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Pedagogical strategies of the teaching and learning processes of mathematics and physics to strengthen ethical values in students

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Abstract. This research project seeks to analyze the relationship of ethical values with the process of teaching and learning mathematics and physics through a pedagogical strategy in students of the eleventh grade of the “Escuela Bicentenario, Universidad de Pamplona, Colombia”, through the technique of the focus group. Thus, the research process allows us to recognize that ethical values such as responsibility, honesty, justice and solidarity are strengthened through the implementation of pedagogical strategies within the classroom and their impact on the formation of the life project, being the development of physical-mathematical thinking a fundamental axis for the strengthening of values.

1. Introduction

This research is based on the need to respond in the educational field to the various situations that arise today in relation to the lack of values in our society and it is there where the processes of teaching and learning mathematics and physics can be used through various teaching strategies in which students without being aware strengthen the values in the actions implemented by teachers.

On the other hand, we present the investigation of some pedagogical strategies that serve as a reference for this study, being of great help when relating one of them and adjusting the one that better provides the theory in relation to the strengthening of values, they are the socio-affective strategies [1].

Physics and mathematics constitute a body of knowledge with internal logic and laws that serve to characterize in a uniform and rational way the natural phenomena that man encounters in his daily life [2]. It should be noted that the development of physical-mathematical thinking is related to the emotional and affective state of mind in which the student finds himself, hence the interest of teachers of these sciences in trying to change this and at the same time lead to academic improvement, which in search of good results creates strategic elements or actions that help to achieve this purpose [3].

2. Theoretical foundations

The research is approached from three theoretical-conceptual foundations. On the one hand, the ethical values addressed in the study are described, as well as guidelines for physical-mathematical thinking, and finally the pedagogical strategy in the educational field.

2.1. Ethical values

In this order of ideas and according to the types of values according to López de Llergo [4], he relates a set of values by classifying them as: universal and terminal. The ethical values proposed in this project



for the teaching and learning processes of mathematics and physics, such as solidarity, justice, responsibility and honesty, are found in the universal values. The socially positive significance of value is given by the degree to which it really expresses a redimensioning of man, of the relationships in which he lives, and not of isolated subjects, groups or particular social classes [5]. The process of value formation goes hand in hand with the cultural levels of people, and this in turn is developed throughout their lives [5]; therefore, it can be said that values are relationships and affects of human life itself that take into account the relationship between the material and the spiritual, the social and the individual. Values are formed in the process as the human being is socialized and is influenced by diverse factors such as the family, the school, the media, the political, social and religious organizations, remaining framed in the life of each student, as he forms his personality he structures a hierarchy of values that become stable in the life of the student.

The values that will be strengthened in this research are: justice, responsibility, honesty, solidarity. Justice is understood as proportional equality: giving each person what is his or her own, or what is his or her due. This shows that justice must be impartial, giving each person what he or she deserves according to the merits worked on in the society of which he or she is a part [6]. This concept is based on the friendship that people form, which is relevant in the sense that the common good of all is always sought, taking into account equality, that is, the equality of conditions and virtues that pursue the good among themselves [7,8]. In theories on responsibility, Kant states that the two concepts, freedom and moral law, are mutually implied: freedom as free intelligible causality determines sensible causality, it founds the moral law, and the moral law proves freedom by conferring it an objective reality [9], therefore people are free to act according to a certain already formed morality that leads them to have actions of which they must think they will have some consequence, taken this as the freedom that people can have to choose to obey or not, making man a being morally responsible for the duty to be as a person [10,11]. Honesty is a virtue that leads the honest person to be consistent with his vocation to be a community member, to be trustworthy and credible; he does not do anything that disturbs living together because his canon of conduct is respect [12].

2.2. *Physical-mathematical thinking*

The level of appropriation of physical concepts is based on the intelligibility and coherence that each person finds in his or her thoughts. Physical-mathematical thinking is the visible representation of the relationship between physics and mathematics. It is based on the development of the five types of mathematical thought and leads to the consolidation of the learning of physics through the construction, interpretation, abstraction and consolidation of meanings for the teacher and the student on physical phenomena [13].

