

Contributions For An Axiological Perspective Of Scientific Activity In The Teaching Of Natural Sciences

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Abstract

Science news highlights the importance of including axiological elements of scientific activity in science teaching processes, as an alternative to overcome traditional conceptions of scientific knowledge, based on an epistemology without a subject and aseptic to human evaluations. Taking into account the axiological perspective can allow a significant citizen scientific training; where they are promoted from the relationships that take place in the school classroom, values of science from an approach that enables the transformation and humanization of this knowledge in the educational context, while being consistent with the dynamics of science and contemporary society. To develop these ideas, the research was approached from a qualitative-descriptive methodological approach of documentary analysis type, which allowed establishing contrasts, interpretations and critical reflections between ideas of the philosophy of science and the teaching of natural sciences with respect to the values of scientific activity and its implications in the pedagogical and didactic field. Elements that revealed some guidelines to think about the educational processes of science and highlight the ethical dimension in contemporary science as a fundamental axis to understand science in sociocultural contexts.

Keywords. Ethical dimension, Science teaching, Values of scientific activity

Introduction

Science teaching in the current educational context must include strategies for social learning and citizen participation, seeking a humanisation and transformation of scientific knowledge in schools (Ferrer, 2020; Gamboa, 2016). For this to be carried out, it is essential to constantly create educational reflections and guidelines that contribute to a socially contextualised teaching of science, and make possible participation and meaningful training processes in the classroom; where adequate scientific literacy, based on the ethical and axiological dimension and processes of critical and reflective thinking (Gomez, 2020; Vesterinen et al., 2014), and thus achieve a significant training of the subjects, in which the knowledge relationships that take place in the school context are promoted, to the construction of knowledge, actions and knowledge, more in line with the dynamics of the contemporary world and the complex relationships between science, technology and society (Vanegas, 2020; Rennie, 2007).

This means that there is a growing need for schools, and specifically in science education, to offer opportunities for discussions on these issues, since personal decisions related to the results of these new relationships are crucial in the responses of society and the educational field. Furthermore, thinking about the inclusion of this type of reflection in the classroom can promote processes of ethical training and values proper to the new perspectives of scientific knowledge, in which the relationships of this knowledge with society, the economy, universities, governments and others are significantly exposed; The aim is to promote a more humane science education that is based on the axiological plurality (Gamboa et al., 2020; Echeverría, 1995) of scientific activity and understands science as a socio-cultural activity.

In this sense, the problem question to be solved in this research is: What educational guidelines can contribute to promote a meaningful education of students in science teaching that is based on the ethical dimension and values in the context of scientific activity? This question is posed as a possibility for the educational context to see the importance of including ethical and axiological elements of scientific activity as an alternative to overcome traditional conceptions of science, in order to achieve a significant human formation of subjects in the field of science and technology (Clément, 2012). This, from the pedagogical and didactic practices in science teaching, in which science can be assumed from a socio-cultural perspective as an opportunity that allows the subjects that are part of the educational context, to think, act, be in the world, and constitute in a complex context of dizzying changes, their existence as aesthetics, politics and work of art. Contributing to conditions in thinking and social knowledge, which directly influence the conscious and ethical actions of the subjects, which ultimately determine the perspectives of the world and reality, and cultural practices that can therefore promote citizen participation and collective well-being from a culture for science and society (Corrigan et al., 2020).

Framework Theoretical

The ethical dimension of scientific activity and the humanisation of scientific knowledge in schools

One of the most frequently asked questions in epistemology and currently in science education is about the importance of values in scientific activity (Hernández-Suárez et al., 2021; Echeverría, 2014). The traditional view is based on positivism, also known today as the inherited conception of scientific knowledge, and is based on the assumption that science is aseptic to the values and ethical dimension of human beings. In spite of this, this idea still presents a very strong debate in the various fields of knowledge of science, specifically in the field of education, mainly in curricula with emphasis on the relations between science, technology and society, if we talk about the numerous researches in science education or in the recent field of the philosophy of science that takes up subjectivity, ethics and axiology in the context of scientific activity, as one of the fundamental scenarios to understand the dynamics of knowledge construction nowadays and its inherent relations with society and culture (Echeverría, 1995).

This reflects that there is an increasingly urgent need for science education in schools to offer the opportunity for discussions on these situations, since personal positions and decisions related to the results of scientific activity and their knowledge are fundamental in society's responses (Macías & Bujardón, 2010). Furthermore, thinking about the inclusion of this type of reflection in the classroom can favour the processes of ethical and value formation proper to the new perspectives of science, where the relationships of this knowledge with society, culture and the natural context are significantly exposed (Rescher, 1999); and in which a science education that is based on the ethical and axiological dimension of scientific activity is made possible. Thus promoting meaningful human training processes, which are based on ideas of transformation and humanisation of scientific knowledge in schools.

