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# Chemie im Kontext: The Students' View on its Adaption in Spain and Argentina — Two Case Studies

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**Abstract**

One of the main problems in science education nowadays, and especially in chemical education, is that the students usually cannot perceive the relevance of what they learn in their classes. There have been some efforts to improve the student interest and motivation without diminishing the understanding of the chemistry concepts. The context-based methodologies allow the students to see the relevance and applicability of what they learn in the chemistry classes, connecting the canonical science with their lives, interests and previous knowledge. One of these methodologies, Chemie im Kontext (Chemistry in Context in German), was developed in Germany to improve chemistry teaching in secondary education. Its main features include the use of contexts throughout the whole teaching unit and the effort to foster student self-learning. At present, there is an ongoing project, supported by the German Academic Exchange Service (DAAD), to assess the use of a German context-based methodology, Chemie im Kontext (ChiK in the following) in four secondary schools in the Madrid region (Spain). Based on a collaboration with the University of Buenos Aires (Argentina) this case study has been accompanied by a second one carried out in Buenos Aires during 2015 and 2016. The main goal of this project is to identify which changes students and teachers perceive when comparing a *ChiK* teaching unit to the traditional teaching approach. This article focuses on the students' opinions concerning the use of a *ChiK* methodology in chemistry classes in Spain and Argentina and therefore allows a first insight into possible effects of this teaching approach.

**Key words:** context based chemistry teaching, students' motivation, case study.

# Chemie im Kontext: Pohled studentů na uplatnění tohoto pojetí ve Španělsku a Argentině – dvě případové studie

**Abstrakt**

Jedním z hlavních problémů přírodovědného, a obzvláště chemického, vzdělávání je v současnosti vnímaná nízká relevance vzdělávacího obsahu. V minulosti proběhly pokusy zvýšit

zájem žáků a motivovat je, aniž by došlo ke snížení jejich porozumění chemickým konceptům. Na kontextu založené (context-based) metodologie umožňují žákům vidět relevantnost a aplikovatelnost učiva chemie, spojuje kanonické přírodní vědy s životy žáků, zájmy a předchozími znalostmi. Jedna z těchto metodologií, Chemie im Kontext (chemie v kontextu, z němčiny), byla vyvinuta v Německu za účelem vylepšení výuky chemie na středních školách. Její hlavní prvky zahrnují využívání kontextů v celé výukové jednotce a klade důraz na utváření schopnosti žáků učit se (self-learning). V současnosti je realizován projekt podporovaný německou agenturou DAAD, který má za cíl hodnotit německou metodologii context-based přístupu. Projekt Chemie im Kontext (ChiK) probíhal na čtyřech středních školách v madridském regionu (Španělsko).
V předkládané případové studii je zmíněný projekt doplněn druhým, realizovaným ve spolupráci s University of Buenos Aires (Argentina) mezi lety 2015 a 2016. Hlavním cílem tohoto projektu bylo identifikovat změny, které žáci a učitelé vnímali mezi ChiK a tradičním pojetí výuky. Tento příspěvek se zaměřuje na názory žáků k využití ChiK ve výuce chemie ve Španělsku a Argentině, čímž umožňuje první náhled na možný efekt tohoto přístupu k výuce.

**Klíčová slova:** výuka chemie založená na kontextech, motivace žáků, případová studie.

During the last decades, a remarkable number of studies have reported worrying results regarding secondary science education. Besides unsatisfying results in the field of content knowledge it seems that affective aspects, such as feelings, motivation, attitudes and interest are often neglected in science teaching (Osborne et al., 2003). In order to foster students' interest, motivation and attitudes towards chemistry, context-based learning approaches, which are being developed for round about thirty years now (Nentwig & Waddington, 2005), try to connect chemistry concepts with the students' everyday lives and previous knowledge, thereby linking their cognitive and affective learning. The use of contexts allows the students to see the relevance and applicability of what they learn, so the newly acquired concepts can be related to their previous knowledge, ideas and interests, allowing a successful learning process (De Jong, 2006). The students can perceive what they learn as relevant to their lives, being able to construct coherent "mental maps" of the subject (Gilbert, 2006).

Many context-based approaches refer to six central process characteristics derived from a constructivist view on learning (Mandl & Kopp, 2005): Learning...

1. ...is an active construction process, where the learner must take an active participation in the learning process.
2. ...is a constructive process, where knowledge is built into already existing knowledge structures.
3. ...is an emotional process, where positive emotions from the learner are needed.
4. ...is a self-directed process, where the learner must control his/her own learning process.
5. ...is a social process, and the interaction with others is needed.
6. ...is a situated process, where the knowledge acquisition takes place in a context or specific learning environment.

There are a number of reports that claim positive effects on students' interest and motivation when these context-based approaches are used (Parchmann et al., 2006, Bennett et al., 2005, 2007).