2.3. *Pedagogical strategy in education*

A pedagogical strategy is based on a series of logical and coherent actions that favour the fulfilment of educational objectives, in other words, all the activities that improve the personal and professional learning of the student [1].

The following pedagogical strategies are applied based on the understanding of the Pedagogy of Humanization: Cognitive strategies: they allow the development of a series of actions aimed at the significant learning of the subjects under study. Meta-cognitive strategies: they lead the student to carry out exercises of awareness of his/her own knowledge, to question what is learned, how it is learned, with what it is learned and its social function. Playful strategies: they facilitate learning through pleasant, emotional interaction and the application of play. Technological strategies: today, in every learning process, the mastery and application of technologies makes any type of student competent. Socio-affective strategies: they promote a pleasant learning environment [1].

3. Method

This research is part of a qualitative approach, as it seeks to study reality as it is presented and its dynamic structure, thus attempting to explain behavior and its manifestations [14]. Likewise, it is carried

out through a phenomenological method, since it aims to study the phenomenon of study as experienced, perceived and lived by the participants, focusing on the experiences of individuals that cannot be expressed, but have great relevance in understanding the mental state of the person [15].

Similarly, the application of the focus group instrument is referred to as the basis of this research, where the answers or opinions provided by the participants through a conversation directed and related to the research study are taken into account. It is a planned conversation, developed in order to obtain information from an area of interest in a permissive environment and to learn about specific aspects of the population or group with which one will be working [16,17].

Evidently from the above, a series of valid information is given to support the research, as well as it organizes a series of results that support the main objective and the specific ones in order to draw conclusions from which true sense can be given to the proposed study in relation to the information analyzed in the development of this research related to the strengthening of values with the teaching and learning process of mathematics and physics that in turn strengthens the development of mathematical physical thinking.

4. Results

The results obtained through the application of the research instruments were analyzed through the hermeneutic analysis of the focus group. The hermeneutic analysis of the focal group is carried out by subcategories.

4.1. *Subcategory responsibility*

From the verbalizations of the participants and the application of the symbolic language of physics, it can be inferred that this value in the students has been of great importance, since, through their growth, from the formation in the family and in the school, it was consolidated. At home, they were already taught to be responsible for their schoolwork so that they would do well in school, just as they felt the same way in school when the teacher taught them to be responsible in their commitments, which was important not only in mathematics and physics but also in other subjects.

The applicability of the concepts of physics, complemented with mathematical rigor, led the student to develop a concern for punctuality, timely delivery and good presentation of the work, taking into account that in this way they could actively participate in the socialization of results. All of the above helped them to reflect and consider themselves responsible, punctual and disciplined thanks to the training they received at the school from the formation in values from mathematics and physics.

Likewise, the young people report that responsibility is a value that they learned through positive reinforcement, but that, at present, they understand the importance of this, without the need for those stimuli that motivated them to put this value into practice. They emphasize that responsibility is an aspect that must be present in all spheres of human life, demonstrating coherence between what is said and what is done, since it is like a letter of introduction to other people.

4.2. *Subcategory honesty*

According to the participants' statements, it can be said that for them honesty is relevant in people's lives, because according to people's way of being in this sense it can be said how the person is and who is, will be something positive for people's lives

As well as being honest and telling the truth, assuming the consequences in order to gain people's trust and consider that thanks to what they were taught at school today they are honest. Academic honesty is born from the activities carried out in the physics laboratory, the reading and interpretation of results and their use for explanation from a mathematical point of view using formal language. They emphasize that by being honest with the fulfillment of these tasks, they also influenced in one way or another their other colleagues, since they had to fulfill and express the veracity of the situation, as it was in the case of the delivery of notebooks and math folders and the realization of physics laboratories along with the delivery of the corresponding reports.

