Assessment of the strategies adopted by teachers in the teaching of science from the perspective of basic education students*

Valoración de las estrategias adoptadas por docentes en la enseñanza de la ciencia desde la perspectiva de los estudiantes de educación básica

Avaliação das estratégias adotadas pelos professores no ensino de ciências na perspectiva de alunos da educação básica

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Abstract

Objective: to characterize and assess the level of development in pedagogical competences through the strategies adopted by Basic Education teachers in the teaching of science from the students' perspective. **Methodology:** A quantitative approach was applied which was of a descriptive and multifactorial nature. The

* This article is derived from the "Proyecto Enjambre" to strengthen the civic, virtual, digital and democratic culture in science, technology and innovation through research as a pedagogical strategy supported by ICT in educational institutions of Norte de Santander" of the "Gobernación Norte of Santander" financed by the General Royalty System. The project started in September 2015 and finished in October 2016.** Doctor en Ciencias Políticas y Sociales. Investigador de Tiempo Completo del Centro de Investigaciones Sobre América del Norte (CISAN) de la Universidad Nacional Autónoma de México, UNAM. Correo electrónico: zepeda_roberto@hotmail.com

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data was collected among the eighth and ninth grade students of the Santiago Apóstol Educational Institution, municipality of Santiago, Norte de Santander, Colombia. A Likert scale was used for students to describe the pedagogical practice of teachers in the area of Natural Sciences including the three aspects that are assessed in the development of pedagogical competence: curricular planning, curriculum development and curriculum assessment (monitoring and improvement). **Results:** the statistical tests show that teachers develop reflective pedagogical practices which require reinforcement in the Research Based Instructional Strategy (RBIS) and in Information and Communication Technologies (ICT) leading to the development of more assertive scientific competences. **Conclusions:** strategies were identified to foster the development of scientific competences in students and the use of didactic resources and laboratory practices, however, they are not articulated to the needs of students.

Keywords: Pedagogical practice; Teaching of science; Competences.

Resumen

Objetivos: caracterizar y evaluar el nivel de desarrollo de las competencias pedagógicas mediante las estrategias adoptadas por docentes de Educación Básica en la enseñanza de la ciencia desde la perspectiva de los estudiantes. **Metodología:** se aplicó un enfoque metodológico cuantitativo de naturaleza descriptiva y multifactorial. Los datos se obtuvieron entre los estudiantes de octavo y noveno grado de la Institución Educativa Santiago Apóstol, Municipio de Santiago, Norte de Santander, Colombia. Se utilizó una escala Likert diseñada para que los estudiantes describieran la práctica pedagógica de los docentes del área de Ciencias Naturales desde los tres aspectos que se evalúa en el desarrollo de la competencia pedagógica: la planeación curricular, desarrollo curricular y seguimiento y mejora (evaluación curricular). **Resultados:** las pruebas estadísticas muestran que los docentes desarrollan prácticas pedagógicas reflexivas que requieren de refuerzo en la Estrategia Pedagógica (IEP) y en las Tecnologías de la Información y las Comunicaciones (TIC) que permitan un desarrollo de competencias científicas más asertivas. **Conclusiones:** se identifican estrategias que promueven el desarrollo de competencias científicas en los estudiantes y se devela la utilización de recursos didácticos y prácticas de laboratorio que, sin embargo, no están articulados con las necesidades de los estudiantes.

Palabras clave: Práctica pedagógica; Enseñanza de la ciencia; Competencias.

Resumo

Objetivo: caracterizar e avaliar o nível de desenvolvimento das competências pedagógicas mediante as estratégias adotadas pelos professores de Educação Básica no ensino da ciência a partir da perspectiva dos alunos. **Metodologia:** foi aplicado um enfoque metodológico quantitativo de natureza descritiva e multifatorial. Os dados foram obtidos entre os alunos de oitava e nona série da Instituição Educativa Santiago Apóstol, Município de Santiago, Norte de Santander, Colômbia. Foi utilizada uma Escala Likert desenhada para que os estudantes descrevessem a prática pedagógica dos professores na área de Ciências Naturais a partir de três aspectos avaliados no desenvolvimento da competência pedagógica: planejamento de currículo, desenvolvimento de currículo e seguimento e melhoria (avaliação curricular). **Resultados:** as provas estatísticas mostram que os professores desenvolvem práticas pedagógicas reflexivas que precisam de um reforço na Estratégia Pedagógica (IEP) e nas Tecnologias da Informação e das Comunicações (TIC), reforços que vão levar a um desenvolvimento mais assertivo das competências científicas. **Conclusões:** identificam-se estratégias que promovam o desenvolvimento de competências científicas nos estudantes e se evidencia o uso de recursos didáticos e práticas de laboratório que, no entanto, não estão coordenados com as necessidades dos estudantes.

Palavras-chave: Prática pedagógica; Ensino da ciência; Competências.

Introduction

In recent years in Colombia, educational policies have been established to develop national education improvement plans responding to the challenges of a contemporary globalized society. Among these policies, there is the creation and consolidation of monitoring and controlling mechanisms on the results of the internal assessments that are applied through the Colombian Institute for the Promotion of Higher Education (ICFES)

The Colombian State also participates in international assessment, such as the PISA (Program for International Student Assessment). PISA, as it is known, is a project that the Organization for Economic Cooperation and Development (OECD) has developed since the late 1990s aiming at assessing how well prepared 15-year-old students are in order to face the challenges of adult life (ICFES, 2013).

