduced new

contexts are used to illustrate these concepts and show their applications. This cyclical relationship between concepts and contexts is also found in the second model of Gilbert where he uses context as reciprocity between concepts and applications.

Examples of context-based projects

There are different approaches of introducing context to science education, as mentioned earlier. In this section examples of context-based projects will be given. These projects have been performed in many different countries and range from short tasks to complete curricula. In this overview the context-based projects will be related to the various attributes and models of context which are described in the previous sections.

The first context-based project was started in the Netherlands in the 1970s with the large-scale secondary physics education program called 'Project Leerpakket Ontwikkeling Natuurkunde' (PLON) (Stolk *et al.* 2009). The purpose of this program was to make physics more attractive and connect it to daily life situations, which would make the content more relevant to students (Lijnse, 1995). The PLON project is a five-year course for students between the age of 12 and 17 (Bennett *et al.* 2007). Each PLON unit started with an orientation on a subject taken from the society of the learner. These contexts accordingly had their origin in the personal domain and the social and societal domain to give meaning, as described by De Jong. The orientation commonly introduced a basic question, which had to be answered by students while working independently in small groups. This question was posed in such a way that relevant concepts had to be introduced according to the need-to-know principle. After the elaboration of the central question, results had to be reported to other groups in class. This process fits well in the three frames of context identified by Finkelstein: the basic question functions as the task, taking place in the situation of small groups working on their answers, while they abide by the rules of the physics program, which can be seen as idioculture.

The British Salters' Advanced Chemistry project was the next context-based course to be developed. It was a two-year program initially designed in 1983 for students aged 17-18 (Bennett *et al.* 2007). This initiative ultimately resulted in set of physics, chemistry and science projects together known as the Salters' approach. The courses start with storylines functioning as familiar contexts. These storylines introduce scientific ideas and concepts, which should increase the appreciation of the relation between science and the natural environment of the students. The development of the used stories should also address the need-to-know principle. The relationship between concepts and contexts is cyclical in this approach, which is in line with the use of context as reciprocity between concepts and applications as described by Gilbert in his second model for the development of context-based curricula. A diversity of learning activities is implemented in the Salters' approach, including an important role for the use of scientific language which is one of the four attributes of an educational context as identified by Gilbert. Other learning activities are for example the application of discussions, decision-making exercises, presentations and problem-solving activities (Bennett *et al.* 2002).

Other context-based projects developed in the 1980s are the American Chemistry in the Community (ChemCom) and Chemistry in Context (CiC) programs. The ChemCom program was initiated after criticism that the American science subjects were presented as a large amount of isolated facts which didn't transfer the knowledge about concepts to the world the students live in. ChemCom is a one-year course for students between the age of 12 and 17 and is designed according to the STS principles (Bennett *et al.* 2007). The approach of the ChemCom program is similar to the PLON project, because it also uses the personal domain and the social and societal domain as the origin of contexts. Another similarity between the ChemCom and PLON project is that learning takes place in small groups of students, who share their thoughts with each other. The units in the ChemCom program start with a social or technological community issue that has to be studied on a need-to-know basis. The ChemCom project also aspires that students develop the feeling of ownership in their learning process. This aspiration should tackle one of the problems in science education, which is mentioned in the introduction, concerning the failure by school students to understand why certain science subjects should be learned. The CiC program is comparable to the ChemCom program. This project is a shorter one-semester undergraduate course, addressing social and environmental concerns. The attention in this course is focused on decision-making (Bennett *et al.* 2002).

Also in Israel contexts were introduced in secondary science education, resulting in the Industrial Chemistry project and the Science for all program. Since the early 1980s context-based learning materials, including case studies, were developed in the Industrial Chemistry project focussing on the chemical industry in Israel (Hofstein *et al.* 2006). Each student learns in the secondary chemistry curriculum at the age of 17-18 at least one of the case studies. The professional practice domain, as defined by De Jong, is clearly used as the origin of contexts in this project, since the contexts are related to the students' prospective career in science. The course was also designed to teach how students have to deal with ethical and societal issues. By showing these environmental issues also the social and societal domain was used as context to give meaning.

The Science for all program was designed for students of the age of 15-16 who have decided not to specialize in the science subjects physics, chemistry or biology (Bennett *et al.* 2007). This interdisciplinary program integrates scientific concepts from the various disciplines by the use of context-based modules and improves the transfer among science classes, which is mentioned in the introduction as one of the problems in science education. By emphasizing a personal implication or societal effect of science, each of these modules uses both the personal domain and the social and societal domain as the origin of contexts.