# 1 The concept of *Chemie im Kontext*

One of these context-based approaches is *Chemie im Kontext* (Chemistry in Context in German, ChiK in the following). ChiK was originally developed in Germany between 1999 and 2008, with the support of the German Ministry of Education and Research (BMBF) and implemented by "learning communities" (Parchmann et al., 2006) of university researchers and teachers. It aims at improving chemistry teaching in 8th–13th grades (12- to 17-year-old pupils) in the German education system. It provides the teachers with guidance, suggestions on possible contexts and collections of material, that they can use to build their own teaching units.

In the ChiK-units the six constructivist characteristics of learning are represented by three major foci (Parchmann et al., 2006):

1. *Contexts:* Learning environments are considered "in context", where learners acquire knowledge and competence on a need-to-know-basis in dealing with an issue relevant for them, starting with their questions and ideas.
2. *Development of basic concepts:* To develop a basic knowledge foundation that can be applied to new contexts and situations, the main principles of chemistry must be derived and abstracted from the contexts. These principles are described as "basic concepts" and they structure and summarize the content knowledge.
3. *Variety of teaching and learning methods:* A variety of teaching and learning methods is one of the key elements for a successful chemistry education: a) because it considers the diversity of interests, pre-knowledge, capabilities and learning styles and b) because it offers the students situations in which they can develop and apply competencies in all areas as demanded by each National Standards (Parchmann, 2009).

In order to promote the students‘ self-concept and autonomy the structure of the teaching units has to combine these three theoretical foci of ChiK in a way that enables the pupils to follow their own questions and to use a variety of activities (research, lab work, discussions, team work) to achieve answers. Therefore, an ideal ChiK teaching unit consists of four phases (Nentwig, 2007):

1. Phase of contact
   Here the context is presented to the students with a special focus on its connection to their everyday life and living environment, and different aspects of the usually quite complex contexts can be discovered by the students themselves. Thus their previous knowledge of the subject is activated. There is a formulation of questions on the subject, as a basis for the development of the subsequent phases.
2. Phase of curiosity and planning
   The students bring out questions on the context. Together with the teacher they discuss which of the questions they will subsequently follow, and they develop research strategies to explore the subject in order to answer their questions.

Hypotheses are formulated, and the research work is planned in a way that students always see how their activities in the subsequent phases help answering their questions.

3. Phase of elaboration
   The students conduct the research, individually or in groups. Their results are presented, the previously raised hypotheses are checked and most of the questions answered. Due to motivational reasons a special emphasis is given on methods that allow for an active learning experience (Kekule et al., 2017).
4. Phase of deepening and connecting
   In this phase, special interests or questions can be focused or some of the findings of the previous phase can be discussed in greater depth, before the contents of the unit are related with other contexts, connecting the newly acquired knowledge with the previous knowledge of the students.

Focusing on the three abovementioned foci and arranging a ChiK-unit into the four phases outlined, different competencies can be developed, as it is exemplarily shown in fig. 1 for the German National Standards.