Colombia's results between 2006 and 2009 in the aforementioned tests, although with variations depending on the areas of knowledge, show that the Colombian students have a low overall performance. In 2012, Colombia's score was lower than the score of the 61 countries' data obtained; in the case of science, it was under 57 (ICFES, 2013). Due to these results, it was decided to create the Synthetic Quality Index, thus each educational institution measures itself based on four factors (progress, performance, efficiency and school environment) to develop improvement plans.

The internal results of the 3rd, 5th and 9th SABER tests in 2015 show that the student´s scores from Norte de Santander are similar to those of the rest of the country, ranging between levels of insufficient and minimum performance. Although, there is no single cause (the educational problems are usually multidimensional), it is possible to infer that part of this low performance of the students is associated with pedagogical practices that do not allow the sufficient development of the specific competences in the area of Natural Sciences (ICFES, 2010).

This hypothesis arises, to a large extent, from the observation of a frequent scenario in basic education in which the lack of relevance and appropriation of the teachers is combined with the knowledge of the specific competences of their discipline and the poor motivation of the students regarding the development of their own competences as students. Among other confirmatory studies surrounding this fact is Veloza (2015).

In relation to this situation, the authors of this research have examined and proposed strategies in order to strengthen citizen, virtual, digital and democratic culture in science, technology and innovation through the use of research as a pedagogical strategy supported by ICT in educational institutions of Norte de

Santander. This paper is a partial report of this research on the description of the pedagogical practice adopted for the development of the scientific competences from the pedagogical model implemented in the municipality of Santiago, Norte de Santander, which is based on the conceptions of the teachers on the competences of the discipline and the evaluation system used in the educational institutions of the region. Specifically, the purpose of this report has been limited to the evaluation of the level of development of pedagogical competences that teachers in the region have achieved in the teaching of Science.

From the observation of the sociocultural and academic contexts (mainly of the poor performance of the eighth and ninth year students) at Santiago Apóstol Educational Institution in the Municipality of Santiago, Norte de Santander Department, the following research questions arise: Do the pedagogical practices in the area of Natural Sciences favor the development of the scientific or specific competences of the students in the eighth and ninth grades of the educational institution? What are the students' opinions about the pedagogical practices that are adopted by the teacher? What pedagogical strategies verify the level of development of scientific competences in students?

As mentioned, these approaches are based on previous institutional assessments, which have recently shown the low results in the known tests in the area of Natural Sciences. To this end, this research would contribute to the search for an answer and a proposal of tools that favor to overcome this situation in the teaching of science.

Indeed, the Ministry of National Education (through its Executive Committee) presented an analysis in 2010 on the results of the SABER tests corresponding to 5th and 9th grade. According to the Colombian Institute for the Evaluation of Education (hereinafter ICFES, 2010):

> In ninth grade, 53% of students are at the minimum level. This figure shows that a little more than half of the students at the end of secondary school recognize some adaptations of the organisms to the environment, compares the properties of different materials, identifies the physical state of the substances from the organization of their particles and recognizes which questions can be answered from scientific research. Additionally, they present their results and procedures appropriately (p.16).

However, 17 out of 100 students in this grade do not demonstrate the minimum competences required in the area of Natural Sciences (ICFES, 2010, p. 16). This data reveals that the area of Natural Sciences needs to undergo revision in order to improve the academic results of external assessment. This paper pursues to offer useful information in relation to the identification of the strategies that foster the development of scientific competences in young people at these levels.

Among the international background related to this research which is mentioned in the work García *et al.* (2010) on educational innovation and improvement of students' scientific attitudes and competences. The research consisted of applying a program of educational innovation to improve the students' attitudes towards the methodology of the behavioral science subjects through the research process. The authors report that in the project the students used real data to contrast their own hypotheses by using different statistical analyzes and applying two key methodological principles for the contrast: sample size and ordinal statements.

This research involved teamwork, the use of databases on the Internet for the development of the theoretical framework, delimitation of the study objectives, definition of variables, selection of strategies for analysis and a discussion of results. When the students' research was finished, academic performance and changes in attitudes towards the methodology were assessed. The results indicated that 1) the conducting of this research contrasted with real data improved the student's education and 2) it involved a contact with the methodological reality that favored their attitudes.

It is expected that the management of methodological strategies such as those described in the previous work, will awaken interest in young people for research. Thus, the contribution of this research is the methodological strategies proposed in both disciplinary knowledge and teaching of natural sciences.

Regarding research limited to the Colombian context, Restrepo (2007) investigated about the research skills of children between 5 and 7 years of age in official and private institutions in Manizales, Caldas. Its purpose was to describe the research skills (classification, planning, hypothesis formulation, experimentation and hypothesis testing) in children from 5 to 7 years to characterize such skills and to establish their level of development, the differences existing between children from the official and private sector and the possible significant differences between genders.

