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José Peñaranda Armbrecht

Georg-August-Universität Göttingen

Alberto Aragón-Muriel

Public Health Laboratory, Valle del Cauca, Col…

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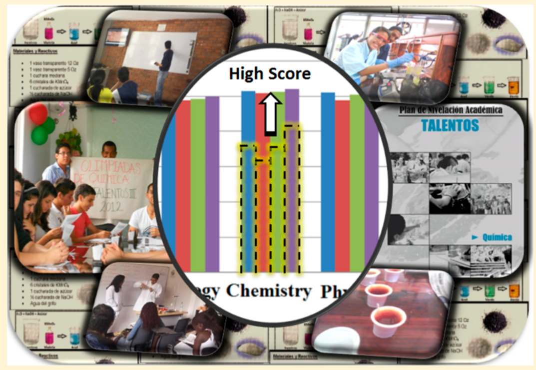
Description and Preliminary Evaluation of a Program for Improving Chemistry Learning in High School Students

José Peñaranda Armbrecht,*[,†] Alberto Aragón-Muriel,[†] and Germania Micolta[‡]

Talents Plan - Chemistry School, Universidad del Valle, Cali, AA 25360, Postal Code 76001000, Colombia

S *Supporting Information*

ABSTRACT: High school students have had some difficulties in understanding chemistry due to traditional ways of teaching this specific science. It is important to improve teaching methods that increase student motivation, not only to enhance their capacity for understanding, but also to generate a greater level of interest in the study of chemistry for their future professional life. Current technologies such as the virtual campus, which complements theory classes with class laboratories, help students feel better trained and more confident about scientific world. This improvement was reflected on the SABER 11° test results in chemistry made up by the Colombian Institute for Educational Evaluation (ICFES in Spanish), which were applied to the students of the leveling program "National Academic Talent Plan" (PNAT). This study found a positive effect when comparing pre-test and post-test scores (effect size of 0.61, *moderate difference*), and it was also observed an increase in the number of students placed at the medium standard and medium high range. This paper presents a description and preliminary evaluation that can be used for teaching chemistry to high school students, along with the results on standardized tests for students participating in the equalization program that applied the methods noted.



KEYWORDS: *Laboratory Instruction, High School/Introductory Chemistry, Distance Learning/Self Instruction, Communication/Writing, Humor/Puzzles/Games, Textbooks/Reference Books, Testing/Assessment, Continuing Education, Computer-Based Learning*

Colombian high schools represent the most forgotten level of education in national educational policy. For more than 10 years, the main goal regarding the quality criteria for education in Colombia has been to reach the educational expectations of the national test and achieve the reforms recommended by international evaluation.[1] The ICFES is an entity specialized in offering educational evaluation at all levels, in particular it supports the Ministry of National Education in conducting state tests and looks forward to advance research on factors affecting the quality of education. The ICFES exam is a standardized test known as SABER 11°, and it is applied to students in their last two years of high school (11th or 12th). The ICFES is in charge of the development and socialization of this test; also this test measures academic skills of the students and how deep they are prepared to start public or private college undergrad studies.

Colombian participation in the Program for International Student Assessment (2006) was the first in its history, reflecting the country's commitment to improving the quality of its educational system.[2] Chemistry education has also been neglected in our country, and unfortunately, many aspects aimed to improve the quality of high school education have been ignored. This fact is directly related to admissions for undergraduate studies. There are few studies on improving chemistry teaching methods in Colombia. One example involves a tool widely used in the teaching of natural sciences: conceptual maps. The study revealed methodologies to assist in the process of self-evaluation of knowledge in chemistry.[3] Work on evaluation methods for teachers and students in chemistry have also been of great interest.[4−6] Novel activities, such as educational games, educational and mobile laboratories, have been implemented to promote interest in the study of chemistry at the high school level.[7,8]

For the reasons described above, and in order to improve the quality of secondary education in Santiago de Cali (Colombia), the National Academic Talent Plan, PNAT, has been developed to achieve better results on national tests. This program was an outgrowth of a strategic alliance between the Universidad del Valle and the Office of the Mayoral of Santiago de Cali in April 2009, with the aim of improving the academic competence of young Cali students that for economic reasons and personal guidance, fail to access superior education. Since then, there were opened three cohorts (years): the first in August 2009 -to April 2010, the second in August 2010 to April 2011, and the third in August 2011 to April 2012, each one with an income of 1500 high school graduates. The selection process consisted in inviting young people to apply to the open call for the Mayoral of Santiago de Cali, verifying compliance with the selection

