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Competences of teachers of natural-physical sciences. An analysis from the perception of the students

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Abstract. This article arises as a proposal in view of the need to evaluate the scientific competences promoted by teachers of the subject of physics at the level of basic secondary and secondary technical education. A valid questionnaire was designed from the application of scalar analysis, factorial analysis and content analysis, which is composed of 49 items evaluated by means of a Likert scale with five levels of response. It was applied in a sample of 249 students enrolled in a public educational institution during 2019, characterized by their good results in the area of physics in state tests. The results allowed the identification of strengths in the four dimensions proposed by the Ministerio de Educación Nacional, Colombia (pedagogical, didactic, disciplinary and behavioural), in contrast with some weaknesses within which the evaluation process stands out as the one with the greatest impact, since the students state that this process is assumed by the teacher as a mechanism of pressure and control. When investigating the teachers in a complementary way, positions were determined that were totally opposite to those held by the students, then it is suggested for future research to consider both the students and the teachers as informants and a supervision of the students' notes as the end of triangulating the results to refine the conclusions, on which future improvement plans will depend.

1. Introduction

Every education professional or teacher must execute very well what he or she has prepared for, which demands the permanent improvement of his or her pedagogical practice. Social development or the overcoming of social problems depends to a great extent on the quality of education, and among other necessary inputs, the quality of the teachers must be guaranteed [1]. Therefore, it is necessary to invest in the professionalization, training and improvement of teachers. Without qualified teachers, educational change is not possible [2].

The teacher must respond to the educational challenges that society demands, with students immersed in the complexity related to changes in technological advances and scientific development; to teach the necessary knowledge that adapts to the characteristics of the new times [3]. In a complementary manner, he must also possess the basic competencies that every professional must use to do things well, which is what his profession requires [4]. In the Colombian context, the “Ministerio de Educación Nacional (MinEducación)”, in its various documents, proposes the definition of competence for the educational system and also structures the conceptual framework for teachers to assume education by competence.

From this point of view, the current research focuses on the actions of natural sciences teachers, specifically in the subject of physics in a public educational institution in San José de Cúcuta, Colombia, with the objective of characterizing teaching competencies from the students' point of view, since these



results will allow the educational institution to implement training plans in the future, in order to solve weaknesses and strengthen strengths of teaching practices.

1.1. Skills and education by skills

Several authors have contributed to the consolidation of the concept of competence [5–8], among which are conceptual unifying elements related to human development: skills, capacities, knowledge, know-how, complex and challenging situations in context, flexible performance and problem solving.

In [8] provides a possible differentiation of generic and specific competences for training. Generic competencies are those that everyone should use for coexistence and by human nature in the exercise of any profession; while specific competencies are specific to each profession or to the field of action of the particular trade. MinEducación, in its various documents, promotes, fosters and orders the formation of competences through the curricular guidelines, the standards of competences of each of the areas of the curriculum of basic and secondary education, is aimed at the development of cognitive, scientific and technological competences among others, to be developed in students.

1.1.1. Teaching skills. The report behind the excellence in teaching [1] it shows the importance of teachers in the world's social and cultural development. While it is true that teachers play a very important role in this respect, it should also be borne in mind that they need to have developed certain special characteristics that correspond to current educational needs. The greatest responsibility for socio-cultural development lies with teachers and their social commitment derived from the performance of their work, which obliges them to show results of their actions and this is not achieved with inadequate or impertinent performance [9], so it is necessary an adequate training according to new teachers for new students [10], because without teachers changes are not possible [2].

For the competences that all teachers should have at present, independently of their disciplinary training, the proposal of the tuning project Latin America [4] stands out, with 27 generic and specific ones respectively, among which we can highlight those for education professionals: a) mastery of disciplinary knowledge; b) ability to develop in their students logical-critical thinking; c) reflection on their own practices; d) mastery of educational theories, methods and models; e) design and implementation of teaching strategies according to the context; f) design, implementation and evaluation of learning environments.