Berrio & Torres (2009) investigated the conceptions of Natural Sciences teachers about scientific competences and their development in classroom practices. Among the results, the authors emphasize that each teacher is an individual who has been constituted historically within a sociocultural context and who has made possible the construction of certain conceptions about science, teaching and learning. It was about creating interaction environments among teachers, who were able to display these conceptions and, to identify other options favoring the changes that they themselves decide to face as well. It was possible to characterize the knowledge translated into actions in the pedagogical practices deeming as: 1) the disciplinary knowledge, 2) the knowledge to teach the emphasis, 3) the criteria of organization and sequencing of contents and 4) the criteria of selection and sequencing of evaluation activities.

Tamayo (2014), meanwhile, establishes a discussion between the object of study in the didactics of science and its relationship with the field of pedagogy, which favors the thesis of the development of critical thinking in a specific domain. To do this, he presents the results of research on the expression of critical thinking in children and teachers of fourth and fifth grades of primary basic education in 56 public institutions in Manizales, in the context of Natural Sciences. The author also describes the conceptions of teachers about critical thinking in the results. This project demonstrates the interest for the development of scientific competences, generated from the very conception of science that the teachers have, from the way they conceive the importance of planning, development and curricular assessment. This is precisely the approach that has been decided to be adopted in the current research.

Finally, Hernández et al. (2017) sought to analyze the perception of the importance and development of skills among teachers who teach natural sciences, both in their training, professional performance and relationship with the educational context. A descriptive study was conducted with a quantitative methodology through which the perceptions of the teachers were analyzed. A total of eight natural sciences teachers participated in the subjects of physics and chemistry at the secondary level of two educational institutions, one of an official nature and the other private, both in the municipality of Cúcuta (Colombia). As a tool, a Likert scale questionnaire based on the generic competences of the Tuning Latin America project was used.

The results highlight discrepancies between the imagination of the actors in relation to the competencies and the degree of development that they really reach within the institutions. It is concluded that teachers, regardless of the educational context in which they work, value positively and give greater importance to the skills developed in professional performance than those acquired during training, especially those related to social values and learning processes. This contrasts, on the other hand, with the little importance that is granted to the competences linked to the international technological context.

In order to theoretically support the investigation, the main references that have been addressed in it are described below:

Conception of the area of Natural Sciences from the Ministry of National Education of Colombia

The Ministry of National Education carefully establishes the conception of natural sciences in the Guide of Curricular Standards as the area of Natural Sciences and Social Sciences, however it is done with some reservation because "it is risky to give a consensual definition on the natural sciences. They are bodies of knowledge that deal with the processes found in life". It is stated that it is about natural processes as to refer to all those processes that, either have nothing to do with the human being or, if they do, they are from the biological perspective. The Ministry of Education (2014) also states that, from a contemporary view of science and teaching, there is a strong conviction that it is necessary to develop the skills of students from the combination of a) scientific concepts, b) methodologies and ways of proceeding scientifically and c) social and personal commitment in relation to scientific and technological development.

In addition, in the same Guidelines, the Ministry of National Education establishes that this pillar of content contains the bases that will allow learners to gradually and rigorously approach knowledge and scientific activity, thus, starting from the inquiry, they progressively reach more complex levels of understanding.

Finally, it is important to assume that science training requires students to develop concrete actions of thought and production required to reach the standards at each grade level. This training process must start from the understanding of the world and reach the application of what students learn, through research and discussion about its importance in the well-being of people and the development of a democratic, just, respectful and tolerant society.

From the concept of competence to scientific competence

The science teachers whose training was based on other pedagogical models often ask themselves what the scientific competence is (OECD, 2016, p.2). The answer offered by the OECD is both simple and complex: "Know how to think as a scientist, know how to do as a scientist and, most importantly, be like a scientist".

According to Mantilla, Morales and Gómez (2011) it could be said that individuals have acquired scientific competence if they are capable of using scientific knowledge in everyday contexts, of applying the processes that characterize the sciences and their research methods, and that, at the same time, is aware of the role of science and technology in society in both solving problems and in the genesis of new questions.

That is why scientific competences refer mainly to the ability of establishing a relationship with science. This relationship can be of two types. The relationship that those who, by profession, are directly committed to the generation of knowledge (scientists and academics) and the one that every citizen can establish with science, although not from a professional perspective. In this regard, Hernández (2005) states that scientific competences refers to the capacity to establish a certain type of relation with the sciences, however the relation the scientists of profession have with the sciences is not the same as individuals who are not directly committed to the production of knowledge about nature or society.

In this regard, Hernández (2005) points out that it would be desirable to develop in all citizens, regardless of their social task, at least a certain degree of scientific competences; thus they would be able to adequately relate to the contemporary world which is increasingly mediated by science, due mainly to technology. In the educational environment it is advisable to develop the two types of scientific competences (which in fact are not at all exclusive), but the second type of competences is of special interest to basic and secondary education because it is related to the life of all citizens.

In this sense, in the pedagogical practice, the teacher must educate both from the construction of knowledge considering the disciplinary and the didactics perspectives. This leads to a more effective teaching-learning process.

The pedagogical practices and their contribution to the teaching-learning process

As stated by Zuluaga (1999),

> Pedagogy is not only a discourse about teaching, but also a practice whose field of application is discourse. The teachers confront their pedagogical knowledge with the discourse of "theories" or "sciences" and the instrument they use for them is the teaching method (p.10).