The discussion about the ethical dimension is usually seen in the field of scientific application, i.e. when the products of science are already being used or have a high impact on society and often have harmful consequences for human beings, as these implications are expressed under the disjunction between science and ethics. In this sense, science education plays a crucial role, so one of its main objectives should be to contribute to the recognition of the ethical and axiological dimension of scientific activity and to highlight the human values immersed in this system of knowledge, which are expressed in science as an activity and as a way of seeing and transforming the world (Agazzi, 1996).

From cultural approaches, science is assumed as a human activity and an attitude of thought and action, which recognises ethics, the values of scientific activity and the notion of the subject, as elements that can contribute so that, in science education, conditions are generated in the thinking and knowledge of individuals (Gutiérrez-Salazar, 2016). Actions that promote and enable perspectives of the world and reality. Elements of reflection in science

didactics that can be taken up as the foundations of the educational dynamic and thus favour the teaching-learning process.

Values education and new positions in science teaching have a close relationship with the nature of social and cultural relations, an aspect that is spontaneously expressed in how its starting points and its ends are understood (Hernández-Suárez et al., 2017; Macías & Bujardón, 2010), the idea is to strengthen the ways of thinking critically and reflectively from the pedagogical discourse of the science teacher; because from this context of knowledge we can try to educate to develop the ability to positively value the various situations of everyday life, this, to assume the need to choose between open options in various contexts of human life, and to develop autonomy, freedom in the judgment on the valuative aspects, supported by the rational justification of each choice and the dynamics of the scientific-technological system and the world of life (Acevedo et al., 2005).

Therefore, from this type of ideas it is intended to relate the teaching of science associated with the values of scientific activity with the formation of the subject, ethical and political, in the sense proposed by Foucault (1994), a subject that exercises criticism and reflection as liberating actions from this field of knowledge and thought, where he assumes it as an aesthetic experience, an ethical perspective that expresses the knowledge of science and the values of scientific activity as a possibility for subjects to be, think and act in the world, and understand the relationships of this knowledge with society, culture and the natural environment; It is based on establishing in pedagogical practice the convergence between the natural sciences and the human sciences in order to promote a more humanised knowledge and complex thinking that allows to assume the evolution of the socio-cultural context; that is, conscious subjects in thought and action, capable of interpreting their reality and transforming it (Aguirre-García & Jaramillo-Echeverri, 2010).

Methodology

The question that guided the research of this work and the purposes set out lead to identifying the importance in the contemporary context of the philosophy of science and science education of addressing the ethical and axiological dimension of scientific activity, and of contributing from this educational field to an integral human education that is based on the relationship between science and society and culture, of contemporary development.

From these ideas, it became necessary to address a qualitative-interpretative research approach, given that this refers to the whole framework of techniques that are based on human meaning in social life, in addition to its elucidation and exposition by the researcher (Hernández et al., 2018). Therefore, the research allowed us to explore conceptual elements of the philosophy of science and science education that allow us to understand the fundamental idea of retaking the values of scientific activity and its ethical dimension, as

elements that can contribute significantly to the educational context and can favour an adequate integral formation of the subjects and, therefore, a cultural one for science, technology and citizenship. In accordance with the above, the educational guidelines and reflections developed in this work are envisioned so that they can be taken into account in the teaching of science from its pedagogy and didactics, and can be seen as relevant guidelines that contribute to the innovation of science and technology education.

Taking up the above ideas, some details of the characteristics of each of the steps that were taken into account in order to achieve the aims of this research are set out below.

Moment 1: Review and choice of philosophy of science texts and science teaching articles that deal with values and the ethical dimension in the context of scientific activity.

This stage consisted of the search, selection and compilation of documents following the guidelines of Porta and Silva (2003), in which from a methodology of documentary compilation based on a technical-methodological perspective, a series of documents were selected taking into account a series of selection criteria that lead to the delimitation and finding of bibliographic material (which in this case are textbooks on the philosophy of science and specialised research articles on science teaching at national and international level, with a margin of publications, titles, key words, search engines, among others) relevant to carry out a significant content analysis with which it was possible to construct the elements of reflection that take into account the values of scientific activity and the axiological plurality of scientific activity in the field of education.

Moment 2: Elaboration and application of a content analysis questionnaire to the selected texts on philosophy of science and science education.