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criteria, which were the following: (1) being high school graduate from a public or private school in Santiago de Cali town or townships, having presented the SABER 11° test, (2) being under 23 years old at the closing date of registration, and (3) housing at levels 1, 2, and 3 (for low-low to low-medium socioeconomic status), regardless of gender. For the selection order, priority was devoted for the youth belonging to lower socioeconomic status, lower age and high school graduates in public schools. These 1500 participants were organized in groups of 35−40 students, who rotated daily in different classrooms according to scheduled learning areas. In the first year, chemistry was taught by physics teachers; for this reason, in this article the authors do not show results for the first year. The chemistry area (since second year) provides classroom teaching once a week for each group. The program invites nominations for the city of Santiago de Cali, and those interested participate in the selection process for free. The PNAT also helps to bridge these differences in terms of public versus private schools, the last of which usually access better resources and thus probability to obtain better results on national tests.

This program is managed by the Universidad del Valle, one of the most prominent public universities in Colombia, whose teachers have a high knowledge regarding their areas and SABER 11° tests. For PNAT teachers, it is very important to deeply understand the structure of the SABER 11° test both for application purposes and for improving student's knowledge in this program leveling. In the development of the test and the application of these improvements in the PNAT, argumentative, interpretative, and proactive type questions should be considered in all areas. For instance, in Chemistry it is important to focus on the interpretation of situations, the setting of conditions, and an approach for formulation of hypotheses and regularities, concerning the physicochemical and analytical aspects of substances. In Violence and Society, the social-economic conflict and political violence in Colombia are unveiled; and in terms of environment, different baselines should be analyzed and discussed.

Therefore, this study originated from the need for imparting high school students with high analytical qualities through the development of skills evaluated by ICFES. The chemistry component in PNAT proposed and implemented teaching methodologies that contributed to the development of competences in Chemistry and others areas included within competencies in Natural Sciences.[9] For this, special reference is made to the following:

(1) *Analytical aspects of substances*, including aspects related to the qualitative and quantitative analysis of substances. On the one hand, problems seeking to establish the nature of chemical components and their distinguishable properties are evaluated; on the other hand, situations regarding the amount of each of the compounds to be determined are also evaluated.

(2) *Physicochemical aspects of substances*, the composition, the structure, and characteristics of the substances from the atomic-molecular theory and from the thermodynamics are analyzed. The first reference shows how atoms, ions or molecules are, as well as how they relate to their chemical structures; the second allows to understand the thermodynamic conditions in which there is greater likelihood that a material, change physical or physicochemically.

(3) *Analytical aspects of mixtures*, the components of a mixture, such as features that can be differentiated from each are described qualitatively. The quantities and proportions of the elements that make up the mixture are determined, and its distinctive features are measured. Therefore, not only the techniques for the recognition, measurement, or separation of mixtures are discussed, but also the theoretical considerations on which they are based.

(4) *Physicochemical aspects of mixtures*, whose interpretations are made from atomic and molecular theory. These statements characterize the discontinuous view of matter (consisting of particles) and, from the thermodynamics point of view, place the materials in terms of their energy interaction with the environment. From the first referent, the formation of chemical entities (atoms, ions or molecules) that make up any material and how they interact according to their constitution is interpreted. Additionally, following the thermodynamics, the conditions under which the material can form the mixture (relative pressures, volume, temperature and number of particles) are also included.

■ DESCRIPTION OF CHEMISTRY ASPECTS OF PNAT

In test development and application in the PNAT, we considered asking argumentative, interpretive, and purposeful questions. The understanding of natural sciences in the context of daily life is acquired gradually through experiences that reflect the studenťs curiosity and knowledge of the language and principles of science gained through schooling. Consequently, tests that constitute part of the state exam in Chemistry seek to evaluate the ability of students to establish connections between ideas and concepts from contexts of science and other areas of knowledge. They also seek to make use of student's critical capacity to assess the quality of information in establishing their own position. The modern world requires individuals to interpret and act socially in a thoughtful, efficient, honest and ethical manner.[10] Along these lines, the chemistry component of PNAT presents teaching methodologies to promote the development of competencies in Chemistry and other fields included within the domain of natural sciences. Figure 1 summarizes the classroom, laboratory and online components of this program and its inter-relating features. Face dedication time to students was 3 h per week (2 h of class and 1 h laboratory class), and the dedicated distance period depended on the student's ability and interest to work online.