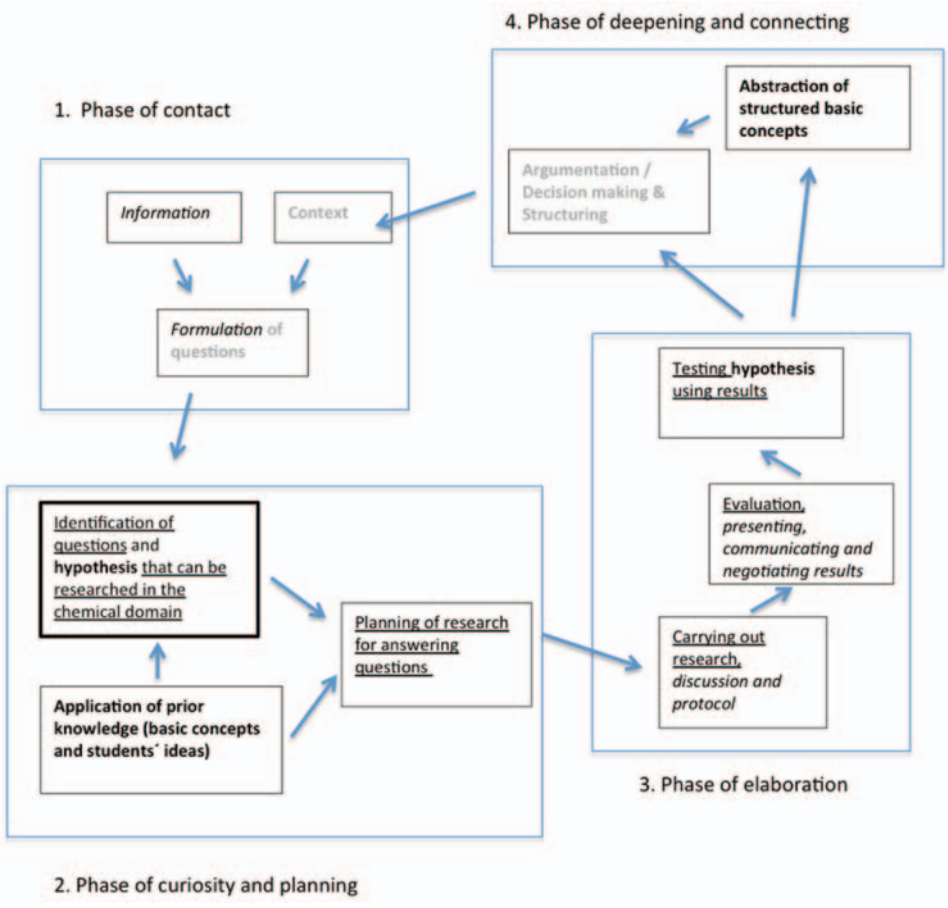


Fig. 1: Phases of a ChiK teaching unit and developed competencies (Demuth et al., 2007)

The results obtained in the evaluations of the ChiK program in Germany were mostly positive: Among the various aspects evaluated, focusing on the effects on students the following results are especially important:

- Students' motivation increases when using this methodology (Parchmann, 2006).
- The use of teacher centered methods decreases (Fussangel, 2008).

- The use of a variety of teaching methods increases (Fussangel, 2008).
- No significant gender differences could be found when comparing the results obtained by boys and girls (Nentwig, 2007).
- The awareness of the students that they are immersed in self-learning processes increases (Di Fuccia, 2007).
- Unlike expected by the teachers, the use of ChiK does not lead to lower content knowledge (Di Fuccia et al., 2005).

But also, problematic aspects could be found regarding the implementation of ChiK:

- It turned out that students tend to lose interest if the context-units are too long (Di Fuccia et al., 2005).
- It is important to make sure that the context is really relevant for students instead of only being felt relevant by the teachers (Di Fuccia et al., 2005).
- As the context do not follow the curricula it is hard to arrange them in a way that the context is treated seriously, and the curriculum is covered as well (Di Fuccia et al., 2005).
- Compared to teaching content traditionally teaching context-based is more time-consuming — especially when isolated context-units are used within a traditional course (Sanchez Diaz & Di Fuccia, 2018).
- There is a danger that students struggling with chemistry can get lost during dealing with a context as learning is not as straight forward as in traditional settings and they may be unable to extract the important information and to clearly understand their relationship and meaning (Di Fuccia et al., 2005; Parchmann et al., 2006).

But as the effects of ChiK could depend on the living environment of the pupils as well as on the education system, there is a need to find out which aspects differ when using this teaching strategy in different regions.

## 2 Research objective and methodology

The overall aim of our project is: To what extent can the positive effects of the German implementation of ChiK be found when this teaching concept is used in a setting where students have a different living environment? In order to answer this question, we are conducting two case studies, one in Madrid (Spain) since 2014, and one in Buenos Aires (Argentina) in 2015 and 2016. The reason for this double-case-study approach is to use this methodology in the very different school and living conditions in Spain and Argentina and to allow an insight into the following aspects:

1. How can the concept of ChiK be adapted to the respective educational system?
2. How can material be developed so that it can be used by teachers in these cities for teaching chemistry in a context-based way?
3. Which effects does the use of the adapted concept and the respective teaching material have?

It is worth mentioning that in both countries the students using the ChiK methodology usually follow a traditional chemistry teaching that uses little or none contexts at all.

In both countries the implementation started by providing translated German ChiK-material and adapting it concerning the teaching situation and the curricula.

In both cases this was done by learning communities following a participatory action research process (Di Fuccia et al., 2007), in which phases of development are alternated with phases of evaluation and revision.

As one of the German members of our group was part of the team that originally developed and implemented ChiK in Germany, it could be assured that the ChiK-characteristics were still fulfilled in the adapted material. The nature of the changes will be described in detail for every case study in the following. In general, it can be stated that the material was mainly adapted concerning:

1. the phase of contact, as it had to be oriented to the students' everyday life.
2. the content, in order to make it fit to the respective curricula.
3. the methodology — this was mostly done to make the material fit to the lab resources, the length of the lessons and the number of students in class and mostly applies to the phase of elaboration.
4. the supporting material for the teachers, as their preparation for teaching context-based differed considerably between the countries involved (see below).

In order to obtain data and results that are comparable between Spain, Argentina and Germany and at the same time being open for adaption to the special circumstances of the implementation in Spain and Argentina, we are following a mixed-methods approach, which is based on the instruments developed, evaluated and used for evaluating ChiK in Germany (Schellenbach-Zell et al., 2008). Therefore, the dimensions used for evaluation in Spain and Argentina were those obtained by the evaluation in Germany, even if the methods used were different due to the different circumstances – like time available for the evaluation or research tradition — in both countries.