4.3. *Subcategory justice*

It is evident that for the participants justice is an outstanding value in the career, emphasizing the need to execute this value in any of the areas and activities in which they are and do, in particular in the collaborative work that is carried out in the physics laboratories and in the evaluation of the reports presented.

4.4. *Subcategory solidarity*

Participants recognize the importance and impact of being supportive, as it not only strengthens their skills, but also allows them to strengthen those of others around them, optimizing time and achieving better results.

4.5. *Subcategory life project*

The participants focus the ethical values towards what they want to be according to what they learned in the school life; however, these values were acquired as they grew up and were taught first in their families, being noticed today that they have served for the life they thought to live in the future. The processes of teaching, in specific areas of great difficulty, such as physics and mathematics in which it requires collaborative work, lead them to learn to relate to others knowing well what they really want for their lives. The participants affirm that training in values from the classroom has been of great importance within the university context, since these values are necessary for the development of their duties and functions.

On the other hand, the young people expressed that for them, the development of physical-mathematical thinking allows them to deal responsibly with problems in their social environment and come up with viable solutions, and that although initially they were not aware of this, they now recognize that without them they would not have achieved what they are now and that even if they had perhaps listened to the advice they would be closer to their goals.

In addition, they indicate that despite not having fully employed the values taught in class, the influence of peers and teachers from the practical side, the work done in physics and mathematics classes was of great importance after school, since most of the participants, managed to enter university and even some already have economic stability, thus achieving the goals of their life project.

5. Discussion

In the first place, the results obtained show that the academic activities carried out to strengthen the development of physical-mathematical thinking strengthen responsibility as something essential in the lives of the participants, so this leads to take into account this virtue in all aspects of life, focused on carrying out any task, for example, for the participants it was crucial to deliver the papers on time and well presented. Also in the way of acting and responding to actions, whether they involve the welfare of others and have also allowed them to develop in a community or society, this result agrees with Fernandez [18] in the legal field presents the responsibility as a fault to the rules that lead to misconduct that does not cause any good to society and the fact that the person who commits the fault is responsible and must compensate the consequence of their misconduct. As well as making every effort to be on time at the entrance to the school or at the end of the break to be on time in the classroom.

On the other hand, as regards honesty, it is shown to be relevant, forming in them confidence in themselves and towards others, strengthening in them this virtue, since they had to say with sincerity that they would fully comply with their commitments. The results of the work in the physics laboratories confirm that this virtue can be defined as the manifestation of truth in the dual aspect of the individual and the social, and it also speaks of the fact that the superior man must make his thoughts sincere, and must watch over himself even when he is alone [19]. A relationship was also found between this value and the concept of honesty, which refers to a value that is proper to human nature, synonymous with truth, sincerity and transparency [12], since they show that in this way they felt that the fulfillment of their duties was in some way a manifestation of the trust that the parents had placed in them.

In accordance with justice, it was found that for the participants it is important to carry out a job or in the same career they chose, because according to their work and functions they should respond in a fair way, making projections that are adjusted to the reality of the work; that is, to be fair in using the necessary and sufficient materials, also giving a price according to the work carried out and working in a fair way with their colleagues so that the relationships are healthier, values that they recognize strengthened not only in physics and mathematics classes but also in the realization and socialization of the assigned work. The above coincides with Aristotle who expressed that justice as proportional equality: to give each one what is his own, or what corresponds to him, this gives an understanding of the importance of giving each one what he deserves, without taking away what he should not and putting in more than what corresponds to him [6].

However, in terms of solidarity, it was found that participants tend to be supportive, as they build their skills and strengthen them through interaction with their peers and by establishing a more affective and trusting relationship as they are reflected in the work organized in teams, particularly in the activities carried out in the physics laboratory. This coincides with Amengual's [7] statement that everyone is responsible for everyone and everyone is responsible for everyone, one for all and all for one, which involves support among people and being able to get ahead all at the same time in the same task. Thus it was also found that it is related to what Aristotle said, saying that this type of solidarity includes friendship understood as the main good that citizens have in the community within a regime of equality, managing to create bonds of affection and mutual aid between the participants by gathering conditions and virtues that served to help each other [20].