More recently, context-based courses were developed in Germany for the different science disciplines. Chemie im Kontext (ChiK) was the first project which was introduced. This course was set up in 1999 at the universities of Oldenburg, Dortmund, Kiel and Saarbrücken (Eilks *et al.* 2004). The other science subjects followed later with the courses Biologie im Kontext (BiK) and Physik im Kontext (PiKo). These im Kontext courses were influenced by the ideas and experiences of the Salters' approach and the ChemCom curriculum. Implementation of all these projects occurred in learning communities, where the experiences, expertises and perspectives of both teachers and researchers are shared (Eilks *et al.* 2004). The im Kontext courses were initiated because there was criticism on the German secondary science

education system and they had the purpose of improving the interest and attitude of students towards learning science. The most important aim of these courses is however to induce the transfer of knowledge. Students are stimulated to apply scientific knowledge outside the classroom in different situations instead of reproducing facts. The extra-situational background knowledge distinguished by Gilbert is in this approach an essential attribute of the educational context. The Im Kontext materials are implemented according to the more modern context-based approach identified by De Jong. Teaching starts with a context, but there is not necessarily a cyclical relationship between concepts and contexts.

In Africa several small-scale context-based projects were implemented in secondary science education. These programs include MASTEP in Namibia, the Matsapha Lessons project and the Linking School Science to Industry and Technology (LISSIT) project in Swaziland and the Namutamba Basic Education Into Rural Development (BEIRD) project in Uganda (Kazeni, 2012). The programs are short-term and focus in general on a specific application or context. In all those projects technological contexts related to everyday life are used as a starting point to teach scientific concepts. The contexts in these science lessons were however regularly used in an unsystematic way and context-based approaches are regarded as unstructured (Kazeni, 2012). Although various attributes of context are slightly touched during the teaching of science in the referred programs, its unstructured nature and the apparent absence of involvement of students in the use of contexts provoke that these context-based programs not always achieve their purposes.

As already mentioned in the introduction, new secondary education curricula for the science subjects chemistry, physics and biology were developed in the Netherlands recently. Starting point of this reformation was to relieve the overload of content, create coherence between science subjects and attract more students to choose for science in further studies (De Putter-Smits *et al.* 2012). The reformed science courses are taught since 2013 and were designed for students between the age of 15 and 18. The concept-context approach was recommended as the main approach in the development of all curricula. In this approach concepts are used as a framework for the gathering of knowledge, while contexts are used to bridge these concepts to reality (Driessen *et al.* 2003). This approach may correspond to the traditional context-based model, as identified by De Jong. Because the definitions and attributes of context-based education were explained in different ways by the committees of the individual science subject which were assigned to develop the various curricula (De Putter-Smits *et al.* 2012), not all courses were implemented according to this model. To relieve the overload of content in science curricula a limited number of concepts and the assessment of context related experimental skills were introduced in a renewed examination program. Authentic practices were used as contexts for learning to create coherence between the different science subjects (Driessen *et al.* 2003).

Impact of context-based science education

The impact of context-based programs on the learning of science by students in secondary education has been analysed in numerous research studies around the world. The interest in the effects of the use of contexts in science education is

increasing, because there are still a couple of reasons which prohibit the implementation of context-based approaches on a large scale. These reasons include a lack of understanding by teachers on how these approaches are composed and also the way how students learn in a context-based learning environment is not fully understood (King *et al.* 2013). In this section the impact of context-based science education on learning outcomes, attitudes, interest and motivation of students will be reviewed, as well as the effects on more general attributes like critical thinking, inquiry skills and decision-making abilities. The impact of the use of contexts on teaching and the behaviour of teachers will also be discussed.

Most studies focus on the influence of context-based education on the conceptual understanding in the performance of students. A detailed systematic review of several experimental studies indicated that the learning outcomes and hence the understanding of scientific ideas obtained from context-based approaches are at least as good compared to traditional approaches (Bennett *et al.* 2007). Most comparative studies do not show significant differences in the acquisition of content knowledge between traditional and context-based education. There are however examples revealing an improved understanding of scientific concepts in the latter approach, for instance in a large-scale study between British secondary chemistry courses which showed that students had developed a better understanding of chemical ideas when the context-based Salters' project was followed (Barker *et al.* 2000). Nonetheless, these researchers also reported some conceptual misunderstandings among students of both courses which were difficult to change. Another example is given by a study on the impact of the use of storylines in a context-based chemistry course for students aged 15-16 in Turkey, which indicated a better understanding of scientific concepts (Demircioğlu *et al.* 2009).

There has been some criticism on the evidence of effects of context-based approaches on learning outcomes, because of the validity of testing methods (Bennett *et al.* 2007). When conventional examinations are assessed in a comparative research, it is likely that traditional concept-based approaches are favoured over context-based approaches.

The evidence of the impact of context-based science education on the increase of interest, motivation and the attitudes of students is much stronger compared to the effect on learning outcomes (Bennett *et al.* 2007). Evaluations of the Salters' Advanced Chemistry course (Ramsden, 1997) and the ChiK project (Parchmann *et al.* 2006) indicated that the interest in the subject by students was enhanced and the motivation for further studies in the field of science was increased. In contrast to their teachers' experiences, students of some context-based ChiK courses described these lessons however as just another chemistry learning experience (Sadler, 2009). The interest and motivation in science subjects and the teaching of these subjects is related to the use of the need-to-know principle. An improved motivation was observed in the learning of a unit about water supply quality, which was based on authentic practices (Bulte *et al.* 2006). Students mentioned that they particularly appreciated this project because they could find out things themselves. It is important to note that besides the personal relevance of science and the application of knowledge, also the role of the teacher has a major impact on the development of motivation, interest and a positive attitude of students (Parchmann *et al.* 2006).