In order to identify how the ethical dimension and the values of scientific activity are addressed in the scientific context, and in science education in order to build guidelines that can favour the educational context of natural sciences and the formation of an axiology of science and scientific citizenship training, a qualitative content analysis was used taking into account the guidelines of the work of (Correa, 2012), which are based on three fundamental points: to carry out an analysis questionnaire for the selected texts according to the purposes to be developed in the research, In this way, the questions asked are directly related to these purposes, the objectives of enquiry of each of the analysis questions, since the questionnaire is an instrument of analysis that must follow a conceptual design that makes it meaningful to extract relevant information for reflection in order to develop a broad analysis at the conceptual level, and the triangulation of ideas, key concepts, relevant arguments expressed in the documents and with which it was possible to systematise the common elements that

allowed reference to be made to the importance of the ethical and axiological aspects of science in its educational context.

Moment 3: Analysis and contrast of the elements of philosophy of science and science education on the ethical dimension and values of science in the context of scientific activity for training in the context of science education.

The analysis expressed at this stage of the elements of convergence and divergence that, in common, arise from the application of the questionnaire that was able to glimpse the content of the texts of the philosophy of science and science education, is presented by identifying common or differentiated elements that are reflected in these documents, where the axiological and ethical perspective of science and the processes of science education are taken into account. These points of encounter and difference will allow especially to evidence perspectives, positions, ideas, concepts, references and other didactic and pedagogical elements that will arise on the reflection of taking into account the values of scientific activity and the contemporary perspective in the teaching of science in the context of current education, an aspect that will be the basis for the construction of educational guidelines of reflection for the processes of training in the natural sciences and that was manifested as the general objective of this research.

Moment 4: Analysis and reflections on the educational practices and experiences of professionals and graduates in the context of science education, and the relationship of these practices with the ethical dimension and values of scientific activity.

This phase is developed in order to reflect, investigate and analyse some of the teaching practices from case studies in the context of science education, and the way in which ethical and axiological aspects are taken into account in the classroom from the pedagogical discourse that is carried out with the knowledge of science at different educational levels. In this case, the idea was to investigate the practices of some graduates and professionals involved in teaching, in order to identify whether the disciplinary and pedagogical training had an influence on bringing these new ideas of philosophy and science teaching to the educational context. In this way, elements in common and to be taken into account so that in the pedagogical and didactic context an integral education can be promoted from the ethical and axiological dimension of science.

Moment 5: Educational and reflective guidelines for the teaching of science from the ethical dimension and values of scientific activity in the scientific school context.

Based on the elements in common that were identified in the philosophy of science, science teaching and its didactic and pedagogical practices, from the analysis of this contrast, the

answers to the questionnaire, the analysis of the contents of the texts from the different guiding questions, and other instruments used for the analysis of the educational practices of some teachers, it was possible to construct some guidelines and elements for reflection that can be taken into account in the development of science teaching proposals at the level of didactic and pedagogical innovation. In which the ethical and axiological dimension of scientific activity can be taken as a reference for the formation of the subjects that are part of the educational processes of science; aspects that can be carried out in concrete didactic proposals, or ideals that can be analysed to think and carry out alternative teaching and learning processes to traditional visions of the scientific field, and that will be much more in line with contemporary science in which the subjects and scientific activity are fundamental elements of development and socio-cultural transformation.

Results and discussion

The results expressed in the development of this research, which answered the guiding question: What educational guidelines can contribute to the teaching of science in order to promote a meaningful education of students, based on the ethical dimension and values in the context of scientific activity? are the following:

- In accordance with the objectives and methodological approach in terms of analysis and reflection on science teaching based on the ethical and axiological dimension of scientific activity:

It was found that this type of research makes it possible to construct theoretical frameworks of conceptual reference and analytical reflections that can identify elements to take into account in order to develop science teaching proposals that take up contemporary visions of science, including the fundamental idea of understanding science as a socio-cultural, dynamic and constantly changing system, perspectives of education in line with the complex relationships established between society and culture. In this same sense, some theoretical aspects were established with which it can be understood that science, as a human activity, is loaded with values, whether epistemic or specific to scientific practice, which are fundamental to develop them in the context of teaching (political values, human values, environmental values, procedural values, etc.), as this is the most significant area of science to promote the processes of human formation from scientific knowledge and thus contribute to a culture for science and technology that allows for equitable and sustainable social development.