# 3 The Spanish experience

## 3.1 Implementation

In Spain, the project began in 2014. Meetings with teachers and principals of several schools were held in order to present the methodology and characteristics of the research project. Positive responses were received from four schools in Madrid region, two private and two public schools. Initially eight science teachers agreed to use the ChiK methodology in their chemistry classes. The contexts of "alcohols" and "acids and bases in everyday life" were chosen to develop the first teaching units.

During the first half of the 2014–2015 school year, regular visits were made to the schools and the four teachers who finally took part in the project. At the end of that school year, the teachers used the ChiK material and methodology during 3–4 weeks in ten different high school classes: four classes of 3$^{rd}$ of ESO (equivalent to Grade 9 in the US school system) and six classes of 4$^{th}$ of ESO (equivalent to Grade 10 in the US). Due to the close collaboration between researcher and teacher in adapting the units to the Spanish situation we were able to avoid some of the above-mentioned problems, especially those concerning the length, the topic of the contexts and their relation to the curriculum.

## 3.2 Methodology of evaluating the effects

In order to assess the effects of using these teaching units in a way that the results could be compared to the German implementation, a slightly shortened version of the pre-test and post-test questionnaires that were used in Germany were used in Spain as well, in addition 22 students from different schools were interviewed.

The questionnaires, following a Likert scale, consist of a series of statements, where the person completing it should indicate to what extent he/she agrees with it. Thus, a value of 4 indicates "I strongly agree" and a value of 1 means "I strongly disagree".

The student pre-test questionnaire contains questions about their feeling on the quality of their current chemistry classes, the type of knowledge acquired, and which features they consider a good chemistry teaching must have. The post-test questionnaire asks for the changes they perceived when the teacher used a ChiK methodology compared with the rest of the year.

As in the German evaluation the items of the questionnaires were summed up in three dimensions:

- Motivation. There are 7 items which focus on whether the classes have been interesting and how their attitude towards the subject has been. For example: "Time flew for me in these latter classes."
- Interdisciplinarity and context-based teaching. Here there are 5 items that measure the relation of what the students have seen in class with their daily life and with the content of other subjects. For example: "I learned how to explain things from daily life with the content that we have seen in the latter classes."
- Self-directed learning and changes in the way the students work in chemistry classes. The 8 items in this dimension are related to how the teacher leads the chemistry class and the promotion of self-directed learning of students. An example of these items is: "I prefer a chemistry class in which the teacher tells me exactly how he wants us to solve a particular exercise."

In total, 166 students from the 10 different classes filled both questionnaires.

In addition to the questionnaires, 22 of the students were interviewed the week after they used the ChiK teaching unit. The interviews were used to clarify some of the results of the questionnaire study answers and to confirm the results of the questionnaires, as well as to gather information that we could not measure with them.

## 3.3 Results and discussion

Students' answers in the questionnaires show an increase of the value in the post-test mean, when comparing with the pre-test mean, for all the three dimensions, which means a positive change for the three categories (tab. 1, fig. 2).

| | | Pre-Test | | | Post-Test | | |
|---|---|---|---|---|---|---|---|
| **Category** | Items | M | SD | Reliability [$\alpha$] | M | SD | Reliability [$\alpha$] |
| Motivation | 7 | 2.68 | 0.56 | 0.81 | 3.04 | 0.53 | 0.78 |
| Context-based structure | 5 | 2.62 | 0.54 | 0.71 | 2.79 | 0.49 | 0.62 |
| Self-directed learning | 8 | 2.47 | 0.36 | 0.55 | 2.87 | 0.37 | 0.62 |

Tab. 1: Results obtained by the students in the pre-test and post-test questionnaires

