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ENHANCING STUDENTS' INTEREST IN CHEMISTRY BY HOME EXPERIMENTS

Aleksandriya Gendjova

Abstract. *This study investigates the effect of home experiments on students' interest in chemistry. The subject of the study are two groups of a total of 213 seventh graders. The control group performed traditional experiments in the classroom, while the experimental group an additional set of different home experiments. To research students' interest the following methods were used: observation, testing, survey. Results show that students from the experimental group acquired higher level of knowledge, expressed positive attitudes toward the subject, and a desire to do extra activities.This results indicate that use of home experiments to connect chemistry with the real life of the students creates the conditions for an increased students' interest.*

Key words: *students' interest, motivation strategy, chemistry home experiments.*

Aleksandriya Gendjova
Sofia University, Bulgaria

Introduction

It is known that the presence of interest in the educational process changes its character, it becomes to a greater degree conscious, active, motivated and creative. When the student participates in such type of activity, it gets personally important for him. He does not stop on the way to the knowledge, and aims to self-development lifelong. Therefore that interest has favorable effect not only on the quality and the results of the students instructional-cognitive activity, but on the complete development of their personalities as well (Krapp et al., 1992; Schiefele, 1991; Schiefele et al., 1992; Stukina, 1988; Deci & Ryan, 1985; Deci, 1992, Babalova, 2000; Genkova& Beneva, 2000). However, surveys made in Bulgaria from Babalova (2000) show that nearly 60 percent of the students learn without being interested in the natural sciences, including chemistry. Similar negative tendencies are discovered also in other countries (Lamanauskas, 2004; Lavonen et al., 2003; Martin et al., 2004).

A series of studies point at some essential characteristics of students' activity, which promote the interest in learning: purposefulness, hands-on, moderate difficulty, possibility for: autonomy, self - control, choice, success, stimulation of thinking, creation, real-world applications, problem solving, positive emotions, etc. (Davis, 1993; Edelson & Joseph, 2004; Faust & Paulson 1998; Deci & Ryan, 1985; Pintrich et al, 1994; Vollmeyer & Rheinberg , 2000; Thomas & Oldfather 1997; Pressley et al., 1992; White, 1997; Slavin, 2003; Ainley, 1998; Mc Combs**,** 1994, Genkova & Beneva 2000).

One of the potential opportunities is the engagement of students in independent experimental activity in chemistry at school. However in comparison with most European Union

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countries (Labwork in Science Education**,** 1998) in most Bulgarian schools, the number of lab exercises has decreased from 21-22 hours per year to only 6-7 hours today (Bliznakov et al.(2003) Extracurricular chemistry activity is disappearing. Almost 100 percent of the seven graders find the experimental work at school insufficient (Gendjova & Boyanova, 2005a). At Bulgarian schools the immediate engagement of students in their role of explorers is neglected. Also, in the chemistry teaching it is not expected to conduct experiments with applicable, practical character, for example with substances used in everyday life. Thus, even chemical knowledge and the respective skills remain only "science", and not "real-world activities". Students do not recognize the chemical nature and interactions of everyday substances, do not understand the role of chemistry in solving important practical tasks and daily domestic problems. Students do not see the practical use of their efforts and the benefit of acquired chemical knowledge. Our preliminary investigations of 7th grade students' opinions (Gendjova, 2007) show that students relate chemistry to its theory but do not see and do not appreciate its experimental and applied aspects. As a result, this subject has become boring and useless to them. Therefore, there is a need of revealing the connection between chemical theory and its real-world applications which may help the development of their interest in the subject.

One of the ways to solve the above problems is broadening the content and the functions of the instructional chemical experiment by including home chemistry experiments in education. We will understand under Home Chemistry Experiments relatively easy and safe chemical attempts, allowing unguided performance by pupils at home. They are made with relatively harmless substances, used in everyday life, with accessible materials and containers. Similar type of experiments are presented in Gardner, 1981; Arnold, 1997; Van Cleave**,** 1989; Parrill 2000; Van Doren,1997; Jacobsen, 2004; Cobb, 1994;.D' Amico & Eich,1996; Mandell, 1990; Ophardt, 2003 , also in a lot of internet sites. They may given by the teachers or chosen by the pupils on their own. The final goal of these type of experiments is not only to acquire instructional knowledge,but also practical skills. They often allow to reveal the connection between chemistry and real life, as a prerequisite or basis for increasing students' interest in the subject.