In this respect, the pedagogical practice consists of a social activity entrusted in large part to the teachers, who must adapt the discourse of the sciences to the age of the learners in a way that is accessible to them. This discourse must be adapted to the forms of daily work in teaching, thus the teachers constitute a kind of hinge to relate the discourses of the sciences with that of their teaching. In the context of teaching, the link between teachers with the knowledge and students is established through the pedagogical practice. The reference to the adequacy of the discourse of the textbooks (which is how Zuluaga specifically refers to the discourse of science) has to do with the fact that in most pedagogical practices, science textbooks are the most used didactic resource. Even for educational technology, the contents of the textbook is what is processed in the instructional objectives, reducing the teaching of science to learning processes (Zuluaga, 1999).

In relation to the above, there is currently a subjection towards quality standards that relate to the basic competencies of the different areas of knowledge according to the age and the level of the students. In terms of pedagogy, it should be noted that in practice one must use methods and learning strategies. On this matter, Palomares and Villareal (2009) affirm that the current information revolution requires a new type of literacy linked to the good use of technologies and information, whose access does not make the individuals technological literate. The relevant issue will be the development of training processes aimed at any individual learning to learn (that is, acquire the skills for independent learning throughout their lives); know how to face information (search, select, elaborate and disseminate necessary and useful information); be qualified for the use of new technologies or information and communication; and be aware of the economic, ideological, political and cultural implications of technology.

Another pedagogical practice developing scientific competences from the teaching method or strategy is associated with the teaching of problem solving, since it is a strategy that allows students to approach a more contextualized and less distorted vision of science, and in turn, contributes to the development of basic scientific competences (Palomares and Villareal, 2009).

In the field of science didactics, problem solving has been studied as a strategy to generate conceptual, methodological and attitudinal changes to overcome the common sense methodology as a capacity related to the structuring of information in the mind; or as a process that can be taught to newbies based on the way experts solve problems, through the design of heuristic tools that guide students in solving problems and, finally, as a strategy to develop creativity in the students (Palomares and Villareal, 2009).

In this regard, the importance of conducting these studies on the teaching of science is framed in the continuous improvement that should be given to the pedagogical practices from the current educational policies, in the case of Colombia those issued by the Ministry of National Education, addressed to the teachers who guide the area of natural sciences and environmental education and who require a change or resignification of the processes of planning, development and curricular evaluation, thus generating a positive impact of motivation and interest of the students for the sciences.

Methodology

Since it is intended to assess the level of development of pedagogical competences within the framework of teaching science through the exploration of students' perceptions of the competences of their teachers, it was decided to establish an analysis of their relationships from a quantitative and descriptive perspective. As a result, efforts were made to highlight the trends and presence of the variables of interest in the population addressed through observation. This was accomplished through the use of questionnaires. The data collected was processed by applying descriptive-bivariate and multivariate analysis.

The level established for the research is descriptive and since multivariate techniques are used to reduce the data to a set of common factors, a multifactorial design is considered. On the one hand, it seeks to diagnose, based on the assessment of the students, what are the planning, development and evaluation competences put into practice by teachers. This report is based on the use of descriptive statistics adapted to the nature of the analyzed variables. The study also considered the use of multivariate descriptive techniques in order to establish a taxonomy within the set of strategies that teachers use. On the other hand, this research included field work which allowed describing the pedagogical practices in the area of Natural Sciences that promote the development of specific or scientific competences in the field of knowledge.

The study followed a sequential approach. In this sense, once the object of the study and the purpose of the study were specified, the following stages were followed: 1) Review of the literature: background seach and theoretical models related to the pedagogical competences for the teaching of the science; 2) Selection of a sample: delimitation of the research context, represented by students in eighth and ninth grade at the *Santiago Apóstol* Educational Institution, seventy students in total; 3) the design and validation of a set of instruments was reviewed to select indicators and create the one which was to be used. The designed questionnaire was validated by experts through the technique of expert judgment and applied to a pilot sample.

Stage 4) was the collection of information: the instruments were applied in situ through the face-to-face modality. This application was made during class hours and under the supervision of the researchers. The data was initially recorded in an Excel spreadsheet format and then transferred to the software for SPSS statistical analysis; 5) Information Analysis: the data was processed through the SPSS software by applying the statistical analysis techniques appropriate to the nature of the variables. The results were presented in summary form with their respective interpretation; and 6) Conclusions and findings: depending on the results, the main theoretical lines that govern the actions are highlighted and the recommendations related to the pedagogical competences of the Primary Education teachers during the teaching of science are proposed. In this final stage, reference is made to some theoretical and methodological implications of the study.

Next, the sequence is detailed:

The population under study corresponds to the students of eighth and ninth grade at the *Santiago Apóstol* Educational Institution, which totals to 70 students. To consider all the students for the study, a census sample is established. The survey was used for the development of the project. The design was a deductive methodology and was based on the teacher evaluation guide of Decree 1278 (Ministry of National Education, 2014) which consists of the evaluation of three types of competences: disciplinary, pedagogical and behavioral. From this triad only, the pedagogical competences were chosen, since they alone represent a great complexity. Among the competences to be evaluated is the planning of the school educational practice, its development, follow-up and improvement taking into account indicators such as the curriculum, the didactics and the methodology and, finally, the evaluation. Indicators were selected, and a Likert scale of five points was established as measurement criterion.