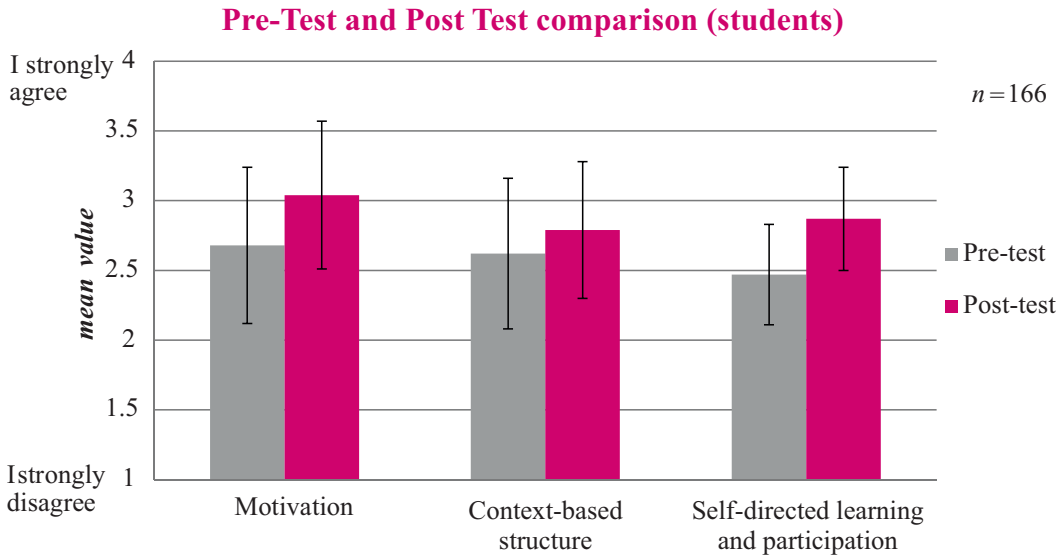


Fig. 2: Comparison of Pre-Test and Post-Test results of the students

In order to calculate the p-values, a Saphiro-Wilk test for each dimension of the students' pre- and post-test questionnaires was used. The calculation was made with Stata data analysis software, and the results corroborated that each group of data have a normal distribution.

As all the variables have a normal distribution, the pre- and post-test samples were compared using a T-Student paired data analysis, also with the Stata software. Differences in values of pre-test and post-test for all the three dimensions were statistically significant (T-Student's paired data, $p < 0.05$).

There are reports that indicate that the acceptable values of Cronbach's alpha range from 0.70 to 0.95 (Nunnally et. al, 1994; Bland et al., 1997; DeVellis et al., 2003). Other reports state that high values of alpha ($> 0.90$) point out redundancy among the items (Tavakol et al., 2011; Streiner, 2003). In other studies, it is stated that figures of alpha values below the conventionally set benchmark of 0.70 can be accepted (Spiliotopoulou, 2009) and that alpha values of 0.50–0.70 indicate moderate reliability (Hinton et al., 2004). According to this, all alpha values obtained show at least a moderate reliability, with three of them showing a high reliability.

Thus, in the "motivation" dimension, items such as "Time flew for me in these latter classes" (value was +0.68 higher in post-test) or "I think that the last chemistry classes were very interesting" (+0.53 higher in post-test) show that the students prefer the classes in which the ChiK methodology was used.

In the "self-directed learning and participation" dimension there are striking answers, like "In these chemistry classes we were able to gather information on a particular subject on our own" (+0.39 higher in post-test) or "In these latter chemistry classes we have been able to plan experiments and activities independently" (+1.14 higher in post-test).

As for the "Context-based structure and interdisciplinarity" dimension, there is one item with an especially interesting difference between pre-test and post-test values. The item "If chemistry classes throughout the course were as in the last weeks, I would better understand some of the problems that affect society" has in the post-test a value +0.55 higher. The change in the mean value is not as big as in the "motivation" and "self-direct learning and participation" dimensions, but it is still statistically significant.

Personal interviews are in line with the results of the questionnaires. Several students define the classes, in which a ChiK methodology is used as "more dynamic". Others point out that "They are not so easily distracted". When they must study for an exam, "It was easier to remember what we have seen in chemistry class" after using the ChiK teaching unit. Also, they "Feel motivated if the teacher does not direct them so much". Almost all students find "the increase of lab work sessions" very positive. In addition to that we couldn't find any hints indicating that this approach was especially problematic for low-achieving students as could be expected based on the German experience. Nevertheless, upon being interviewed themselves, all teachers stated that, under the current conditions in Spain, it is difficult to use a methodology like ChiK in a continuous way during the whole course as it turned out to be very time-consuming. (Sanchez Diaz & Di Fuccia, 2018)

# 4 The Argentine experience

## 4.1 The Argentine situation

In the following, one has to keep in mind that the educational system in Argentina is quite different from the European one. First, the time to teach chemistry is comparably lower, as there only is one mandatory science course of two hours per week for two years, covering all natural sciences and one additional course in those schools that are natural-science oriented. This forces chemistry teachers to teach only selected topics and not to go into detail too much despite a very large suggested syllabus.

Second, the workload of the teachers is extraordinary high. They have to teach up to 40 hours per week, often in different schools, so that they have to travel between the schools. These travel times are neither recognized for their workload nor paid, so that the teachers only have very little resources for preparing lessons. This is made worse by the economic situation of Argentina which is characterized by a high inflation and great cuts in public spending especially for education.

## 4.2 Implementation

In order to adapt the *ChiK* methodology to the above mentioned Argentine situation, special material covering the context "oil" has been prepared by the researchers in Argentina, supported by the German colleagues.

The 'Oil in Context' material consist of a quiz for the students and an e-text with explanations for the teachers and students.

The quiz features ten sections with interdisciplinary contents related to the context 'oil' and therefore brings the scope of this context into the students' attention. Those sections are: 1) Can oil erupt spontaneously?, 2) Was there oil in ancient times?, 3) Black gold or dangerous disaster?, 4) How has Petroleum been formed?, 5) How is oil extracted? 6) Fracking, innovation or danger?, 7) Oil price and demand, 8) Oil distillation and refinement, 9) Uses of petroleum: fuels, 10) Other uses of petroleum: plastics and other products.