Lectures and Module

Lectures are developed in two ways: first, through presentations with slide projector where relevant chemistry themes are exposed in units through slide presentations. Second, the teacher uses other resources, such as the board, where slide topics are more specifically noted and clearly explained. In addition to that, students are assigned tasks and additional work either online or in class. They also have a module where all the chemical units are presented (Unit 1, Matter, Elements and Compounds; Unit 2, Stoichiometry; Unit 3, Structure of Matter; Unit 4, Bonds; Unit 5, Gases; Unit 6, Solids and Liquids; Unit 7, Thermochemistry; Unit 8, Solutions; Unit 9, Chemical Balance; Unit 10, Ionic Balance; Unit 11, Chemical Kinetics; Unit 12, Organic Chemistry; and Unit 13, Biochemistry). This module, which was drawn from the year II as a curricular book, is free and delivered within the PNAT facilities in order to adapt concepts and develop practical exercises that are not considered in the lecture. The module (book) is also found included in the MOODLE online course management system. With this methodology the students are

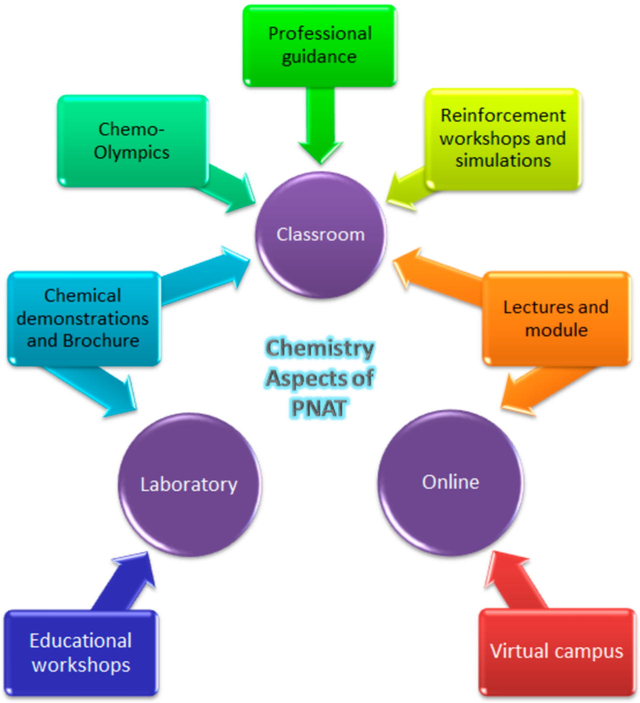

Figure 1. Interrelationship diagram for the major components in Chemistry Aspects of PNAT.

able to develop skills that ICFES evaluates in chemistry and in the natural sciences.

Virtual Campus

For weekly evaluation of the topics covered in class, a MOODLE online course management system was implemented by the Universidad del Valle. The assessment consists of 10 multiple choice questions, and is intended primarily to prepare the student to take the SABER 11° test. These assessments were performed weekly for 30 min and were rated on a scale from 0 to 5, low to highest score, respectively. The questions were stored on the database of the virtual campus and made available for any subsequent application. In addition to these assessments, there are readings for each study unit, workshops, videos, virtual applications and links of interest included in the platform by teachers. In the virtual campus, teachers have the option of creating a chat account to interact with students. This method often facilitated the dissemination of information throughout the students. The new informational technologies in the Virtual Campus allowed students to have access to the module in digital form.