To determine the validity related to the content, the instrument underwent a process of validation by council of experts, through which the opinion and suggestions of university professors who specialize in the area were considered. Based on their observations, the pertinent improvements were made. Additionally, a pilot test was designed to analyze the behavior of each item and calculate the reliability of the scale. Once the instrument was applied to the pilot sample of 30 subjects, and the suggested questions from the council of experts and item analysis had been modified or removed, the Cronbach's Alpha statistic was again calculated, which yielded a value of 0.70, indicating that the range of reliability of the acceptable scale (Pardo and Ruiz, 2002).

Consequently, it can be said that the scale designed has credibility, internal consistency, and can be taken as a reference for future studies. Regarding the purpose and content of the instrument, it was aimed at students to evaluate their teachers in the area of Natural Sciences from the three aspects in which pedagogical competence is broken down: curricular planning, curriculum development and curricular evaluation (monitoring and improvement).

For the results analysis phase, a software was chosen that allowed the quantitative analysis, specifically, the IBM SPSS Statistics, version 24. First, a descriptive analysis is reported based on joint frequency tables that show the three main dimensions of pedagogical competences. Then, and in order to identify underlying variables or factors that explain the configuration of the correlations within the set of observed variables, an exploratory factor analysis was carried out to obtain a summarized version of the analyzed competences.

Results

The descriptive results are presented by their type of pedagogical competence: planning, development and curricular evaluation. A description of the factor analysis is made, at first it reports a verification of assumptions for the application of this technique, and then the extraction and interpretation of factors.

Table 1 shows the distribution of the frequency of items 1 to 9, that correspond to the first component of the pedagogical competence called curricular planning. This data clearly shows a trend of a high frequency on students' assessment with at least four of the items in this scale: applying a diagnostic test at the beginning of the school period (92.6%), use of different types of materials to teach the classes (87.6%), clarification of doubts that arose before evaluations (81.3%), and socialization and feedback of the students' failures (85.1%). In contrast, around 65% of the students state that individual work activities are never or almost never encouraged, and approximately 28% affirm that the teacher rarely uses technological resources or links science projects with other subjects.

Table 1. Pedagógical competences: Curricular planning

Indicator		Never	Hardly ever	Sometimes	Almost always	Always
1. Application of a diagnostic test	f	0	3	3	17	57
	%	0.0%	3.8%	3.8%	21.3%	71.3%
2. Use of different types of materials	f	0	0	10	17	53
	%	0.0%	0.0%	12.5%	21.3%	66.3%
3. Use of examples related to the environment	f	1	0	23	31	25
	%	1.3%	0.0%	28.8%	38.8%	31.3%
4.Development of projects related to other subjects	f	7	15	30	14	14
	%	8.8%	18.8%	37.5%	17.5%	17.5%
5. Use of technological resources	f	14	8	34	18	6
	%	17.5%	10.0%	42.5%	22.5%	7.5%
6. Use of scientific publications	f	8	9	40	15	8
	%	10.0%	11.3%	50.0%	18.8%	10.0%

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7. Promotion of individual work	f	19	33	25	1	2
	%	23.8%	41.3%	31.3%	1.3%	2.5%
8 Socialization and feedback of students' faults	f	0	4	16	19	41
	%	0.0%	5.0%	20.0%	23.8%	51.3%
9. Clarification of doubts before the evaluation	f	1	5	9	19	46
		1.3%	6.3%	11.3%	23.8%	57.5%

Source: Self-compiled by researcher

Table 2 shows the distribution frequency of items 10 to 19, 23 and 24, that correspond to the development of school educational practice (curricular development). As the main indicators, 90% of students say that their teachers clarify doubts when they are working in groups, approximately 79% invites students to reflect and contribute to the development of contents, and 75% confirm that teachers often promote participation in the classroom

Table 2. Pedagogical Competences: Curricular Development

Indicator		Never	Hardly ever	Sometimes	Almost always	Always
10. Present contents apart from real life	f	14	12	28	14	12
	%	17.5%	15.0%	35.0%	17.5%	15.0%
11. Link the topics with current phenomena	f	1	5	31	30	13
	%	1.3%	6.3%	38.8%	37.5%	16.3%
12. Monotonous and boring class	f	4	6	22	23	25
	%	5.0%	7.5%	27.5%	28.8%	31.3%
13. Invite reflection and make contributions	f	0	1	16	29	34
	%	0.0%	1.3%	20.0%	36.3%	42.5%
14. Clarify doubts	f	0	0	8	16	56
	%	0.0%	0.0%	10.0%	20.0%	70.0%
15. Promote participation	f	0	3	17	22	38
	%	0.0%	3.8%	21.3%	27.5%	47.5%
16. Constantly evaluate and give results feedback	f	2	2	32	29	15
	%	2.5%	2.5%	40.0%	36.3%	18.8%
17. Promote self-evaluation	f	0	9	21	25	25
	%	0.0%	11.3%	26.3%	31.3%	31.3%

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18. Promote co-evaluation	f	3	10	33	19	15
	%	3.8%	12.5%	41.3%	23.8%	18.8%
19. Delay in the delivery of evaluations	f	10	6	28	19	17
	%	12.5%	7.5%	35.0%	23.8%	21.3%
23. Use of strategies based on the evaluation results.	f	0	5	27	19	29
	%	0.0%	6.3%	33.8%	23.8%	36.3%
24. Difficulty to explain according to the stated time	f	6	6	12	15	41
		7.5%	7.5%	15.0%	18.8%	51.3%

Source: Self-compiled by researcher

On the other hand, 65% of students point out that their teachers do not link the contents with real life, 45% claim for feedback evaluation results, and 16% state that co- evaluation is very little promoted. Although, at least 60% have a positive assessment on strategies based on evaluation results, 55% of the students complain about punctuality in the delivery of the evaluation results.