Each section contains problems/questions with answering options as it is known from TV quiz shows; Those answering options comprised the correct answer as well as typical misconceptions or 'common sense ideas' about the respective content and students were allowed to choose more than one of them. The underpinning goal of the quiz is to present problems which answering options can either generate students' motivation to know the correct answers or eventually provoke some intellectual

discomfort by the awareness of the extent of lacking knowledge that they had and thus lead to additional motivation.

Due to the shortage of time for teaching chemistry in the Argentine schools the ChiK adaptation used by the teacher consisted of a quick individual answering of the quiz before teams of students were required to prepare a 10-minute video about any of the topics of the quiz, in a one month extra class project (Gama & Barroso, 2017). In order to support the teacher and to enable the students to produce their videos an especially designed e-text was developed which discusses the quiz problems and orientates the readers about confident websites where more information could be found. By conducting important parts of the work as an extra class project, the problems of the length of the unit as well as the feasibility of using such units in everyday classes could be bypassed. On the other hand, this poses a clear limitation of implementing context-based science teaching in the current Argentine system.

The context 'oil' was selected to work with one chemistry teacher (in the City of Buenos Aires) after hydrocarbons and combustion contents have been taught. The 'Oil in Context' teaching approach was successfully tested during 2015 (Pergola et al., 2015a; Pergola et al., 2015b; Pergola et al., 2015c) and a qualitative research was carried out during May of 2016 involving five courses of one teacher (132 students in sum). By this it should be ensured that the context is accessible and relevant for students.

## 4.3 Methodology of evaluating the effects

A qualitative methodology to measure the students' motivation, their opinions on the context-based structure and the interdisciplinarity of the material as well as on the self-directed learning and participation during the ChiK experience was used, which was based on the dimensions obtained in Germany and already used in Spain.

It consisted of applying a questionnaire where students were asked to select words and emoticons representing their feelings on seven aspects of the implementation: 1. Answering the questionnaire; 2. Using the e-text; 3. Producing the video; 4. Giving an opinion on their own video; 5. Giving an opinion about others' videos; 6. Receiving others' opinion on their own video; 7. Being evaluated by the teacher.

Words students could use to express their motivation and their feelings in the survey were:

> Easy – Amazing – Boring – Bad – Enjoying – Unforgettable – Extraordinary – Forgettable – Surprising – inconsequential – Complicated – Difficult – Incomprehensible – Cool – Ugly – Very nice

In addition to that the students had to choose one of 16 different provided emoticons to express how they have felt when working with the material. The method of "words plus emoticon" was used before in Argentina (Pergola et al., 2014) and chosen as it proofed feasible in the Argentine context to evaluate the emotions of the students via the emoticons whilst cognitive aspects and reasoning of the students can be obtained analyzing the chosen words.

Both words and emoticons were classified as positive, negative or neutral (Pergola et al., 2014) for further analysis of the survey (see tab. 2). In order to learn more about the reasons for the words and emoticons chosen students had the opportunity to give free comments, which were characterized as positive, negative or neutral and analyzed as well.

| Tasks | Words | | | Emoticons | | |
|---|---|---|---|---|---|---|
| | positive | negative | neutral | positive | negative | neutral |
| Answering the quiz | 23 | 51 | 26 | 38 | 55 | 7 |
| Using the e-text | 36 | 36 | 28 | 52 | 43 | 4 |
| Producing the video | 66 | 28 | 6 | 66 | 34 | 0 |
| Giving an opinion on their own video | 67 | 15 | 18 | 72 | 17 | 11 |
| Giving an opinion about others' videos | 76 | 12 | 12 | 70 | 18 | 12 |
| Receiving others' opinion on their own video | 58 | 12 | 30 | 60 | 25 | 15 |
| Being evaluated by the teacher | 65 | 22 | 13 | 62 | 28 | 10 |

Tab. 2: Student's selection of words and emoticons concerning the seven aspects of the didactic experience

In addition to that each of the 27 videos produced by the students was evaluated by the teacher for content as well as for the commitment with which students worked on it.

## 4.4 Results and Discussion

Out of the 132 students taking part in the case study in Buenos Aires, 92 answered the survey (choosing words and emoticons) about their feelings when working on the 'Oil in Context'. Tab. 2 shows the results.

Tab. 2 shows that the students liked all activities related to the video most, while dealing with the quiz and the e-text weren't their favorites.

The free comments allow a deeper qualitative insight into why the students answered in this way. Concerning the task "Answering the questionnaire" students mentioned positively: "I liked it, but I felt ignorant"; "There were things I did not know"; "Interesting, difficult"; "Long but interesting" whilst the negative comments were like: "boring", "unnecessary" and "complicated". Since each problem of the questionnaire involved interdisciplinary knowledge, some students perceived it as a positive challenge, but the awareness of difficulties was a negative issue for others. The fact of being aware of one's own cognitive limitations is nevertheless one of the interesting points highlighted in the approach chosen that promotes the "self-regulation of learning" (Zimmerman et al., 2009) and it is obviously perceived by the students.