- With regard to the values and ethical dimension of scientific activity and current educational scenarios in science education:

In the development of this research work it was possible to recognise that science as a practice or social activity is loaded with an enormous plurality of values that are constructed in its relationship with culture and society. In this way, when reference is made to educating in values from science teaching, it is not only supposed to promote adequate ethical or moral training, but these actions also directly involve the various values that are present in the educational processes and in one way or another teachers can contribute to strengthening this field of values in the classroom from their pedagogical discourse and didactic practices, here the fundamental context of teaching in the scientific school context. In this scenario it can be mentioned that not only moral values will have a significant value, but that there will be room for the diversity of values that arise from the dialectic between science and society, such as technological, epistemic, aesthetic, ecological, political, democratic, economic, etc. values, in this aspect science teaching is based since scientific activity is somehow related to all these subsystems of social values. This is a key idea in the contemporary context of science and its educational context.

- In relation to didactic aspects and the possibility of an integral education based on the axiology and ethics of scientific activity:

It was possible to take into account that science teaching proposals should be based on a sociocultural perspective of science. Science in the contemporary context is understood from much more plural and inclusive visions, also because current studies in epistemology, history, philosophy of science, anthropology, sociology, among other areas of knowledge of science, have created in recent decades abundantly and as a call to retake ethical and axiological visions of scientific work, fundamental inputs to achieve more meaningful educational processes and that are based on human training, the values of science as a sociocultural activity, the recognition of the other and the natural environment.

- On educational reflections and guidelines for the transformation and humanisation of science teaching in the context of the values and ethics of scientific activity:

If these guidelines, reflections and works are taken into account as fundamental axes in science teaching, and the various values of scientific activity and its ethical dimension are highlighted, the contexts are diversified and the subjects are understood not only as a scientific community in the case of science, but also as individual builders of knowledge regardless of the levels of schooling they belong to, but also as a network of actors that includes politicians, knowledge managers, social groups and population communities that are supported by cultural diversity, and collective constructions of world and reality perspectives, since science is social, is historical and works between two aspects, knowledge managers, social groups and population communities that are supported by cultural diversity and collective constructions of perspectives of the world and reality, since science is social,

contextual, historical and operates between two aspects that converge in its dynamics, the internal aspects of the community that participates in the construction of knowledge and the external aspects of the society and culture to which they belong.

These elements can allow science education to be constituted with the philosophy of contemporary science for which the axiological plurality of the scientific world is recognised and which assumes it as a human activity, it will allow the understanding and significance of the social motives that lead to scientific-technological development, an aspect in which the role of social values takes on a primordial significance, The notion of the subject is taken up again, and by recognising that science is not neutral to values, social responsibility is placed on a fundamental plane in both the world of science and the context of science education, and therefore in the society of which it forms part, allowing new scenarios of human training and social development that is inclusive and based on the common good.

Conclusions and perspectives

The development of this research allowed us to recognise the importance of addressing the ethical and axiological dimension of scientific activity in science teaching processes at different levels of education and from different didactic proposals. A fundamental area of scientific work that is expressed when it is understood as a human, social and cultural activity, and which as a practice expresses a plurality of values that respond to the knowledge it produces and the actions that are carried out in this context. Based on these elements, the process of school science education will make it possible to promote a system of values specific to scientific activity and science teaching, which will make it possible to humanise scientific knowledge, strengthen the ethical dimension of the subjects and understand the complex and dynamic relationships established between science, society and culture as a relational and representational scenario that makes it possible to understand the world and act creatively in it for its transformation.

Finally, from the analyses carried out to construct the conceptual and methodological framework of this work and the reflections carried out in the analysis of the content proposed with the texts studied and the training practices seen, several elements were identified that should be taken into account to think about and develop science teaching proposals that take up contemporary visions of the scientific context; among these, the fundamental idea of understanding science as a sociocultural, open, dynamic and changing system, and in accordance with the complex relationships that are established with society and culture. In this same sense, it was recognised that science as a human activity is loaded with values, whether epistemic or specific to scientific practice, which are fundamental to take into account in the context of science teaching, as they are a dimension that favours human formation from scientific knowledge, and can promote a culture for science that involves in

a sustainable way and with awareness in actions that allow the well-being of nature and society.