Methodology of Research

Our study had two main tasks. Firstly: on the basis of appropriately chosen chemical experiments to create conditions for increasing students' interest in chemistry by organizing and performing autonomous experimental activity, conventionally called "Relation between chemistry and the real world", as soon as the teaching in chemistry begins. After that to answer exploratory question: whether the application of home experimental chemistry activity in the beginning of teaching the subject will contribute to the increase of students' interest in chemistry?

The selection of home experiments was performed based on the following criteria: originality, practical and fun-like value, multidisciplinarity, stimulation of self-reliance, correspondence to the 7th grade chemistry content and students' ability. The specific design of all experiments to be performed by the students at home was aimed at creating conditions for more independent and open-ended type of activities that promote self-control and motivation (Gendjova & Boyanova 2005a, b; Gendjova 2006a)

Between ten and fifteen home experiments were offered after studying of every group of chemical elements taught in 7th grade. The full list of performed home experiments is presented in (Gendjova, 2007). Two of the experiments per group were mandatory, the rest were not mandatory. For example for II A group were presented the following mandatory experiments: At the first - *Exploration of household substances* students prepared phenolphthalein indicator papers and tested for basic properties some substances solution from the household: salt, baking soda, vinegar, soap, washing powder, shampoo, fruit or vegetable juice, tap water, diluted household bleach, diluted amonia solution. At the second *Electrolysis of sodium chloride* students obtained sodium hydroxide from sodium chloride by means of an electric battery and proved it that with phenolphthalein indicator. The rest home experiments were not mandatory: *Barbie Soap, Coloring Without Crayons, Ice On A String* (Ophardt, 2003), *An Active volcano* (Van Cleave, 1989); *Blowing Up A Balloon with Lemon Juice* (Mandell, 1990), *How phenolphthalein indica-*

tor is changed in gelatine solution (Olgin, 1995), *The Fireproof fibre* (Stoyan, 2002), *Color crystals* (Arnold, 1997) and others.

The experimental tasks, defined as mandatory, were to the greatest extent connected to the curriculum, while the rest were defined as optional. It was guaranteed to the students that their grades in chemistry would not be affected by both the mandatory and optional experiments. After the students had chosen their tasks the teachers distributed special worksheets with the tasks, gave the necessary instructions and clarified the safety rules. Students were given the option to do any of the remaining experiments in the group if interested in doing so. After the experiments were performed, the teachers collected the worksheets and talked to their students about their activity and the results from it (Gendjova & Boyanova 2005a, b)

From what was already said it may be concluded that interest is manifested in character of activity and its results. In order to evaluate student's interest in a complex manner, three methods for evaluation were used in the present study: observation of students' behavior, tests of their acquired knowledge, and survey of students' opinions (Babalova, 2000; Markova et al., 1990; Baranova, 2005).

Overview of the experimental design is presented on figure 1.

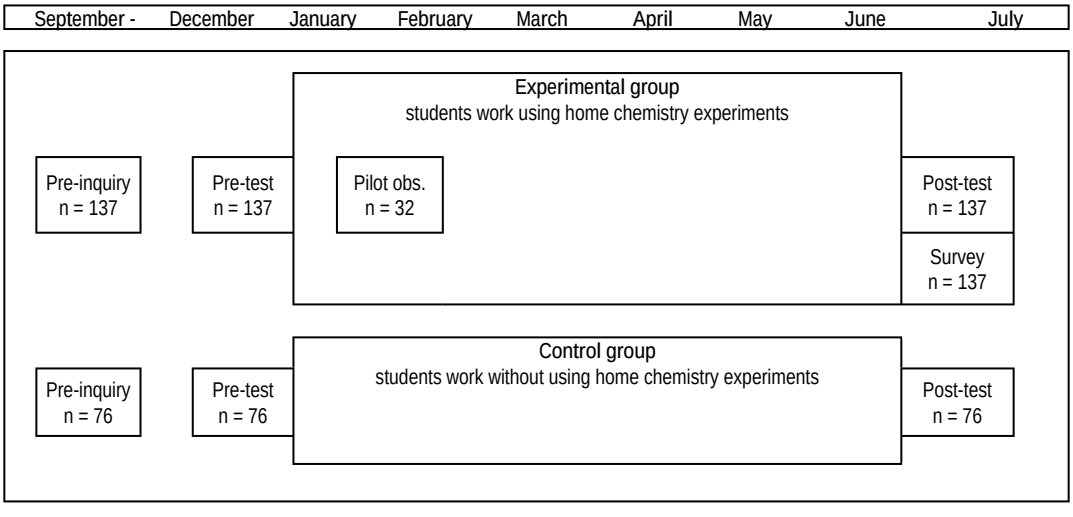

Figure 1. Overview of the experimental design.