Table 3. Pedagogical Competences: Monitoring and Improvement (Curricular Evaluation)

Indicator		Never	Hardly ever	Someti-mes	Almost always	Always
20. Development of content according to the stated time	f	0	1	7	27	45
	%	0.0%	1.3%	8.8%	33.8%	56.3%
21. Imposition of own criteria	F	17	15	22	15	11
		21.3%	18.8%	27.5%	18.8%	13.8%
22. Use of different means and instruments for evaluation	F	1	6	24	26	23
	%	1.3%	7.5%	30.0%	32.5%	28.8%
25. Relation of the practicals to the topics studied in class	F	6	9	13	14	38
	%	7.5%	11.3%	16.3%	17.5%	47.5%
26. connecting learning as to understand real phenomena	F	0	1	9	19	51
		0.0%	1.3%	11.3%	23.8%	63.8%

Source: Self-compiled by researcher

Table 3 shows the results of items 20, 21, 22, 25 and 26 that correspond to monitoring and improvement of school educational practice, commonly known as curricular evaluation. Approximately, 90% of the students answer that their teachers frequently develop the stated contents and that they promote the learning of science to understand real phenomena. Approximately, 70% do not pinpoint the teacher as a controller when establishing criteria, and 65% state that the teacher always relates laboratory work with the topics studied in class. On the other hand, about 40% state that different methods and instruments of evaluation are regularly used.

A Factor Analysis (FA) with an exploratory nature was applied as a second approach to the data, as well as, to reduce the dimensionality of the applied indicators and to group items through their correlations as to identify common factors or categories. The application of this multivariate technique assumes at least the consideration of three assumptions (Pardo and Ruiz, 2002): 1) The determination of sample adequacy index (KMO). 2) A value of the determinant of the correlation matrix other than zero, and 3) Barlett's sphericity test that shows that the correlation matrix is different from the identity one. The KMO value reached 0.65, which is a minimum value of adequacy for a sample to continue with the analysis, the determinant value is 0.017, different from zero, and the Barlett test reveals a value of $\chi 2 = 653.23$ with gl = 325 and an associated p-value of $p = 0.00 < 0.05$. This fact leads to reject the null hypothesis that the correlation matrix is the identity matrix. On the other hand, a visual inspection of the correlations indicates a large majority with values higher than 0.30, which confirms the convenience of applying AF (Hair, Anderson, Tatham, and Black, 2002).

After evaluating the basic assumptions, FA was carried out, adopting the main components as a method of extracting factors (Peña, 2002) that establishes the default method provided by the SPSS software. Based on the review of theoretical foundations about pedagogical practice and strengthening of scientific competences through a literature review as well as the guidelines and curricular standards of the Ministry of National Education of Colombia, the optimal number of factors was set to five. The composition of the explained percent variation by factor is shown in table 5.

Table 5. Total explained variation

Component	eigenvalues			The sum of saturations to the square of extraction			Sum of the saturations to the square of the rotation [a]
	Total	% of variance	Accumulated	Total	% of variance	Accumulated	Total
1	5,391	20,733	20,733	5,391	20,733	20,733	4,035
2	2,180	8,386	29,120	2,180	8,386	29,120	3,105
3	1,684	6,475	35,595	1,684	6,475	35,595	3,776
4	1,563	6,012	41,607	1,563	6,012	41,607	2,125
5	1,499	5,767	47,374	1,499	5,767	47,374	1,880
6	1,345	5,173	52,547				
7	1,300	4,999	57,545				
8	1,218	4,685	62,231				
...	....	...	....				
26	, 137	, 526	100,000				

Source: Self-compiled by researcher

The five factors described in the table explain approximately 47% of variability of data set which is considered optimal (Hair, Anderson, Tatham and Black, 2002). Factor 1, the main factor and the one that contributes the most to the explanation of the variance, represents 20.7% of the solution. The second factor explains approximately 8%. The remaining three factors explain between 6% and 5% of the solution. The number of twenty-six original variables was significantly reduced to these five factors.

