"CHEMIE IM KONTEXT" IN SPAIN: ADAPTATION OF A CONTEXT BASED METHODOLOGY FOR CHEMISTRY TEACHING

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ABSTRACT: *Chemie im Kontext* (Chemistry in Context) is a German project that aims to improve the chemistry teaching in secondary education. It is a context-based methodology that uses a student-centered approach.

An ongoing research project in Madrid (Spain) is carried out in order to adapt this teaching concept to the Spanish educational system and to evaluate its effects. A context-based material was developed and used in 4 different schools. 4 teachers and 166 students participated in this study during the first year of the project. Their opinions were gathered with pre- and post-test questionnaires.

Students showed an increase in their motivation and their perception of being immersed in a self-directed learning process when using the *Chemie im Kontext* approach. Teachers considered that their students were more motivated when using this methodology.

KEYWORDS: Chemistry, chemical education, context.

INTRODUCTION

Chemie im Kontext (*ChiK* in the following) is a German Project that aims to improve chemistry teaching in secondary education. It was developed by a group of researchers in chemical education and implemented by "learning communities" of university researchers and teachers and funded by the German Federal Ministry of Education and Research (BMBF). The theoretical basis of *ChiK* comprises three aspects (Parchmann, 2006):

1. *Context-based learning*: 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).

Ideally, each teaching unit follows a 4-phase methodology (Nentwig, 2007):

1. Phase of contact (where the context is presented to the students, and they make some question on the subject, based on their own ideas and previous knowledge).
2. Phase of curiosity and planning (the students develop research strategies to give answers to the questions of the previous phase, and they prepare the research work for the next phase).
3. Phase of elaboration (The students conduct the research, individually or in groups, and they present their results, and the previously raised hypotheses are checked).
4. Phase of deepening and connecting (The contents of the unit are related with other contexts, connecting the newly acquired knowledge with the previous knowledge of the students)

The results obtained in the evaluations of the *ChiK* program in Germany were positive: Among the various aspects evaluated, 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),
– teachers do not have the feeling of losing the control of their classes (Fussangel, 2008)
– the awareness of the students that they are immersed in self-learning processes increases (Di Fuccia, 2007).

But as students' everyday life and their living environment differ considerably from region to region, the effects of using contexts may vary when using this teaching strategy in different regions as well.

METHODOLOGY

In order to find out to what extend the positive effects of the German implementation of *ChiK* can be found when this teaching concept is used in a setting where students have a different living environment, we conduct a research project in Madrid (Spain), using a participatory action research approach (Eilks, 2002) and phases of empirical assessment, aiming at:

1. adapting the concept of *ChiK* to the Spanish educational system,
2. developing material that can be used by teachers in this region for teaching chemistry in a context based way and
3. evaluating the effects of such a teaching approach on teachers and students.

The project began in 2014. Meetings with teachers and principals of several schools were held in order to present the methodology and the research project. 4 schools in Madrid region accepted to be part of the project. The contexts of "alcohols" and "acids and bases in everyday life" were chosen, to develop the first teaching units.

Some of the original German *ChiK* material was translated into Spanish, and new material was developed, including some teaching unit proposals, providing the teachers with supporting material that they could use in their classes.

At the end of the 2014-2015 school year the teachers used the *ChiK* material during 3-4 weeks in 10 different high school classes: 4 Grade 9 classes and 6 Grade 10 classes. Each teacher had complete freedom

when it came to use the material. They know the four-phase structure of the *ChiK* methodology, and they were encouraged to try to use them all during the teaching unit, but the final decision was up to them.

In order to assess the effects of using these teaching units we used pre-test and post-test questionnaires. 166 students from 10 classes filled both questionnaires (83 girls and 83 boys). Besides, the 4 teachers who participated in this study and 22 of the students from different schools were interviewed.

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

In the pre-test questionnaires, teachers were asked about their *ChiK* methodology expectations before using it, and about the characteristics of their own teaching. The post-test questionnaires had items about how had he/she felt when using the *ChiK* methodology and about the changes he/she perceived with respect to a traditional teaching.