Chemical Demonstrations and Brochures

Another teaching practice that deals with the lack of familiarity of laboratories by students consisted of demonstrating chemical applications (in the local high school) by using easily accessible chemical reagents to illustrate the theoretical concepts being studied. These experiments conducted by the instructor (undergraduate chemistry student from the Universidad del Valle) were complemented by a "Brochure" which contains a summary of the topics covered in class, the list of materials and chemicals used in the demonstration, the procedures performed and questions related to the experimental section. This allowed strengthening of comprehension on a variety of issues. In some of the developed experiments under the supervision of the teacher and instructor, students of PNAT participated actively managing simple and low risk materials, because the intention of the lab class is to provide greater understanding of theoretical concepts through the practice. The activities in which students participated include determination of pH in household products, using indicator paper prepared with cabbage juice; factors affecting the rate of reactions, using a tablet of Alka-Seltzer and cold and hot water; preparation of "crazy ball" using white glue, borax, food coloring (the program provides basic security features such as latex gloves), among others. This last experiment was intended to modify the properties of a polymer (polyvinyl acetate); among others. The proposal for a laboratory activity and example for brochure (Ionic Equilibria) is in the Supporting Information. These experiences were supported by a short video presentation (downloaded from different web pages) for the student to facilitate an understanding of the application of chemistry developed in each unit and helped them to perform laboratory activities on their own using these resources as a guide.

This teaching methodology seeks for the students to gain confidence in proving that chemistry is not such an "unreachable" task and that it was simple to perform an experiment. The practice helped encouraging them positively toward chemistry, and convincing them that it was not just a task for advanced scientists. Also, the students were able to develop skills in the comprehensive use of scientific knowledge, which is closely related to the ability to understand and to use concepts, theories and models of science in solving problems. The students participate in all the chemical demonstrations, due to its simplicity. It is expected that the mayoral of Santiago de Cali together with secretary of education promote this type of practice in city high schools.

Chemo-Olympics

One of the best tools accepted by PNAT participants was the development of the Chemo-Olympics. It was presented as a competitive-evaluative tool where technological resources were used (e.g., a computer and a Video Beam) in the submission of a slide prepared with questions of differing difficulty (see Supporting Information). Teachers organized the questions into three categories: easy, medium and hard, each with a score (and response time), i.e., 10 points (1 min), 20 points (2 min), and 30 points (3 min), respectively. Each group had an opportunity to respond in turn. If they answered correctly, it was noted on the accumulated score and all groups were given the option of immediately responding with the respective justification. Groups were formed of 3−5 students (8 groups per course, for a total of 80 groups per day or 320 per week). The competition began in the classroom, to afford recognition of the group winner. The Chemo-Olympics were held for 3 h every day for 2 weeks. Groups were competing for the highest score. In the third week, the winning groups competed with each other to obtain one representative per class who participated in the final. In the fourth week, three teachers serving as jurors were responsible for completing the competition by consecutively posing three open questions per day. Thus, the first three students who adequately responded to the questions were determined winners and were both recognized and rewarded. This activity was carried out in the last month before submitting the SABER 11° test to maintain continuous training. In addition to covering the four skills of the chemistry component (analytical aspects of substances, physicochemical aspects of substances, and the analytical and physicochemical aspects of mixtures), the Chemo-Olympics allowed for a wide inquiry concerning the ability to ask questions and review procedures, and to search, select, organize and interpret relevant information in answering these questions. The science inquiry process involved looking closely at the situation, asking questions, searching for cause-effect relations, using books and other informational resources, making predictions, posing experiments, identifying variables, and performing measurements, in addition to organizing and analyzing results.

Reinforcement Workshops and Simulations

To obtain more thorough results for indicating the efficiency of the methods mentioned above and to promote continuous improvement, face-to-face Reinforcement Workshops were developed and implemented that were applied in the weeks before the presentation of the SABER 11° test. The method consisted of using an evaluative work tool with the intention of developing skills in chemistry. The workshop started with a question being posed. Depending on the correct answer, it continued with a logical sequence of multiple choice questions having unique responses. This compelled the student to correct mistakes from the previous question and was a good strategy as it forced the student to evaluate their response and find the correct answers for each question. Example for Reinforcement Workshops is in Supporting Information. This was a written activity under the guidance of an advisor and instructor.

The PNAT simulations consisted in written tests and were conducted twice during the duration of the year group as students faced similar challenges with multiple choice questions from all areas offered. Improving performance and academic quality was the purpose identified. Also, these simulations were used to allow students to follow-up on their performances during the semester. By employing this teaching method, it was hoped that the student would be motivated to develop skills, such as communication, group work, and greater willingness to recognize the social dimension of knowledge and responsibly assume it, as presented in other studies like the impact of motivation on learning of secondary school students.[11] In addition, the virtual evaluation and simulations promoted readiness for the SABER 11° test as there were questions involving inquiry, analytical aspects of substances, physicochemical aspects of substances, and the analytical and physicochemical aspects of mixtures.