MinEducación, structures teaching competences into three major groups: disciplinary, pedagogical, and behavioural [11]. The disciplinary are of three kinds: conceptual, didactic, and evaluative. The pedagogical are: curricular, didactic-methodological, and evaluative; but, for all of them it is necessary to fulfil the due planning, with the execution and, the pursuit and improvement. The behavioural refer to the teacher's attitude towards their pedagogical practices, such as leadership, sense of belonging, problem solving, school environment among all members and professional development, among others.

Since 2015, it has been called formative diagnostic evaluation, in which four criteria will be assessed (context of the educational and pedagogical practice of teachers, reflection and planning of the educational and pedagogical practice, pedagogical practice and environment in the classroom), which in turn are divided into different components. These are evaluated based on evidence of actions or attitudes in their teaching practice (video recordings), not with paper and pencil tests as they were until 2014 [12].

Within the teaching task, it is important to consider what are the most important aspects of the subjects taught, since in this way the teacher can improve the competences necessary for the transmission and generation of knowledge. In the case of the natural sciences (biology, chemistry and physics), manipulation and exploration processes of phenomena and materials are addressed that allow obtaining information, obtained through descriptive, analytical, meticulous processes and in some experimental cases through which the construction, reconstruction, organization and reorganization of ideas and experiences are promoted. For this reason, natural sciences teachers must have competencies focused on scientific rigor and the development of critical-reflective and systemic thinking [13].

With this research, it is expected to propose a scale that is valid for the evaluation of the scientific competencies of teachers, which could be replicated in various educational institutions as an instrument for evaluating teacher performance in current processes for improving the quality of teaching. Education.

2. Methodology

In this research, was used a Likert-type survey with 49 items were designed and applied, within the conceptual framework of natural science-physics teacher's competences, ordered by the MinEducación [11], for annual performance evaluation and teacher career relocation evaluation. This survey was applied to a representative sample of students (249 students between the ages of 10 and 19) from the public education institution in the city of San José de Cúcuta, Colombia, the name is not known for ethical principles. It allowed to know, from the student's perspective, the competences of the five teachers responsible for the processes of teaching and learning of natural sciences – physics of this same institution: in terms of disciplinary, didactic, pedagogical and behavioral.

With the data from the application of the survey, a statistical analysis was carried out by groups of questions belonging to each dimension, from which, through the percentage value of each item and its arithmetic mean, comparisons are made between the results of each one and thus establish which of them are well valued by the students and which of them do not achieve sufficient approval. From these calculations, one can see the strengths and weaknesses of the pedagogical practices of the teachers under study, from the point of view of the students.

3. Results and discussion

3.1. Validation report

The validation process followed for the design and application of the questionnaire was as follows: after the background review on the subject, it was identified that there were a diversity of proposals, some without a validation report, for this reason the reference document of the MinEducación is assumed [11] and based on it, a first version with 60 items is proposed, applying a Likert scale with five levels. A pilot test was applied with a group of students from another educational institution, but with similar characteristics.

The validity analysis yielded a Cronbach's alpha coefficient of 0.85, which is considered adequate for this type of study. Additionally, a factor analysis is carried out after verification of its assumptions, which allowed reducing the questionnaire to 49 items and guaranteeing an increase in the alpha value to 0.87. the resulting version of the instrument was subsequently analyzed by a panel of three teachers, one from physics, a statistician and a teacher from Spanish to analyze the validity of the content. after these processes, the final version of the questionnaire is generated, which is subsequently applied to the students of the sampled educational institution.

3.2. Quantitative results

To explain the results obtained from the questionnaire applied to the students, the design for the operationalization of variables is presented on Table 1. After the application of the instrument, results are obtained that could be an x-ray of the aspects that are recurrent in the Colombian educational system. For example, it was possible to identify a good number of strengths in the pedagogical practices of physics teachers.

On a pedagogical level, teachers present their students at the beginning of each academic period with the work plan to be developed, which allows the student to have a clear understanding of the training process since the contents, competencies and performance expected in each period are detailed. By reviewing the plans, it is possible to verify that they are organized taking into account the theoretical foundations and in accordance with the reality of the institution and consistent with the definition of the [14].

