

University, Biodiversity, and Education

Ludwig J. Gutiérrez Montilla¹, Rogelio A. Díaz Castillo² & Fernando Bacardí Soler³

¹ORCID <https://orcid.org/0000-0002-3705-3814>, Ezequiel Zamora National Experimental University of the Plains (UNELLEZ), Barinas, Bolivarian Republic of Venezuela, ²ORCID <https://orcid.org/0000-0002-6947-2781>, University of Las Tunas, Faculty of Educational Sciences, Department of Biology, Las Tunas, Cuba, ³ORCID <https://orcid.org/0000-0003-1884-9769>, Ignacio Agramonte Loynaz University of Camagüey, Center for Educational Sciences Studies, Cuba.

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Correo electrónico: ludwiggut@gmail.com

Abstract

Context: Biodiversity is a condition of human existence. By transforming nature, man has also transformed its context, with ensuing progressive degradation of biological diversity. This study stems from the need to improve the treatment of biodiversity from an educational perspective that includes professional education.

Objective: The aim of this paper is to establish proper professional training interaction with biodiversity within their scope of action. It would be effective through more activities intended to achieve integration between professional education and the global issue of biodiversity.

Methods: Empirical methods were used to reveal insufficiencies and potentialities. Theoretical methods were used to lay the foundations of this study, including its background; modeling was also used.

Results: The contribution of this study consists in a pedagogical model to facilitate interaction of biodiversity with environmental education, and other factors that promote students' culture in biological diversity.

Conclusions: Assessment of transversal treatment of biodiversity throughout environmental education of undergraduates revealed positive effects on the participants. The pertinence of these actions was corroborated. Besides, emphasis was placed on the importance, topicality, and need of further research aimed to achieve proper professional training interaction with biodiversity within their scope of action. This would be effective through more activities intended to achieve integration between professional education and the global issue of biodiversity.

Key words: professional education, environment, biodiversity, transversality.

Introduction

Biodiversity, as a synthetic expression of biological diversity (or diversity of the biological world) has been used since 1985 to designate the variety of life on earth. Though it more frequently is used in relation to species diversity, which also includes genetic variety; in a broader sense, it comprises the variety of communities and ecosystems. C. Palau (personal communication, University of Sancti Spiritus, Cuba, February 17, 2016) noted that diversity should not only consider the variety of species, but also equitability; that is, the number of individuals per species.

The large variety of subregions and ecosystems in Latin America and the Caribbean, the Andes, the oceans, and the Amazon, makes it critical to state an

environmental policy toward biodiversity (concrete) in keeping with changes in environmental assessment by the society.

Thus, biodiversity is not just the results from the efforts of human activity, but its ultimate and supporting condition. The progressive transformation of nature by man, as a consequence of disproportionate development, has changed its context and natural space to the extent of degradation which leads to progressive reduction of biodiversity.

This diversity of ecosystems also comprises a social diversity expressed in ethnic and cultural terms through spatial occupation and proper use of biodiversity permanently. This not only transforms the environments and landscapes during its historical process, but also human populations.

In spite of the wealth produced, the damage caused to life on earth and to other basic natural resources needed for sustenance has been considerable. Accordingly, the environmental situation, particularly biodiversity, has generated more spaces for discussion at different international fora. Since before the Tbilisi Declaration, in 1977, and even after the signing of the Agreement on Climate Change, in Paris, 2015, all stakeholders have agreed on studying the growing problems related to the environment, the importance of environmental education, and biodiversity. Emphasis has also been placed on arranging a pedagogy of action and for action that redesigns education into a sustainable development approach.

Concerns about environmental problems have gradually increased. Environmental education is given higher importance as a way to train professionals to address these issues, including knowledge and capacities to manage ecosystems, biodiversity, and cultural diversity.

In that sense, Environmental Education is an academic response that conjugates social justice, sovereignty, and construction of a democratic and participatory society that guarantees social transformation, ecological balance, and the exercise of environmental sovereignty.

In view of the above, the new professionals should be committed to the local, national, regional, and global environmental needs, integrated in the human, natural, and created subsystems.

Therefore, there is a need for relevant and significant contents to solve critical and everyday problems, with emphasis on critical, humanistic, and social education of students. (Almaguer, Mestre & Díaz, 2010), so that the graduates can participate in the construction of a new society, and contribute to the protection of the environment and sustainable development, in accordance with the objectives and goals stated in the 2030 Agenda of the United Nations.

Consequently, adequate environmental education implies the need of knowledge on the current situation of biodiversity and its possibilities for sustainable use, as an essential element of this kind of education. The new professionals should have a broad and solid environmental culture, which will be completed thoroughly after graduation. Therefore, teachers should meet the highest professional demands, not only derived from the complexities of the curriculum, but also be oriented in a flexible and contextual manner, in order to change the local context where they live and work.

Research done by Rivera & Cárdenas (2003) and Rincón (2011) in the area of education includes the transversal axes leading to methodological changes in the training process, especially in universities, which must embrace the study of biodiversity.

The literature reviewed in relation to biodiversity in Cuba, showed the existence of studies like Cardona, Díaz & Vera (2013), who suggested an inter transversal strategy for elemental environmental education to teachers of natural sciences in senior high schools. Also, Méndez (2010), suggested a didactic strategy to tackle biodiversity contents with an interdisciplinary perspective, in high schools.