For teachers, 4 different dimensions were assessed:

- Characteristics of *ChiK* methodology. 8 items. In this set questions related to a context-based education and the way the teacher works in his/her class are included.
- Changes in students. There are 10 items in this dimension related to the development of students´ skills, their participation in class, etc.
- Changes in teachers. The 8 items in this category measure the teachers control on the class, the possibility of using some aspects of *ChiK* in other subjects than Chemistry...
- Feasibility. 8 items. Here there are items related to the possible use of this methodology in a complete course (not only as individual teaching units).

In the case of students, the pre-test questionnaire contained questions about the characteristics 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 had questions about what changes they perceived when the teacher used a *ChiK* methodology.

For students, in the questionnaires we assessed 3 dimensions:

- Motivation. There are 7 items which focus on whether the classes have been interesting and how their attitude towards the subject has been.
- Interdisciplinarity and context-based structure. These 5 items measure the relation of what the students have seen in class with their daily life and with the content of other subjects.
- Self directed learning and changes in the way the students work in chemistry classes. The 8 items in this category are related to how the teacher leads the chemistry class and the promotion of self directed learning of students.

In addition to the questionnaires, we interviewed all the teachers and 22 of the students 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 gather new information.

RESULTS

Students

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 (Table 1). 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).

Table 1.
Comparison of Pre-Test and Post-Test of students

		Pre-Test			*Post-Test*		
Dimension	Items	Media	SD	Reliability [α]	Media	SD	Reliability [α]
Motivation	7	2,68	0,56	0,81	3,04	0,53	0,78
Multidisciplinarity	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

From a gender perspective, there is almost no difference in the values for boys and girls, both in the pre-test and the post-test questionnaires (Table 2 and Fig. 1).

Table 2.
Students results in the pre-test and post-test questionnaires, segregated by sex

		Girls						*Boys*					
		Pre-Test			Post-Test			Pre-Test			Post-Test		
Dimension	Items	Mean	SD	Reliability [α]	Mean	SD	Reliability [α]	Mean	SD	Reliability [α]	Mean	SD	Reliability [α]
Motivation	7	2,72	0,54	0,79	3,10	0,51	0,78	2,64	0,58	0,82	2,98	0,55	0,79
Multidisciplinarity	5	2,63	0,58	0,70	2,80	0,50	0,68	2,61	0,50	0,73	2,78	0,49	0,58
Self-directed learning	8	2,47	0,37	0,53	2,90	0,40	0,66	2,47	0,35	0,58	2,83	0,34	0,57

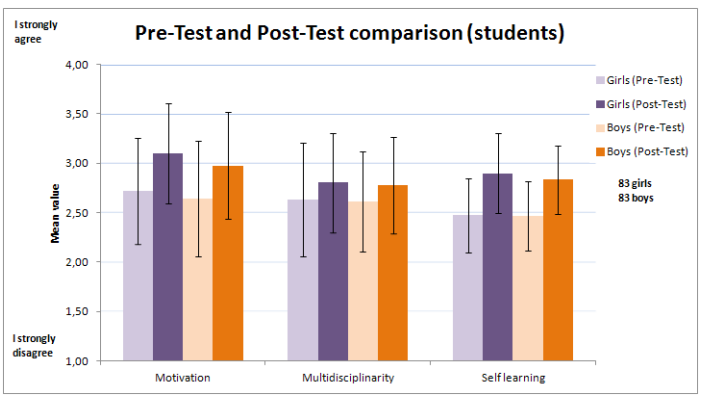

Fig. 1. Comparison of Pre-Test and Post-Test results of the students, segregated by sex

When analyzing the results for the whole group of students we found some important aspects:

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 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, 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 in this dimension is not so big as in the "motivation" and "self-direct learning and participation" ones, but it is still statistically significant.

Personal interviews were in line with the results of the questionnaires. Several students define the classes, where 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 very positive "*the increase of lab work sessions*".