At the disciplinary level, students recognize the domain that teachers have over the scientific knowledge of the area they teach, thus motivating students towards intellectuality, inclining their life projects towards a profession with high levels of conceptual requirements. This is consistent with the professional choices that predominate in the institution, where 34% of the graduates are inclined towards engineering programs.

Table 1. Structure of the variables used in the attitude survey.

Variable	Dimension	Indicators	Items
A	Pedagogical	Planning of school educational practice	1, 2, 6, 7, 10, 11
		Development or implementation of school educational practice	3, 12, 13
		Monitoring and improving educational practice	4, 5, 8, 9, 14, 15
		Curricular competences	1 – 5
		Teaching s competences	6 – 9
	Didactics	Evaluation competences	10 – 15
		Procedures	16 – 17
		Methods	18 – 20
		Techniques	21 – 26
	Disciplinary or scientific	Educational Aids	27 – 32
		Professional competences	33 – 36
		Scientific didactic competences	37 – 41
	Behavioural	Interpersonal relations	42 – 44
		Institutional and vocational identity	45 – 47
		Personal and social projection	48 – 49

A: Teaching competences in pedagogical practices.

At the didactic field, they claim to have several strategies to support student learning, allowing them to maintain the interest and motivation of students at an adequate level and thus facilitate learning. The current education demands a change of paradigm that allows the overcoming of the traditional towards strategies with processes that effectively achieve in the student to obtain learning in the area of physical science [15]. It establishes clear relationships between the concepts of the area and situations of the context and converts the contents of physics in learning situations known by the students, forcing the learner to make a transfer of knowledge to the real world and develop the ability to solve problems in their environment, both particular and general. This must be a competence proper to teachers that they must execute very well, since it is inherent to their pedagogical practice as referred to in [16]. All of the above contributes to the recognition of the importance of physics for humanity, which results in the student's appreciation of scientific knowledge and awareness of knowledge for the appreciation and valuation of nature and the universe.

At the behavioral level, teachers favour agreements and solutions to school conflicts, contributing to improve or maintain a good institutional environment among the members of the educational community and this in turn results in the educational quality and academic results of the students. Likewise, teachers organize, carry out or collaborate with institutional events or activities, contributing to the cultural, social and sports enrichment of the members of the educational community, especially the students, guaranteeing them the integral formation that is part of the institutional mission [17] Finally, they demonstrate their leadership, driving the educational community toward the achievement of important goals and continuous improvement, while contributing to the life project of each of the students. Among the aspects to improve of the teachers, in opinion of their students are characterized by their low scores against the other items, are mentioned.

On the pedagogical side, teachers do not make adjustments to area plans even when student results are not satisfactory, thus assuming a rigid stance against the curricular flexibility that should exist for the benefit of the student [18]. As regards the evaluation process, the teacher is preventing evaluations

from having the formative, constructive, and scientific effect that they should have, becoming instruments of repression and even blocking the effects of comprehensive education [19].

In the didactic aspect, teachers do not have an adequate evaluation process of the laboratory practices, essential in the conceptual understanding of physics. They limit themselves to the generation of a report without carrying out the process of revision and feedback of it. Another weakness found is the absence of debates, discussions or development of science projects, since this type of activities would motivate students to look for information, clarify ideas and go into a subject in order to assume positions around a relevant topic. The lack of these leads students to see the processes of teaching and learning as moments very alien to their interests or of little importance, far from the development of arguments, conceptual or de-motivating and routine positions [18].

In terms of discipline, students show the scarcity of laboratory materials which could be remedied with the implementation of virtual laboratories, since today's society is interconnected, intercommunicated or globalized, using media and advanced technology devices and available to all, *ie*, within the reach of students in basic and secondary education, forming in them some particular characteristics, but in turn requires that they are trained to respond to these challenges. The characteristic also of the teachers should respond to this need, which can be supported by videos, virtual laboratories, animations and experiments among others, to facilitate the development of processes of understanding the theories and concepts of physics, therefore, their training or skills in information and communication technologies (ICT), should be commensurate with the needs or current educational situation [20,21].