The subject of this study was two groups of seventh graders from three different Bulgarian schools. Both groups consisted of students of similar abilities. They are assigned after pre - tests and accountancy to the students' results in chemistry from the first instructional term. Thus, they represent independent sample. The control group followed the traditional curriculum performing experiments in the classroom. In addition to school experiments, the experimental group performed also experiments at home. As a whole, 402 seventh graders participated in the study – 189 in the preliminary study of 2004/05 and 213 students in the study performed in 2005/06.

Pilot observation

The goal of the pilot observation is to give an initial idea of home experiments' influence on the formation and development of students' interest. In order to evaluate the effect of experimental activity on students' interest in chemistry at school conditions. The behavior of a pilot group of 32 students was measured according to Baranova (2005). Twelve chosen criteria some of which were partially modified: preliminary preparation for work; type of experimental task chosen; emotional attitude; degree of concentration during work; independence; dynamics of the emotional state; attitude towards the contents and the formal side of an experiment; desire to go on with the experimental work; willingness

to complete the task; aspiration to perform the task conscientiously; total number of performed tasks; attitude toward the obtained result.

To evaluate the observed phenomena an assessment of the degree of their manifestation a rank scale was used. Low, average and high levels of agreement corresponded to ratings of 0, 1 and 2 respectively. If a student shows a high degree of interest, he or she will receive a maximum score of 24 points. When the actual score of every student is divided by the maximum score, a relative coefficient is obtained. This relative coefficient shows the degree of interest manifested by each student. This coefficient is conditionally called "coefficient of interest". In the present survey which is based on similar surveys (Markova et al., 1990; Baranova 2005) the degree of interest is assessed using the following scale (see Table 1).

Table 1. Scale for assessment of the degree of interest.

% of max. Score	Coefficient of interest	Degree of interest
0 — 29	0—0.29	Insignificant
30 — 49	0.30—0.49	Weak
50 — 69	0.50—0.69	Average
70 — 89	0.70—0.89	Strong
90 —100	0.90—1.00	Very strong

Pre- and post-experimental tests

The goal of the tests was to establish the levels of the students' knowledge and skills as an indicator of their interest before and after using the home experiments. The tests were administered to a total of 213 seventh grade students, both from the control and from the experimental group. The tests, marked as Test 1 (Pre-test) and Test 2 (Post-test), consisted of multiple-choice and open-ended answers (Gendjova 2007). They aim to measure the results of the learning (relating the acquired knowledge) of instructional content of chemistry in the seventh grade (Bliznakov at al., 2003).

In addition, the test questions reflected the practical, real-world side of chemistry.

For example: One of the post-test open-ended questions was:

"At home you come across a bottle of preparation of cleanup without a label, containing uncolored liquid. Your parents suppose that this is a preparation for cleaning ceramic tiles, containing acid. Describe how you would prove experimentally the presence of an acid in the solution? What safety requirements in the work with acids would you observe? Describe how would you act if you accidentally drop some acid on your hands?"

Tests 'results are presented by variable: average value of coefficient of acquired knowledge K_x, where K_x= student's score /maximum score for test. The statistical analysis of experimental data was performed. The normality of the empiric distribution is checked using the χ^2 criterion according to Claus & Ebner (1971). It was established that the results of the tests of two groups are distributed normally. Therefore, parametric criteria were used. The Fisher's test for comparison of data set variations was used. The comparison between the average values was performed using the confidence interval. Including of "0" in confidence interval is indication for non-significant difference between compared average values according to Massart et al. (1997).

Survey of students' opinions

The survey aims to investigate students' views along the following criteria: self-evaluation of students' work; difficulties they meet; extent to which students understand and apply the acquired knowledge and skills; feelings experienced while performing the home experiments; desire to engage in additional cognitive and experimental activity; and change of attitude towards the subject matter. In addition, students were given the opportunity to express freely their opinions and impressions about the performed home experimental activity. The survey was conducted with 137 seventh grade students.

Results of Research

Pilot observation

The relative frequency distribution of degree of interest, manifested by students from the pilot group (n=32) working with home chemical experiments is shown in Figure 2.