In relation to the life project, it was obtained that the participants have made an effort to visualize their goals through the values inculcated from the family and the strengthening of the same, preparing themselves day by day from the application of mathematics and physics in different activities of life, since the work with the teacher was focused on reflecting on the enrichment of the values, through the actions in which it allowed them to verify the importance of them for their life in society and at the same time they recognize that without them they would not have been able to begin to build their future life and how they carry it at this moment, what agrees with what D' Angelo mentioned the project of life is conformed by psychological structures that express the essential directions of the person, in the social context of material and spiritual relations of existence, that determine their position and subjective location in a concrete society from the experiences and the relation with the others, they are reflected in those situations that favor what today is known as project of life and it helps them to transform their styles of life [14].

On the other hand, the teacher's role in the development of physical-mathematical thinking should lead to actions that become positive for the students' lives and not to form automatons complacent to a society. The work or profession should not be something that is only to prepare educated minds; it should also reflect a human being formed in values with love for other people and appreciation of the authentic feeling, history and philosophy of physics and mathematics. Therefore, the teacher must have ethics as one of the pillars of his or her pedagogical practices. Ethics is perceived as magnificent in human conduct, directed towards what is good and right, and is strengthened when rules are internalized without being pressured by situations or entities that force compliance. This means that the ethics of a physics or mathematics teacher originates from his or her training, which means that the teacher must act, carry out his or her work ethically, and be an example through his or her behavior and a suitable lifestyle.

Therefore, it is also relevant that the teacher, just as he or she is trained to teach physics and mathematics, rather than theory and knowledge, should establish some criteria for the training of mathematics and physics educators based on the formation of ethical values which will be reflected by their students when they come to the classroom to guide the teaching-learning processes. Likewise, the student sees in his physics and mathematics teacher a model to follow, since he recognizes in the teacher each and every one of these virtues that they may be able to capture in their actions and behavior in some future, seeking in some way to be more productive for themselves, for a society that is forging a better quality and lifestyle.

6. Conclusions

In accordance with the design of pedagogical strategies that develop physical-mathematical thinking and facilitate learning and strengthen ethical values in students, the respective researches were carried out regarding a series of pedagogical strategies applicable at the time of guiding the classes in the process of teaching and learning the specific contents of mathematics and physics and in relation to them emphasizing with greater reason those pedagogical strategies that have to do with the strengthening of ethical values, such as socio-affective strategies. Finding in this strategy a different way of teaching mathematics and physics, if we strengthen in the attitude, the love towards something, if we form subjects with social responsibility and with sense, meanings and social thought, we will not need to worry anymore about the academy, about academic rigor, this will come by itself with seduction.

First, a focus group was held that gave rise to a series of values that the students expressed are a constant today in the different roles they play, either as students or performing a job or trade, these values are: responsibility, justice, honesty and solidarity and others that stem from these as: respect, punctuality, teamwork, friendship, perseverance, among others.

By designing the pedagogical strategies presenting a set of specific actions for the development of physical-mathematical thinking and the strengthening of ethical values, it served for the students, without being aware, to develop skills and abilities in each of the physical-mathematical processes and to make an effort to carry out corrective activities to solve doubts and advance academically, among others. So, with this set of actions, the students saw the purpose of strengthening values in the mathematics and physics classes as timely.

Through the expressions or opinions of the students, according to a series of questions directed precisely to those results that they obtained in the eleventh grade, the satisfaction of the application of the pedagogical strategies implemented by the teacher was appreciated, as well as when the classes always talked to them about the relevance of ethical values without diminishing the importance of specific knowledge of mathematics and physics.

The development of the physical-mathematical thinking, not only allows to favor the development of the scientific competences, generating in the student a thought that allows him to identify scientific questions, to explain the phenomena and to use specific tests, but also they form him in values developing competences that will form a critical citizen with a set of values oriented to the search of the truth and the common good.

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