Most context-based approaches also intend to have some impact on the development of other attributes of students like problem-solving and decision-making abilities, argumentation, inquiry skills and critical thinking. There are however not that many studies focussing on the evidence of impact on these attributes. There is still not enough empirical evidence to relate context-based science education to improved decision-making abilities (Sadler, 2009). A study on the development of reflective judgement was performed on American students of the age of 16-18 in anatomy and physiology classes (Zeidler *et al.* 2009). When in these classes current social issues were embedded in scientific contexts, students showed an increased ability of reflective reasoning and argumentation. A study on a chemistry course about a local creek which used contexts as social circumstances, the fourth model for the development of context-based curricula as described by Gilbert, showed that this approach enabled students to develop higher-order thinking skills like drawing conclusions and solving problems (King *et al.* 2013). These higher-order thinking skills were however not developed by low-achieving students.

Teachers play an important role in the implementation and shaping of context-based curricula. As mentioned before, the investments of teachers in the use of contexts strongly influence the experiences of students. A couple of recent studies focus on the impact of context-based approaches on teaching and the behaviour of teachers. Several of these studies remarked that it was particularly difficult to let teachers engage with an approach of science instruction beyond the traditional procedure (Sadler, 2009). Therefore a framework was designed to empower teachers in their professional development of context-based teaching competences (Stolk *et al.* 2009). Subsequently an instrument was developed to map the learning of teachers in creating a context-based learning environment (de Putter-Smits *et al.* 2013). This instrument could also be used to analyse differences in context-based approaches implemented in the various science subjects and in different countries. A small-scale study on the effects of teaching methods on the impact of a context-based approach in a physics course indicated that a traditional teaching method was more effective in improving conceptual understanding compared to a learning cycle teaching method, which includes several phases in the learning process to enhance learning outcomes (Peşman *et al.* 2012). This result could also implicate that teachers achieve better in conventional teaching methods. Teacher behaviour was studied in context-based chemistry courses by measuring perceptions of students and this indicated that there was less affiliation and interpersonal control compared to traditional courses, while there was no increase in context-based teacher behaviour shown (Overman *et al.* 2014). The observed decrease of affiliation could even lead to less motivation and interest of students.

Discussion

Traditional science courses have a strong focus on theoretical concepts, which have to be learned and memorized. These facts and theories are taught in a fixed and logical order, an educational structure which was difficult to reform for a long time. Several problems in secondary education were associated with this kind of courses, including a lack of transfer of these concepts to the daily life of students. This lack of relevance could cause a decrease of students' motivation, interest and attitude towards science.

The introduction of contexts in science education attempts to address these problems by involving students more in their own learning activities and by taking their interests, skills and knowledge they already possess more into account. The elaboration of context-based projects varies, because there are a lot of different interpretations and attributes of context distinguished which are used in various ways. There are a couple of shared common aspects detected in these context-based programs, however: the curiosity of students is triggered and issues are introduced by using a recognizable context as the starting point of education, each project has some characteristics of the need-to-know principle implemented and the use of contexts triggers students to be actively involved in their own learning activities. An increasing amount of studies have been performed on the impact of different aspects of context-based science education. The occasionally contrasting outcomes of these studies are also caused by different interpretations of context and varying research methods. The validity of these methods has sometimes been criticized, because the evidence of the impact of context-based approaches can be doubted when the same test is used for the analysis of two different teaching approaches which focus on different learning goals. Results from these studies are generally in favour of context-based education, because the understanding of scientific concepts obtained from these approaches is at least as good compared to traditional approaches and the interest, motivation and attitude towards science of students is usually improved in context-based education. The lack of improved learning results might be caused by a weak relationship between concepts and contexts, because many innovative curricula use traditional education structures and hence conventional connections between concepts (De Jong, 2008). This happens for instance when contexts are only used for illustrational purposes as the direct application of concepts. These contexts are often not taken seriously by students, because they are not included in tests. In spite of all studies which have demonstrated the benefits of context-based science education, these approaches are still not applied in the majority of the classrooms (King *et al.* 2012). Presumably most teachers consider the use of a context-based approach as too time-consuming or find it difficult to engage with this innovative approach and keep practicing their traditional teaching styles as a consequence. Besides the use of contexts in their lessons, it is therefore required to find a way to stimulate teachers in adopting an approach based on the active learning of students. The correct use of a context-based approach can have a major influence on the learning experiences of a student in secondary science education, the understanding of scientific concepts and the development of their interest, motivation and attitude towards science.

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