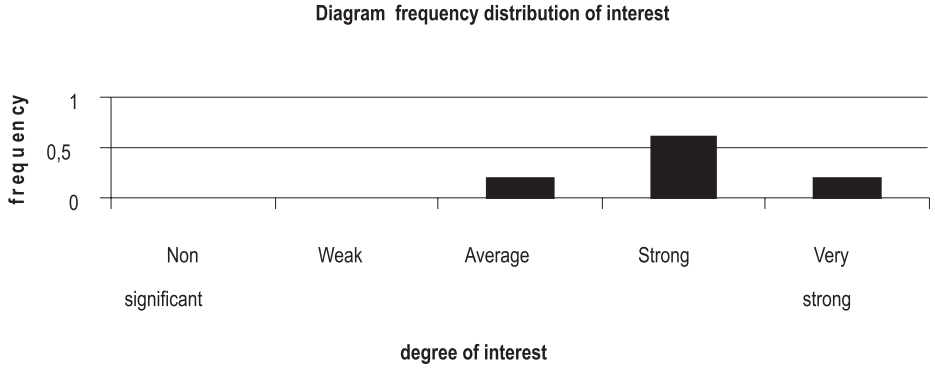

Figure 2. Frequency distribution of interest of pilot group students (n=32).

The results of comparing boys and girls interest are presented in Figure 3.

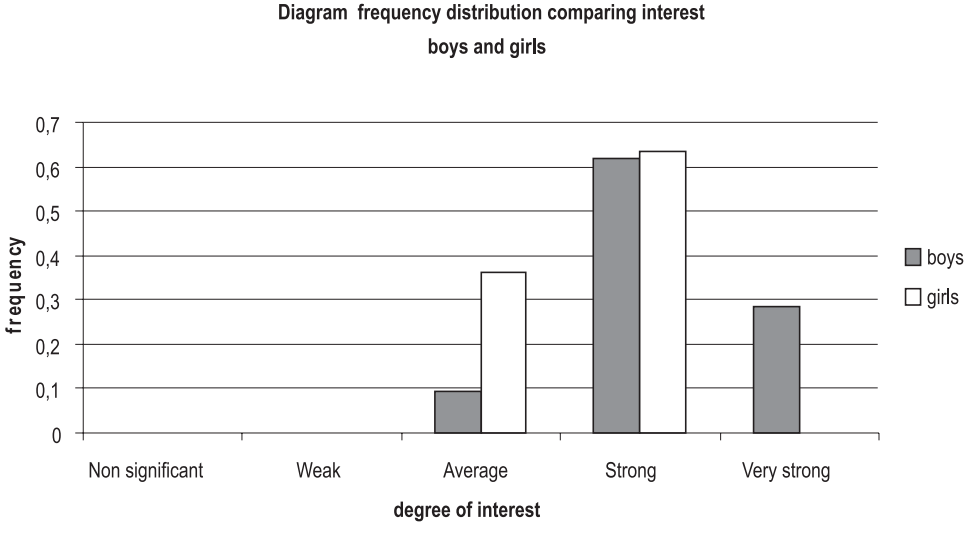

Figure 3. Frequency distribution comparing interest shown by girls and boys in pilot group.

Pre-and posttests

Tests 'results are presented by the following statistics: average and variance of K_x, where K_x= student's score /maximum score for test in table 2.

Table 2. Basic statistics.

Test	Group	Number	Average K_x	Variance
Pre-test	Control	76	0.67	0.043
	Experimental	137	0.66	0.034
Post- test	Control	76	0.68	0.048
	Experimental	137	0.81	0.019

In the table 2.1. are shown comparing of group variances by p –value, and comparing of group averages by confidental interval D.

Table 2. 1. Comparing of groups values.

Comparing of group variances			Comparing of group averages		
Test	**Group**	**p -value**	**Test**	**Group**	**Conf. interval D**
Pre-	Control&	0.12	Pre-	C & E	0.47; -0.49
	Experimental		Post-	C & E	-0.07; -0.18
Post-	Control&	1.10^{-6}	Pre- & Post	Control	-0.06; 6.80
	Experimental		Pre- & Post	Experimental	-0.07; -0.18

Additional information was obtained when all test questions were classified into three categories (levels) using Bloom's taxonomy (1984): recall data; comprehension; application**.** The results by average value of coefficient of acquired knowledge K_x are shown in a Figure 4:

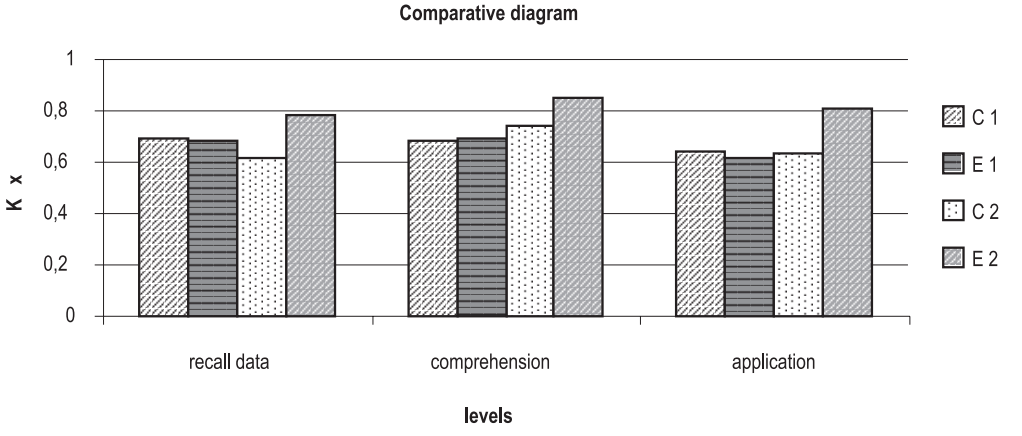

Figure 4. Comparative diagram of both groups tests results shown by knowledge levels.
Legend: C 1, C 2 – pre-and post-test results of control group; E 1, E 2 – pre-and post-test results of experimental group.

Survey of students' opinions

The results of the survey are presented by the relative frequency of students' assessment in percents in table 3. Some of survey' results are published in Gendjova, 2006b.

Table 3. Results of Survey of students opinions.

Aspects of students assesment and their relative frequence in percents							
A. Students' assessment of the home experimental activity (%)							
excellent	very good	good	fair	poor			
52	39	9	0	0			
B. Students' assessment of the home experiments difficulty (%)							
very easy	relative easy	difficult	very difficult				
7	83	9	1				
C. The difficulties, which the students have faced (%)							
no difficulties	preparation of the experiments	performing of the experiments	explanation of the experimentation	lack of time and other			
72	14	7	4	3			
D. Students assessment of self- ability understand and explain the phenomena' essence (%)							
can fully explain	can explain incompletely	can not explain					
58	40	2					
E. Students' emotions experienced by the students in the course of the experiments (%)							
joy	satisfaction	impartiality	boredom				
66	30	4	0				
F. What students liked most when they performed home experiments (%)							
the final result	the visible effects	everything	independence	novelty	the success	domestic materials use	other
33	21	17	12	8	4	3	2
G. Students' assessment of acquired knowledge and skills by home experiments (%)							
I have learned	I have learned, but want to learn more	I have learned little	I have learned nothing				
45	40	13	2				
H. Applicability of the acquired knowledge and skills by the home experiments (%)							
only at home	in life as a whole	only in chemistry lessons	not applicable				
39	39	20	2				
I. Students' necessity of doing experiments at home (%)							
yes, of course	rather yes than no	rather no than yes					
76	21	3					
J. Change in students' attitude to chemistry (%)							
in a positive way	no change	in a negative way					
85	13	3					

Discussion

Pilot observation

The conducted observation of the students' behavior as a whole showed a presence of significant manifestations of interest. The seven graders participated in home chemistry experimental activity with willingness. They were concentrated, worked actively, conscientiously and independently. Students did not experience any difficulties during their experimental work and its explanation. Seven graders wanted to continue the activity and kept their general positive emotional attitude towards the work. Quantitative data show also that there were no uninterested students (see Figure 2). Nearly all of them showed strong or very strong interest in the experimental activity and no one expressed weak level of interest. There was, a gender gap between boys and girls (see Figure 3). There were no girls expressing very strong interest in the experimental activity and very few boys expressing just an average level of interest.

The pilot observation provided us only with some initial information about the positive effect of the home experiments on the interest among the students.

Pre-and posttests

After comparing of tests groups values (Table. 2.1) the following conclusions can be drawn:

- There are significant differences between the control group's achievements and those of the experimental group after performing the experimental activity;
- The experimental group's results on the post-test were significantly higher than those of the control group;
- There are also significant differences between the results of the experimental group at the beginning and at the end of the activity.

That difference is a clear indicator of the effect of using home chemical experiments on the instructional results, as criteria of the students' interest.

The analysis of the results classified into some knowledge levels from the experimental group indicated following: There is a certain augmentation in the recall data level, a less increasing in the comprehension level, and a signigicant enhancing level of knowledge application.