On the behavioral side, teachers have student monitors to support the other students. It is valid to use peers to facilitate the understanding of processes or procedures whether scientific or technical [21]. Strengths represent aspects that teachers should maintain and belong to good pedagogical practices, while, in relation to the aspects to be improved, students demand significant changes in the pedagogical practices of their teachers and are elements that prevent the improvement of the quality of education.

3.3. Integration of results

In a complementary manner and based on the results expressed by the students, we proceeded to interview each of the five teachers of the educational institution in order to strengthen the validation of the instrument in terms of the quality of data collection. The opinions of the two groups of informants were then contrasted on various topics.

As for the planning of the educational practice in schools, the students express that there is a curriculum planning in the area of natural sciences, and that this is done in accordance with the institutional educative project and the institutional reality. However, students question the planning of the evaluations since some of them are eventual and without previous notice; while the teachers affirm that they plan their evaluations taking into account the contents, the students and the context [12].

In terms of development or execution of school educational practice, students approve of the diversity of strategies, but question the purpose of the assessments, while teachers claim to focus on the development of student competencies [12]. In terms of monitoring and improving school educational practice, students' question whether teachers are monitoring and adjusting elements of their teaching practices; contrary to what teachers say, they claim that their process is flexible [12,21].

In terms of didactic skills, students contribute as strengths, that teachers use both inductive and deductive strategies, which also use various techniques relating the contents to real life situations, whether it is with the board and the scoreboard; however, they question the way group work is executed, the use of ICT, the use of student tutors, diversity of conceptual representations and the varied use of guides, workshops and bibliographic material [21].

As for the disciplinary-scientific, students agree that the mastery of concepts and theories of the area of science is a strength of teachers, also say that teachers know how to contextualize all this knowledge by applying educational theories to bring them to their level. However, they question that there are few opportunities to carry out research processes or scientific projects. As for behaviour, most students approve of the attitude of physics teachers, in relation to interpersonal relationships, institutional identity and personal and social projection.

4. Conclusions

After this research process, it was possible to build an instrument in accordance with state policies regarding the evaluation of the scientific competences of physics teachers, which can be applied in any educational institution, but it is recommended to include teachers as complementary information sources and to carry out a documentary review of the teacher's field diary and the students' notes. Only in this way can the results be triangulated in order to obtain the current state of the pedagogical process that is carried out within the subject.

The characteristics of the pedagogical practices of these teachers present strengths in some respects and weaknesses in others, supported by coinciding elements in the processes of qualitative and quantitative analysis. The disciplinary aspect, knowledge and mastery of physical concepts is considered a strength; but on evaluation and didactics they are not so strong. In the pedagogical aspect, planning represents a strength of teachers, which is carried out taking into account the institutional reality and the students, in addition it is done according to the area and classroom plans of the area; but, a palpable and demonstrable weakness is the monitoring and improvement, both of what is planned and of what is executed and evaluated; and also represents a weakness the evaluative aspect from its very planning, execution and up to the monitoring and improvement. In the behavioural aspect, all of these are considered to be strengths accepted by both students and teachers themselves, that is, all contribute to the improvement of the institutional environment and results from the point of view of the teacher's attitude. It is also highlighted that teachers and students recognize the value of obtaining knowledge derived from subjects such as natural sciences, taking into account that scientific, analytical and systematic research is promoted through their learning through which can analyze, understand and resolve situations or phenomena related to basic competences in science and technology.

In addition, it should be noted that within the subjects under study basic competences in mathematics, science and technology are concentrated through which the processes of understanding phenomena and physical and chemical laws are strengthened, as well as processes relating to basic competences associated with the scientific method such as registration, organization, interpretation, systems, analysis and generation of data or new knowledge, necessary for the development and significant advancement of society from all spheres of development or knowledge. The above, taking into account that through the course of these subjects teachers through procedural, disciplinary, pedagogical, evaluation and didactic competences promote the development of logical and critical thinking that contributes to the generation of theoretical frameworks that allow interpreting, understanding and generate knowledge through the use of various models, methods and techniques.

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