Table 6. Factor rotation structure

	Component				
	1	2	3	4	5
9. Clarifying doubts before the evaluation	,772	,327	,303	189	,288
14. Accompanying the groups in clarifying doubts	,759	,251	,292	,097	,018
15. Promoting participation	,744	,056	,270	,106	118
8. Socializing and giving feedback	571	,050	,477	406	,382
2. Using different types of materials	,389	,343	,285	,148	- 226
10. Presenting topics apart from real life	-,298	-,022	- 152	-,285	-,005
7. Promoting individual work	,011	-,628	-,126	,114	,132
22. Using different ways of evaluation	,245	586	,288	441	-,089
26. Linking learning with real problems	,177	515	,262	110	,006
13. Promoting reflection and make contributions	,503	,510	,365	,299	,026
4. Conducting projects related to other subjects	330	,509	,128	-,129	,318
11. Linking topics with current phenomena	164	,472	,033	,027	,195
18. Promoting co-evaluation	366	461	,398	-,314	- 115
1. Applying diagnostic tests	,304	.381	362	-,007	-,279
23. Planning strategies based on results	529	,327	736	157	-,060
12. Monotonous and boring class	,257	-,125	,647	,394	450
25. Linking the practice with topics studied in class	519	,097	626	,312	,059
3. Using examples related to the environment	- 116	,294	605	,016	,005
16. Evaluating continuously and giving feedback	331	069	580	,078	,000
17. Pomoting self-evaluation	,340	410	,510	-,087	-,209
24. Having difficulties explaining in the stated time	,280	-,322	,065	661	,312
20. Developing content according to plan	,227	,060	,134	,516	-,019
21. Imposing own criteria	,139	-,238	-,161	-,513	,054
19. Delay in the delivery of evaluations	,124	-,167	,000	,043	668
6. Using scientific publications	,121	,200	,062	,008	,542
5. Using technological resources	-,059	,291	,470	341	,486

Source: Self-compiled by researcher

Then, factor rotation was carried out: "based on the fact that the factors obtained can be correlated with each other, an oblique rotation method was adopted" (Pardo and Ruiz, 2002) to obtain a rotated solution that facilitated the configuration and subsequent interpretation of the factors. Table 6 shows the distribution of observed variables in reducing five factors.

The factor loadings represent the weight of each of the variables in the factors obtained in the factor solution. It is considered that the observed variable saturates better with that of a higher factor loading. Table 6 shows the factor loadings of each variable observed in each of the factors obtained and highlights the greater factorial weight where the variable is saturated. This table facilitates to obtain the factorial structure based on the observed variables.

The factor loadings obtained oscillate in absolute value between 0.48 and 0.77 which reflects the significant weight that each variable represents in the factor where it best saturates. The first factor explains that 20.73% of the variance of presented factorial model, is composed of items 2, 8, 9, 10, 14 and 15. The second factor groups eight items: 1, 4, 7, 11, 13, 18, 22 and 26, and it represents 8.38% of the solution. Factor three is made up of items 3, 12, 16, 17, 23 and 25, and it represents 6.4%. The fourth factor covers items 20, 21 and 24, representing 6% of the solution. The fifth factor includes items 5, 6 and 19 and represents 5.7% of the solution explanation.

From this process, it is possible to name each of the factors in order to attribute the significance of the findings. "The process involves the substantive interpretation of the pattern of factor loadings for the variables, including their signs, in an effort to name each factor" (Hair, Anderson, Tatham and Black, 2002). All the variables of the factor and at the same time, the load that each one represents in its interior, its factor loading, were considered during this process.

Factor I is called *feedback*. It describes the actions that are developed in pedagogical practicals under the responsibility of the teacher in the area of Natural Sciences. The students state that from their perspective, the teachers clarify doubts and concerns during the classes and that support their teamwork, likewise, the teacher uses different types of materials for the class, and at the same time, promotes student participation and involves mechanisms of socialization of faults in evaluations, although teachers sometimes do not link the topics with the reality.

Factor II, called *evaluation strategies*, describes the teachers' actions for the fulfillment of evaluations carried out as a mechanism for monitoring and controlling the processes developed in pedagogical practicals. In this sense, students say their teachers always administer diagnostic tests and promote co-evaluation processes and workshops that motivate reflection and production of contributions relating to updated issues that foster individual work, problem solving and developing projects with other subjects.

Factor III is called *didactic strategies*. According to the respondents, the teacher conducts the classes according to the plan and relates the topics with the environment, uses various strategies and takes into account the results of the evaluations. The teacher maintains a permanent and continuous evaluation based on contents studied in class and guides self-evaluation, although sometimes, the class is monotonous and boring.

Factor IV is *content development*. According to the students, the teacher develops the contents taking into account only his/her criteria. The teacher also tries to cover all the programmed contents, although shows difficulty in explaining some topics.

Finally, Factor V is called *teaching resources*. To this point, students affirm that teachers use diverse strategies and technological resources in order to innovate, using for example: internet, computers, tablets, video beam and other means through which they seek to motivate pedagogical practices and promote research to facilitate understanding of the topics; however, this fact sometimes delays when distributing of grades.

The findings of the research allow to guide, on the one hand, a description of the strategies used by science teachers in their pedagogical practice analyzed from the students' perspective, and on the other hand, an identification of strategies that promote the development of scientific competences. In general, the use of didactic resources and laboratory practices is revealed. However, these actions are not always according to the needs of students, as they express that sometimes the classes are taken out of the context of reality and become monotonous and boring.

The descriptive results highlight that teachers see the need to have diagnostic tests as a basis for curricular planning and based on it, the materials to didactic sequences are selected, and it fulfills the basic functions of evaluation to determine the situation of each student in the classroom (Jorba and Sanmartí, 1993).