This means that the use of home experiments improves students' acquisition on all three knowledge levels. However, the most positive effect of the home experimental activity was most pronounced in recall-data and application knowledge levels.

Survey of students' opinions

As a whole, students appreciate very highly the home experimental activity (Table 3.A). This positive assessment is an indicator of a general positive attitude which is a pre-requisite for the formation of interest among the students towards chemistry.

Most seventh graders think that the experiments they have performed were not difficult (Table 3. B).The fact that they find themselves competent to perform the experiments is a condition for the development of their interest in the subject.

The survey of the difficulties the students have faced (Table 3. C) indicates that the seventh graders experience more difficulties in the preparation of the experiment (finding materials) than in performing and explaining it. This shows that the home experiments have been accessible, in conformity with the students' age and abilities. The large number of students, who share the opinion that they did not face difficulties in conducting and explaining the home experiments shows that they feel confident to manage and control their own experimental activity, which is a condition and an indicator of interest in chemistry.

The results of study of students' assesment of their ability to understand and explain the essence of the observed phenomena show: More than a half of the students think that they can fully explain the experiments performed by them, and a comparatively large part reckon that they can present an incomplete explanation (Table 3. D). The experiments have remained apparently inexplicable to a

small portion of them. The students' opinions show their self-criticism of the not high level of mastery of chemical knowledge and skills, and in particular the insufficient formation of such specific skills as presentation and explanation of the experimental results. This is due, on the one side, to their early stage of education in chemistry and on the other, to the comparatively small number of lab classes during the school year.

The research of the effect of the home experiments on the students' emotions (Table 3. E) indicate that almost all students experience positive emotions in the course of the experiments, which is an indicator of the presence of interest in chemistry.

Students offered various responses to the open-end question 'What did you like most when you made the experiments?' (Table 3. F). This variety of the answers can be interpreted in several ways. On the one side, it shows the possible reasons for the positive emotional attitude towards the experiments like the appearance of something new, different, unexpected; the contact of the students with the concrete phenomena; the opportunity to see familiar materials from everyday life in a new way; the chance to work independently in a new field and to accomplish success. On the other side, the answers show different motivation of the students to conduct the experiments like presence of cognitive motives, interest and curiosity, as well as such motives as development of self-confidence and a sense of achievement.

To the question 'Have you acquired more knowledge and skills by the home chemistry experiments?' the students answered in a variety of ways. Nearly half of them answered that they have, less than half responded that they have, but want to learn more. A comparatively tiny portion thinks that they have learned little or nothing (Table 3. G). These results display that the experiments were useful for acquiring more chemical knowledge and skills to a very large part of the students. The fact that more than one third of the students wish to learn something new, is interesting. This aspiration of the students to make an effort and to grasp the essence of the observed phenomena is a certain indicator of interest in the subject as a consequence of their independent experimental activity at home.

The views of the students regarding the question about the applicability of the acquired knowledge and skills by the home experiments are divided (Table 3. H). The large percentage of students who believe in the applicability of the acquired knowledge and skills shows students' awareness of chemistry's importance in their own life and as a prerequisite for further development of their interest.

After the performance of many home experiments students' views about the necessity of doing experiments at home are searched (Table 3. I). The large number of positive answers shows the need of the students to perform home experiments. This is an expression of their free choice to participate in independent experimental activity in chemistry, which would make them satisfied and is an indicator of their interest.

Students are expressed the opinion that the home experimental activity has improved their attitude towards chemistry (Table 3. J). The number of students with a negative attitude is insignificantly low. The presence of a high appreciation of the subject is a qualitative indicator of the appearance of interest in the students.

Conclusion

Home experimental activity in chemistry at the seventh grade level lead to:

- higher level of acquired knowledge (recall data, comprehension and application);
- increased students' sense of self-confidence and satisfaction;
- a positive change in their attitude toward chemistry as a subject;
- a demonstrated desire to learn more;
- better understanding of the practical applicability of their knowledge and skills;
- a demonstration of positive emotions, caused by the activity and its results;
- an expressed desire to broaden their own horizons by additional extracurricular and real-life oriented activity in chemistry.

These results substantiate the belief that the use of home chemical experiments to connect chemistry with the real life of the students creates the conditions for an increased students' achievement and interest in the subject.

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Aleksandriya Gendjova

Research Laboratory on Chemistry Education
and History and Philosophy of Chemistry,
Department of Physical Chemistry, University
of Sofia,
1 James Bourchier Blvd., 1164 Sofia, Bulgaria
Phone: 35928161395
E-mail: agendjova@chem.uni-sofia.bg