Teachers

When analyzing the results of the teachers (table 3) (Fig. 2), two points are important: First, as only four teachers participated in this phase of the project, the statistical evidence is low, so we do not calculate standard deviations or statistical significance. Second, as the pre-questionnaire was used before the teachers used the *ChiK* methodology, the result of the pre-test show the expectancies of the teachers. In the pre-test, the item "*I hope that with this methodology my students could rise their interest and motivation in my chemistry classes*" had an average value of 3,75 out of 4. In the post-test, the item "*I have the feeling that the motivation of my students rises when I use teaching units from the ChiK methodology*" had an average value of 3,25. This means that, although the students´ motivation was increased with the *ChiK* teaching unit, this increase was not as big as teachers expected in principle.

Table 3.
Comparison of pre-test and post-test of teachers

Dimension	*Items*	*M (Pre-Test)*	*M (Post-Test)*
Characteristics of *ChiK*	8	2,97	3
Changes in students	10	2,93	3,13
Changes in teachers	8	3,13	2,98
Feasibility	8	2,59	2,09

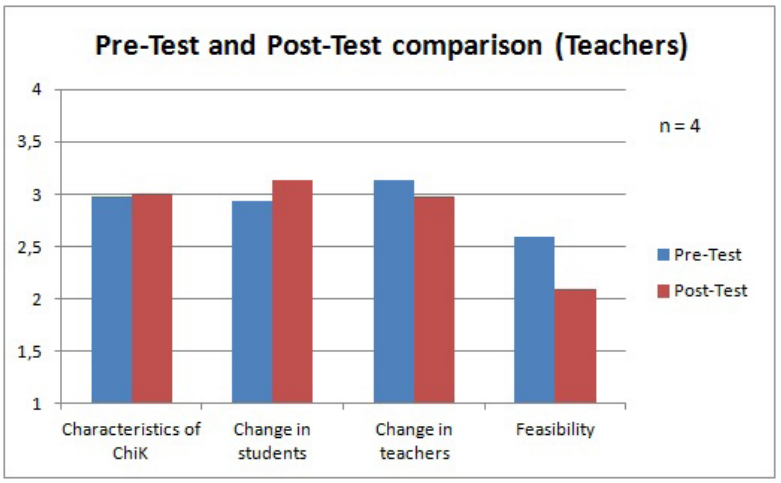

Fig. 2. Comparison of Pre-Test and Post-Test results of the teachers

The results of the questionnaires on the "characteristics of the methodology", as well as on the "changes in students" and "changes in teachers" are around a value of 3 on a 1-4 scale. Teachers had high expectations on the methodology before start using it, and that these expectations were fulfilled after using the *ChiK* methodology. All teachers stated in the interviews that their students were more motivated when using the *ChiK* methodology.

In the "feasibility" category there is a remarkable decrease in the values obtained in the post-test. All teachers believe that under the current conditions in Spain, this methodology could not be applied throughout the whole course, due to a lack of time (the syllabus is extensive) and resources (primarily manpower). Nevertheless they stated in the interviews that using the methodology for single topics from time to time would be possible.

CONCLUSIONS

The most remarking aspect regarding the student's perception of the teaching process is an increase in their motivation, comparing it with a more traditional approach. Besides, they perceive that they take a more important role in the teaching process when they use the *ChiK* methodology. This methodology also fosters the lab activities, which are appealing for the majority of the students. It is worth to mention that the students who used the *ChiK* methodology usually follow a traditional chemistry teaching that uses little or none contexts at all. With the positive results obtained during the testing of the *ChiK* methodology in this project so far, we can affirm that:

– the *ChiK*-approach can be adapted to very different situations and living environments and
– the positive effect on students' motivation seems to be quite independent from the school systems and living environment of the students.

Even considering the problems that could hinder the implementation of a complete *ChiK* course (length of the syllabus, lack of teacher experience in context-based courses…), teachers´ opinions towards this methodology were positive. Although there still remains a lot to be done, like using different contexts and teaching strategies and to focus on the teachers' perceptions and their preparation in their teacher training, we can 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 to start working on including contexts in their chemistry classes.

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