Professional Guidance

Given that the student community of PNAT involves the secondary educational level, it has students who wish to enter higher educational institutions. As a consequence, we provided career orientation information for careers in chemistry that showed the application of this science and its worldwide relevance. The topics developed (for 3 weeks) were as follows: (1) Chemistry: professional guidance (see Supporting Information) and life applications, (2) Chemistry projects developed at the Universidad del Valle, (3) Movie: Lorenzo's Oil. For the first topic, slides entitled "Chemistry as a central science" were presented which relate chemistry directly or indirectly to professions which the students wish to access. The second topic had teachers present their experience in industry and research, as well as the part of their undergraduate and graduate work done at the Universidad del Valle. This was relevant as most students wanted to enter the university. Also, an experimental activity class was developed where the student became a participant in activities of the discipline. For the third topic, chemical applications in medicine were highlighted with the presentation of the movie "Lorenzo's Oil". This movie illustrates a case drawn from real life where biochemistry played an important role in society.

Educational Workshops

Students interested in education were trained to develop educational workshops under the guidance of a teacher and an instructor in the chemistry area, referred to as "Development of cleaning and toilet products" and "Perfumes and chemicals in everyday use". The workshops consisted of 2 h per week of theoretical class about developing products (history and chemical basis) and then a lab experience with intensity of 4 h per week to make the product. Necessary material for the development of workshops, as well as safety instruments, was provided by the Talents Plan, and an initial training for laboratory equipment and safety standard was given. These encouraged safety in handling of instruments. The objective was that, through education, students nurture their interest in learning chemistry through positive experiences and increasing confidence in dealing with scientific environments. These workshops support the development of a scientific laboratory course, similar to that developed in the chemistry department at Washington & Jefferson College.[12] The workshops were offered by the Area of Chemistry which had the top enrollment, a fact that has been noticed and positively evaluated. We observed many young people becoming comfortable with their orientation and interest in professional chemistry programs. Finally, the processed products were presented to the community at an event scheduled by the Universidad del Valle and the Office of the Mayor of Santiago de Cali to give closure to the leveling program. Examples of these application activities can be seen in Figure 2: nail polish, scented candles, perfumes and splash, teacher instruction for handling laboratory materials.

Figure 2. Activities and products carried out in "Perfumes and chemicals in everyday use".

■ EVALUATION RESULTS AND DISCUSSION

The Direction of New Technologies and Virtual Education at the Universidad del Valle collected individual data on PNAT participants through a descriptive secondary analysis of the National System of Educational Evaluation (consultation for results SABER 11° test).[13] The tables and graphical presentation of the data was conducted by PNAT for the Academic Information System.[14] The SABER 11° test results in the chemistry area (see Supporting Information) were analyzed using the absolute average stated in the "Comparative Report" and the "Tiered Consolidated Report" contained in the PNAT Information System.

The analysis of SABER 11° test scores for admission of the total population, and finals for 117 (7.4%) and 952 (63.9%) participants (percentage of participants) from years II and III, respectively, enabled us to organize the most relevant results (absolute averages scores and maximum points in the chemistry complement). This information is presented in Table 1 and Figure 3. To determine the standardized mean difference, the effect size (Cohen's d) was calculated using eq 1,[15] comparing the mean pre/post scores; the standard error of the effect size (σ_d) was determined using eq 2.[16] The maximum limit (L_{max}) and minimum limit (L_{min}) of effect size were determined using eqs 3 and 4, respectively, for 95% confidence interval.

Table 1. Initial and Final Average Scores in Chemistry for PNAT Participants and Effect Size

SABER 11° test	Year II Initial	Year II Final	Year III Initial	Year III Final
Average, in ICFES score	49.66	54.40	45.99	51.35
Standard deviation (S), in ICFES score	6.44	8.11	6.68	8.16
Variance, in ICFES score	41.50	65.80	42.61	66.57
Median, in ICFES score	49.45	55.00	45.69	51.00
Mean, in ICFES score	49.12	54.10	45.05	50.00
Maximum, in ICFES score	70.32	72.00	76.27	87.00
Minimum, in ICFES score	35.02	35.00	25.14	27.13
Participants (N)	117		952	
Effect size (d)	0.61		0.61	
Standard error (σ_d)	0.13		0.05	
L_{max}	0.87		0.70	
L_{min}	0.35		0.52	