In addition, there is evidence that, although teachers deal with updated topics in their classes, there are other aspects that should also be involved in the didactics of Science to promote motivation and interest in classes. In this sense, the epistemology and didactics must be reinforced, specific to the discipline, as established by the Ministry of National Education in the Basic Standards (2004):

> The Didactics of Sciences has steeply developed and begins to contemplate itself, at present, as a discipline with its own theoretical framework that at the same time should favor conceptual, attitudinal and methodological foundation in students to account for the problems associated with teaching and science learning (p.43).

From the findings, it is inferred that when in pedagogical practicals a specialized didactic is adopted in the teaching, the student is drawn to reality which allows them to understand the scientific phenomena and constitutes to one of the proposals that is fundamental in the quality standards of Natural Sciences should be implemented in the curricular development.

The results also highlight that the follow-up and curricular evaluation is addressed only by the teachers, without any participation of students. Students demand more practical work as part of the evaluation process and in the solving of contextual problems, and that both must be increasingly implemented within the improvement plan as the students' contributions. In this regard, it is important to remember that, for the Ministry of National Education of Colombia, in the document of Basic Standards of Competencies in Social Sciences and Natural Sciences (2004) it establishes that

> If science is formed by a set of knowledge that is constantly changing, where the review and critical analysis of what is done is fundamental, evaluation is a component that cannot be lacking in science education. An evaluation that is seen, like science, as a process, that is to say, permanent, that sheds a light on the path traveled and the one that will continue to be covered (p.112).

The above is consistent with the results of the survey applied to students, because "an evaluation aimed at detecting errors and breaking points is not acceptable. It is an evaluation focused on identifying strengths that allow to overcome the weaknesses, an evaluation to determine what the students are really learning " (MEN, 2004: 112). According to the results, different evaluation instruments must be used, and moreover, in a permanent way.

Conclusions

One of the conclusions drawn from this study is that the curricular standards of MEN highlight that the evaluation process must identify the student's strengths to overcome the difficulties. These guidelines underline that teachers must find the adequate tools to guarantee the teaching-learning process. On the other hand, the methodological guide number 31 issued by the Ministry of National Education of Colombia (2008) establishes the parameters of the Yearly Evaluation of Work Performance and it describes the criteria teachers must have in order to demonstrate the work of the educational organization, this work highlights the functions of planning, development and evaluation of different curricular activities that favor institutional projects and also consider the context of the students.

The categorization of items within factors determines that the teachers action is more concentrated in didactic aspects than on a true scientific education for their students, it shows the need to bring together scientific communities in order to allow the exchange of strategies, methods and research products to strengthen the development of scientific competences of the area according to the students schooling level. According to the Basic Standards of Competence in Natural Sciences (2004),

> In order to strengthen these learning experiences in the students, it is also necessary for the teacher to be involved in the processes of forming a scientific community and, with other teachers, sharing their experiences, discussing their positions, deepening their knowledge - both in their discipline and others- and evaluating their own teaching actions. These collaboration networks among teachers can be of great value to maintain critical and reflective positions on the practice itself and introduce adjustments to the pedagogical practice. (p.11)

Regarding scientific competences, it is necessary to work deeply on their development with Primary Education students, especially in the use of scientific knowledge, examination and explanation of phenomena. The low development of skills during pedagogical practice of teachers is explained from the statements made by Furió and Gil (1994) on the problems in teaching science: The first aspect has to do with the teachers own preconceptions both which refers to scientific subjects (Carrascosa and Gil, 1985) and mainly to the teaching method (Bromme, 1988, Hewson and Hewson, 1987). The second problem related to this deals with the familiarization of students with scientific work.

This epistemological reflection is necessary not only to favor a more creative orientation of practical work, but also to show the deep epistemological and methodological change associated with the emergence of modern science and learning of scientific knowledge. The issue of common sense preconceptions and "conceptual change" thus it converges with the familiarization with scientific methodology and "methodological change" (Gil and Carrascosa, 1985).

The stated approaches reaffirm the importance of approaching this from appropriate epistemological conceptions and curricular development. In this respect, it is essential that in Basic Education institutions, the teachers of the discipline further deepen their epistemological and didactic foundations that allow the adequate promotion and development of specific competences of natural sciences.

In this way, the Basic Standards of Competence in Natural Sciences (2004), as a national educational policy, have established that the aim is that:

> students, teachers approach the study of sciences as scientists and researchers, since every scientist – adult or boy - get knowledge in a similar way, starting from questions, speculations or hypotheses that initially arise from their curiosity about the observation of the environment and its capacity to analyze what it is observed (p .8)

From this perspective, the national educational policy established the need to approach teachers and students to the study of science as scientists, which is only possible when the teacher guides pedagogical practices from the discipline's own didactics.

Regarding the inclusion of ICT, for a while, its use has been essential in planning, development and curricular evaluation, since with it pedagogical practices are strengthened and therefore the learning process as well. These reflections have been revalidated during this research.

Finally, this research generates reflection of pedagogical practices around the pedagogical component: planning, development and curricular evaluation, from the students' perspective as a pedagogical actor in their training process. In addition, the process generated critical factors that should be taken into account in current criteria issued by the Colombian Ministry of National Education in the evaluation of teaching competence: school context, curricular planning, pedagogical practice and classroom environment.

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