In addition to that, a number of students commented positive on the e-text which should help them finding the correct answer to the topic and to enable them to produce a video with proper content, their comments were: "Very useful and easy to understand information"; "Well explained, rewarding"; "Accurate and useful"; "Useful as an introduction to the topic". Reasons for negative ratings of the e-text were: "unnecessary"; "endless", "complex"; "difficult to understand".

Summing up all the aspects related to the video, reasons for positive students' ratings were given as "enjoying"; "very amusing task", "it required a lot of research"; "difficult but enjoying"; "we could learn more things"; "creative, funny, well done and interesting outcomes"; "It is another way to learn". Those who chose negative words or emoticons on some of the aspects related to the videos commented "tedious

work"; "oil is not an attracting subject"; "I do not like other people to give opinions on my work".

As tab. 2 and the open comments show, students liked producing the video very much. This result is supported by the teacher's analysis of the videos and the process of producing them. The teacher reported that all the students showed great commitment to the tasks and willingness for teamwork; most of the videos proved to be ingenious and creative either in contents or technical qualities (Valente et al., 2016). In addition to that, no evidence was found that this activity posed special problems for low achieving students.

Summing up, most of the students liked a demanding self-regulated task and accordingly could make metacognitive reflections about their knowledge. This is consistent with the finding that students invested a lot of effort in producing their original videos, with creative animations and spoken texts and searching for information and images that had not been mentioned in the e-text (Valente et al., 2016). The motivation and commitment derived from this type of approach furthermore demonstrates abilities that there are not usually evaluated in traditional classes (Zimmerman & Moylan, 2009).

# 5 Conclusions

Although the ChiK methodology was not used in its complete extent (for example, the Spanish teachers found the 4-steps structure of an ideal ChiK teaching unit too demanding to implement it directly), the experiences in both case studies show that:

- the concept of ChiK is adaptable to very different situations, school systems and living environments;
- it is possible to develop material with which it is possible to teach chemistry following the adapted concept;
- the use of such an adapted ChiK-based approach has shown positive impacts on the student point of view in both case studies, especially the increase of motivation and self-directed learning;
- the positive effect on students' motivation seems to be quite independent from the school systems and living environment of the students.

In addition to that, in both case studies aspects can be found that can hinder the ChiK adaptation (for example, the length of the syllabus, the lack of resources for the lab sessions and the overloaded teaching conditions), but these are more related to the teacher and the curricular point of view and it could be shown that by using the experiences from other implementations some of the problems can be prevented.

It has to be stressed that we only conducted two quite limited case studies with only some special contexts in only two cities. So, there remains a lot to be done, like e.g. using different contexts and teaching strategies and to focus on the teachers' perceptions and their preparation during their teacher training, nevertheless, based on our experiences so far, it seems justified to conclude that:

- the inclusion of more contexts during the chemistry classes, even if they do not follow the ChiK approach, could be useful from a motivational point of view and
- the results obtained and the experiences gathered in this project could be encouraging and helpful for researchers and teachers in all regions of the world to start working on including contexts in their chemistry classes.

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# References

Bennett, J., Hogarth, S. & Lubben, F. (2005). A systematic review of the effects of co ntext-based and Science-Technology-Society (STS) approaches in the teaching of secondary science on boys and girls, and on lower-ability pupils. In *Research Evidence in Education Library.* London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Bennett, J., Hogarth, S. & Lubben, F. (2007). Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. *Science Education*, 91(3), 347–370.

Bland, J. & Altman, D. (1997). Statistics notes: Cronbach's alpha. *BMJ*, 314, 572.

Demuth, R., Parchmann, I. & Ralle, B. (2007). *Handreichungen für den Unterricht. Chemie im Kontext – Sekundarstufe II.* Berlin: Cornelsen.

De Jong, O. (2006). Making chemistry meaningful: conditions for successful context-based teaching. *Educación Química*, 17, 215–221.

DeVellis, R., (2003). *Scale development: theory and applications.* Thousand Okas, CA: Sage.

Di Fuccia, D., Ralle, B. & Schwarz, W. (2005). Lehrer planen gemeinsam. Ein Einblick in die Arbeit des Projektes Chemie im Kontext. *MNU*, 58, 388–393.

Di Fuccia, D., Schellenbach-Zell, J. & Ralle, B. (2007). Chemie im Kontext: Entwicklung, Implementation und Transfer einer innovativen Unterrichtskonzeption. *MNU*, 60, 274–282.