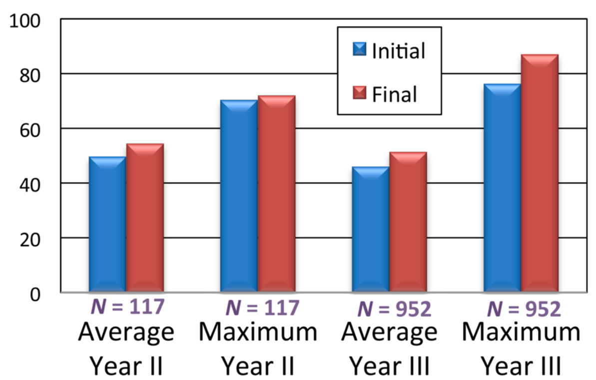

Figure 3. Averages and maximums ICFES scores in chemistry for PNAT students.

$$d = \frac{\bar{X}_{\text{post-test}} - \bar{X}_{\text{pre-test}}}{S_{\text{post-test}}} \quad (1)$$

$$\sigma_d = \sqrt{\frac{N_1 + N_2}{N_1 \cdot N_2} + \frac{d^2}{2(N_1 + N_2)}} \quad (2)$$

$$L_{max} = d + (1.96)\sigma_d \quad (3)$$

$$L_{min} = d - (1.96)\sigma_d \quad (4)$$

The results in terms of the effect size presented in Table 1 show that the values determined for the effect size (d) are similar both for Year II and Year III. Therefore, we can infer that improved teaching methods in this study provided the same effect for those two years. A value for d = 0.61 indicates that the average in the group with the highest mean (post-test) surpasses in the group with lower mean in 73% (determined by the normal distribution table),[17] whose effect size is considered *moderate difference*, according to the orientations proposed by Cohen.[18] All this indicates that there is indeed a positive difference generated by the application of PNAT program to the participants of this study, and that it is worth continuing with the program. As might be expected, the standard error of the effect size is smaller when the means of large groups are compared. This is the reason the 95% confidence interval is lower (0.52, 0.70) in the year III. To further our undertanding, a new study is recommended using large groups as in the year III.

The results illustrated in Figure 3 were satisfactory because, at the start of the observations, both averages were maximal in terms of ICFES scores, and, at the end of the observations, all exceeded the values of the initial scores. This is highlighted in the third year group with an individual score of 87.00. This result indicates that dedication and responsibility well met the program expectations. The virtual campus was noted as a fundamental tool in monitoring and providing guidance to students, for being a technological resource, and for increasing interest in developing technology.

The most interesting tools for students under the criterion of conceptual, educational and instrumental repertories were the laboratories and experiments developed in the final hour of daily class. "Brochures" highlight some of the fun activities involved in these educational experiences. For this last tool we employed a novel, attractive and practical design which in a short but timely manner was used to display different concepts related to the unit of study. In the classroom practice and assessments criteria, the Chemo-Olympics activity attracted much attention from students as did the reinforcement workshops (suitable for the last 2 weeks before SABER 11° test which contained multiple-choice questions with unique answers). The workshops were used for evaluation purposes and were uploaded to the virtual campus platform. Another evaluation tool included the development of the workshop in class. The latter proved much more motivating. The information contained in the "Report for Consolidated Levels" Information System shows that in years II and III there was an increased percentage of participants with ICFES scores found in the "Medium High" category (average increase of 7.22%) and in year III in the "High" level (1.06% increase) as shown in Table 2. The level ratings were as follows: Significantly Low (0.00−10.00), Very Low (10.01−20.00), Low (20.01−30.00), Medium Low (30.01−40.00), Medium Standard (40.01−60.00), Medium High (60.01−70.00), High (70.01−80.00), and Superior (80.01−100.00).

Worth highlighting is that this preliminary evaluation is not a mixed-methods evaluation approach and can only be suggestive in the results presented here. There are also weaknesses as the number of young students (population) was not the same in the comparison by years; thus, the analysis did not discriminate age, gender, socioeconomic status, or type of school (public or private). To measure the confidence and motivation degree of the students, it is necessary to provide other tools such as attitudinal surveys from participants and interviews (both for

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Table 2. Established Averages in the "Report for Consolidated Levels" of the Results in SABER 11° Test in Chemistry