References

- Acevedo, J. A., Vázquez, Á., Martín, M., Oliva, J. M., Acevedo, P., Paixão, F., & Manassero, M. A. (2005). Naturaleza de la ciencia y educación científica para la participación ciudadana. Una revisión crítica. *Revista Eureka sobre Enseñanza y Divulgación de las ciencias*, 2(2), 121-140.
- Agazzi, E. (1996). *El bien, el mal y la ciencia - Las dimensiones éticas de la empresa científico-tecnológica*. Tecnos.
- Aguirre-García, J. C., & Jaramillo-Echeverri, L. G. (2010). La ciencia y el sentido común: por la enseñanza de un sentido común crítico. *Educación y Educadores*, 13(3), 477-494.
- Clément, P. (2012). Values in Science and in Science Education. *Science & Technology Education for Development, Citizenship and Social Justice (IOSTE-14)*, 1(1), 1-26.
- Correa, K. (2012). *La secuenciación de contenidos de ciencias naturales: compilación bibliográfica (1990 - 2011) (tesis de pregrado, Universidad del Valle)*. Repositorio Institucional Univalle. <https://bibliotecadigital.univalle.edu.co/bitstream/handle/10893/4573/CB-0460807.pdf;jsessionid=6853C7E4EA4C1CDCF5043D46E75CE7EA?sequence=1>
- Corrigan, D., Bunting, C., Jones, A., & Fitzgerald, A. (2020). The Shifting Sands of Values in Science Education. An Introduction. In: D. Corrigan, C. Bunting, A. Fitzgerald, A. Jones (eds.), *Values in Science Education* (pp. 1-4). Springer.
- Echeverría, J. (1995). *Filosofía de la Ciencia*. Akal.
- Echeverría, J. (2014). *Innovación y valores: Una perspectiva europea*. UNR/ CBS. Reno. NV.
- Ferrer, A. (2020). The History, Philosophy, and Sociology of Science in Science Teaching. In: N. Charbel, M. Pietrocola, E. F. Mortimer & M. R. Otero. *Science Education Research in Latin America (Vol. 22)* (pp. 345-366). Brill.
- Foucault, M (1994). *Las palabras y las cosas*. Siglo XX.
- Gamboa, A. (2016). *Calidad de la educación superior. Pretensiones y realidades institucionales*. Ecoe Ediciones.
- Gamboa, A. A., Hernández, C. A., & Prada, R. (2020). Competencias científicas, investigativas y comunicativas: experiencias desde una línea de investigación en enseñanza de las Ciencias. *Plumilla Educativa*, 25(1), 13–26. <https://doi.org/10.30554/pe.1.3827.2020>
- Gómez, J. A. (2020). *Transformaciones curriculares en la educación superior en América Latina*. Editorial FEDICOR.

- Gutiérrez-Salazar, C. A. (2016). Los valores de la actividad científica en la enseñanza de las ciencias desde la perspectiva sociocultural. *Tecné, Episteme y Didaxis: TED, (Ext.)*, 832-836.
- Hernández, R., Fernández, C., & Baptista, P. (2018). *Metodología de la investigación*. McGraw-Hill Interamericana.
- Hernández-Suárez, C. A., Avendaño-Castro, W. R., & Rojas-Guevara, J. U. (2021). Planeación curricular y ambiente de aula en ciencias naturales: de las políticas y los lineamientos a la aplicación institucional. *Revista de Investigación, Desarrollo e Innovación*, 11(2), 319–334. <https://doi.org/10.19053/20278306.v11.n2.2021.12758>
- Hernández-Suárez, C.A., Pabón Galán, C.A., & Prada Núñez, R. (2017). Desarrollo de competencias y su relación con el contexto educativo entre docentes de ciencias naturales. *Revista Virtual Universidad Católica Del Norte*, (51), 194–215.
- Macías, M. E., & Bujardón, A. (2010). La educación en valores desde el enfoque ciencia-tecnología-sociedad: la simulación educativa como herramienta didáctica avanzada. *Didasc@lia: Didáctica y Educación*, 1(4), 31-46.
- Porta, L., & Silva, M. (2003). La investigación cualitativa: el análisis de contenido en la investigación educativa. *Anuario Digital De Investigación Educativa*, (14). <http://revistas.bibdigital.uccor.edu.ar/index.php/adv/article/view/3301>
- Rennie, L. (2007). Values in science in out-of-school contexts. In D. Corrigan, J. Dillon & R. Gunstone (Eds.), *The Re-Emergence of Values in Science Education* (pp. 197-212). Sense Publishers.
- Rescher, N. (1999). *Razón y valores en la Era científico-tecnológica*. Paidós.
- Vanegas, J., Gamboa, A., & Gómez, J. (2022). Perspectivas epistemológicas en el locus de las Ciencias Cognitivas. *Jotamar*.
- Vesterinen, V. M., Manassero-Mas, M. A., & Vázquez-Alonso, Á. (2014). History, philosophy, and sociology of science and science-technology-society traditions in science education: Continuities and discontinuities. In: M. Matthews (eds), *International handbook of research in history, philosophy and science teaching* (pp. 1895-1925). Springer.