Fußangel, K., Schellenbach-Zell, J. & Gräsel, C. (2008). Die Verbreitung von Chemie im Kontext: Entwicklung der symbiotischen Implementationsstrategie. In R. Demuth, I. Parchmann & B. Ralle (Eds.), *Chemie Im Kontext: von der Innovation zur nachhaltigen Verbreitung eines Unterrichtskonzepts* (49–81). Münster: Waxmann.

Gama, E. & Barroso, M. F. (2017). Student's video production as formative assessment. *Scientia in educatione*, 8(special issue), 165–171.

Gilbert, J. K. (2006). On the nature of "context" in chemical education. *International Journal of Science Education*, 28(9), 957–976.

Hinton, P. R., McMurray, I., Brownlow, C. & Cozens, B. (2004). *SPSS Explained.* London: Routledge.

Kekule, M., Zak, V., Jeskova, Z., Kimakova, K., Ganajova, M. & Kires, M. (2017). Inquiry based science education and getting immediate students' feedback about their motivation. *Scientia in educatione*, 8(special issue), 207–213.

Mandl, H. & Kopp, B. (2005). "Situated learning: Theories and models". In P. Nentwig & D. Waddington (Eds.), *Making it Relevant: Context Based Learning of Science* (15–34). Münster: Waxmann.

Nentwig, P. & Waddington, D. (Eds.) (2005). *Making it Relevant: Context based learning of science*. Münster: Waxmann.

Nentwig, P. M., Demuth, R., Parchmann, I., Gräsel, C. & Ralle, B. (2007). Chemie im Kontext: Situating learning in relevant contexts while systematically developing basic chemical concepts. *Journal of Chemistry Education*, 84, 1439–1444.

Nunnally, J. & Bernstein, L. (1994). *Psychometric theory.* New York: McGraw.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25, 1049–1079.

Parchmann, I. (2009). Chemie im Kontext: One approach to realize science standards in chemistry classes? *Educació química*, 2, 24–31.

Parchmann, I., Gräsel, C., Baer, A., Nentwig, P., Demuth, R. & Ralle, B. (2006). "Chemie im Kontext": A symbiotic implementation of a context-based teaching and learning approach. *International Journal of Chemistry Education*, 28, 1041–1062.

Pérgola, M., Galagovsky, L., Valente, B., Sánchez-Díaz, I. & Di-Fuccia, D.-S. (2015a). Investigación sobre enseñanza de petróleo en contexto: aportes de estudiantes de de una escuela secundaria. *Journal of the Argentine Chemical Society*, 102(1–2), 600–604.

Pérgola, M. & Galagovsky, L. (2014). Puesta a prueba de una unidad didáctica dentro del enfoque de química en contexto. *Revista de Educación en la Química*, 20(2), 143–155.

Pérgola, M., Galagovsky, L., Sánchez-Díaz, I. & Di-Fuccia, D.-S. (2015b). Química en Contexto: tema petróleo. Una investigación argentino-alemana. In *XVII Meeting of the Argentine Chemistry Teachers*, ADEQRA. CD-ROM. Chaco Austral: Universidad National.

Pérgola, M., Goyeneche, M., Rodriguez, M., Sanchez-Diaz, I., Di-Fuccia, D.-S. & Galagovsky, L. (2015c). Investigación sobre enseñanza en contexto del tema petróleo: aportes de estudiantes de profesorado. *Journal of the Argentine Chemical Society*, 102(1–2), 593–596.

Sanchez Diaz, I. & Di Fuccia, D. (2018). Chemie im Kontext: Outcomes of an implementation of a context-based methodology for chemistry teaching. In *12th International Technology, Education and Development Conference Proceedings* (5283–5288). Sevilla: ATED.

Schellenbach-Zell, J., Rürup, M., Fußangel, K. & Gräsel, C. (2008). Bedingungen erfolgreichen Transfers am Beispiel von Chemie im Kontext. In R. Demuth, C. Gräsel, I. Parchmann & B. Ralle (Eds.), *Chemie im Kontext* (83–124). Münster: Waxmann.

Spiliotopoulou, G. (2009). Reliability reconsidered: Cronbach's alpha and paediatric assessment in occupational therapy. *Australian Occupational Therapy Journal*, 56(3), 150–155.

Streiner, D. L. (2003). Starting at the beginning: an introduction to coefficient alpha and internal consistency. *Journal of personal assessment*, 80(1), 99–103.

Tavakol, M. & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, 2, 53–55.

Valente, B., Pérgola, M. & Galagovsky, L. (2016). *Experiencia didáctica a partir del tema hidrocarburos en la material Química, de quinto año de escuela secundaria.* XXXI Congreso Argentino de Química, 25–28th October, Buenos Aires, Argentina.

Zimmerman, B. J. & Moylan, A. R. (2009). Self-regulation: Where metacognition and motivation intersect. In D. J. Hacker, J. Dunlosky & A. C. Graesser (Eds.), *Handbook of Metacognition in Education* (299–315). New York: Routledge.

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