		Year II			
		Initial		Final	
Level	Sublevel	Number of students/Total	Percentage (%)	Number of students/Total	Percentage (%)
LOW	Significantly Low	0/1565	0.00	0/117	0.00
	Very Low	0/1565	0.00	0/117	0.00
	Low	8/1565	0.51	1/117	0.85
MEDIUM	Medium Low	182/1565	11.63	2/117	1.71
	Medium Standard	1353/1565	86.45	107/117	91.45
	Medium High	22/1565	1.41	7/117	5.98
HIGH	High	0/1565	0.00	0/117	0.00
	Superior	0/1565	0.00	0/117	0.00
		Year III			
		Initial		Final	
Level	Sublevel	Number of students/Total	Percentage (%)	Number of students/Total	Percentage (%)
LOW	Significantly Low	0/1489	0.00	1/952	0.11
	Very Low	1/1489	0.07	0/952	0.00
	Low	9/1489	0.60	5/952	0.53
MEDIUM	Medium Low	270/1489	18.13	71/952	7.46
	Medium Standard	1182/1489	79.38	757/952	79.52
	Medium High	24/1489	1.61	108/952	11.34
HIGH	High	3/1489	0.20	9/952	0.95
	Superior	0/1489	0.00	1/952	0.11

students and faculty) before and after the experiences. More detailed information will provide better insights on the impacts of this work.

The implementation of teaching methods in chemistry through PNAT, expanded the interest in high-school graduates to enroll in chemistry careers. This is reflected in the results presented in Table 3, which notes that in the year III 10.87% of students admitted to a university were admitted to some program related with chemistry, which improved results compared to the year II. With the use of the information provided by the Admissions Area and the Extension Office and Continuing Education at the Universidad del Valle, the result of students admitted to an academic program involving chemistry (technological and professional level) was obtained. The admission list for chemistry programs is presented in the Supporting Information.

Table 3. Number of Students Admitted to Some Program Related with Chemistry

Program	Year II	Year III
Chemistry	10	12
Chemical Technology	13	12
Chemical Technology (Yumbo)	12	0
Chemical Engineering	2	0
Pharmaceutical Chemistry	1	1
Number of students/Total	38/499	25/230
Percentage	7.62%	10.87%

More than two years after the International Year of Chemistry (IYC), hard work continues for the worldwide promotion on the achievements of chemistry and its contribution to the welfare of humanity.[19] The aim is to increase public appreciation of chemistry as a fundamental tool to satisfy the needs of society, to promote young people's interest in this science, and to generate enthusiasm for its creative future.[16] It should be noted that for a middle school student interested in our area, it is necessary to have the financial resources, the teacher's motivation, and the student's availability.

CONCLUSIONS

The preliminary evaluation presented by chemistry PNAT area has been developed in order to improve the teaching of chemistry and promote the understanding of high school students. The Virtual Campus has been a way of applying new technologies not only for teaching but also for the evaluation, making the student aware of their responses and enhancing their capacity of criticism. "Chemo-Olympics" reinforced student teamwork abilities, as well as provided ongoing training for the SABER 11° test. Class laboratories, professional guidance, and training workshops managed to motivate students to express interest in entering careers related to chemistry. Additional training workshops gave the opportunity to apply chemistry as a means for personal development regarding entrepreneurship. Data from several participants in chemistry that included finals from the SABER 11° test showed that the teaching methodology in applied chemistry was positively evaluated, finding a *moderate difference* according Cohen's orientations with positive effect size (d = 0.61). The program managed to increase the number of students who are ranked Medium Standard and Medium High. Many of these achievements benefited students coming from economically depressed origins. This study further suggests that these types of chemistry teaching methods are needed to improve the quality of secondary education in countries such as Colombia.

ASSOCIATED CONTENT

Supporting Information

Admission List for Chemistry Programs; Chemo-Olympics Part 1; Chemo-Olympics Part 2; Example for Brochure (Ionic Equilibria); Example for Reinforcement Workshop; Example Laboratory Activity (Ionic Equilibria); Formative Workshops

(Activity Report); Poster (International Seminary ICFES 2012); Professional Guidance (Applications); Total Averages (Simulations and SABER 11° test). This material is available via the Internet at http://pubs.acs.org.

AUTHOR INFORMATION

Corresponding Author

*E-mail: jose.penaranda@correounivalle.edu.co.

Notes

The authors declare no competing financial interest.
†Chemistry Teacher PNAT.
‡Coordinator Chemistry area PNAT.

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