Although the previous authors did not mention this coverage as transversal axis of biodiversity, they explained their contents through the activities recommended. Similarly, Guerra (2011), suggested a pedagogical strategy toward biodiversity education and preservation, to teachers of natural sciences at pedagogical colleges; the author also directs her strategy to all natural sciences teachers.

All research has demonstrated the potential of the curriculum and its theoretical limitations to treat biodiversity in professional education; hence, it is possible to provide adequate treatment to education in biodiversity, in keeping with the particular professional activities.

Concerning preservation of biodiversity, it is an important and present-day objective, though it is dealt with as a general, out of context aspect, which leads to the absence of suitable integration into learning (Clavel 2015). Therefore, the graduates lack the knowledge and skills needed to deal with biodiversity as professionals.

The fact that proper assessment aspects linked to biodiversity are not stressed is quite generalized. The need for participation in related activities, and the importance of field work, are two aspects to consider, but they not always materialize. Likewise, the lack of practical use of the local context calls for better initiatives to achieve proper methodological treatment to develop general training environmental strategies.

All that situation is reflected in the poor knowledge and skills in biodiversity by graduates. A significant group of teachers show little interest to include that content in terms of social and environmental problems, especially those linked to the territory, so creative and transforming influences are not implemented in communities and ecosystems where professionals live and work.

Therefore, it can be said that though there is a set aspiration to train environmentally skilled professionals who can understand, explain, and assess the relationship between man and nature, several insufficiencies are observed in terms of mastery of biodiversity, as an expression of limitations in conducting an environmental training process designed to fulfill this aspiration.

The challenge of education in biodiversity

How can education in biodiversity be used to train professionals? This reality is a challenge to transformation processes undergone by the pedagogical process today, which demand creative and effective responses to understand and handle varied and rich ecosystems. This challenge becomes even bigger in view of the absence of a coherent theoretical system that helps disclose the grid of essential relationships that take place among the elements through teaching-learning.

This work is conceived as a dialogic and transforming process that implies understanding environmental education as a social construction, arisen from interpersonal, intrapersonal, and intercultural dialogue. The principle of learning how to learn is closely related to it, and it means a rupture of the teacher-student polarity.

This paper suggests a transversal treatment of biodiversity toward a more comprehensive environmental education. This transversality should make proper use of all the experiences gathered in this area, the theoretical grounds of environmental education, and the particular character of treating biodiversity in every curriculum and territory. In other words, contextualization of this process.

The methods of research have stemmed from systematization of contemporary environmental education, particularly, the treatment of biodiversity in the process. This has led to modeling of transversal treatment of the topic during environmental education of professionals, and the design of actions in that direction.

Workshops were made, and surveys were applied to experts in order to perfect the results achieved. Empirically, observation, interviews, and tests, helped corroborate the effects of these actions on students, at the Bolivarian University of Venezuela. Barinas, Portuguesa venue.

The novelty of this proposal lies in presenting the community and the ecosystems that interact as the comprehensive educational context within the environmental education process in biodiversity. The link including spatial diversity, personal experiences, and conceptual cores enables a transversal treatment of biodiversity periodically, in a flexible, repeated, and complex manner, in order to perceive, create awareness, and transform problems related to biodiversity, based on sustainability criteria.

The theory of environmental education in biodiversity is enriched with the explanation of this pedagogical model of universal treatment of biodiversity, whose cognitive, affective, and procedural components establish essential relations putting man as a bio-psycho-social entity, in terms of experiences and integration.

This theory is realized in actions oriented to transversal treatment of biodiversity, according to the previously mentioned model, for implementation in environmental education of professionals within the context of the communities. All this favored the pertinence of the educational process, the quality of graduates regarding scientific-environmental training, within an updated context, and the repercussions of this process integrally.

Environmental education in universities and the treatment of biodiversity

A deeper look into the epistemological assumptions that back transversal treatment of biodiversity revealed the historic background of environmental education in universities; i.e., professional training to discover, confront, and solve environmental problems, namely, disproportionate loss of biodiversity.

This is an integral part of professional education directed to solving environmental problems. However, the ways to treat environmental issues has been historically restrained, to postgraduate education. Recently, awareness has grown on not postponing environmental education to professionals. Particularly, the curricular strategy of environmental education in Cuban universities, is contextualized in every syllabus, depending on the potential of content, and the characterization of students and their future scope of action as graduates. (Pérez, García, 2013)

There is gradual understanding of the need to train professionals to act in concert with communities and other social actors, sharing an ecological culture associated to comprehensive and sustainable development programs, into new social and environmental realities, based on cooperation, equal exchange, tolerance, and sustainability.

A graduate with these characteristics will be aware of their responsibility toward society, expressed in the struggle against the causes of poverty as one of the most excruciating social problems, improvements in life quality, rehabilitation conservation and preservation of the environment within the legal frame in effect, transformation of institutions, and community participation.

Proposals and projects derived from national environmental strategies to treat biodiversity, as well as strategies of environmental education of professionals in general and in specific terms. This evidences the emergence of a movement in favor of cultural and professional development, which introduces a new conception and definition of categories related to environmental education and biodiversity, which are analyzed in this paper.

The concept of environmental management represents actions undertaken, which are consciously directed with accurate intentions to protect, preserve,

improve, and use the natural resources moderately (renewable or not) in a sustainable way. Therefore, management is projected toward the environment and participation of citizens, knowledge, preservation, and sustainable use of resources, which must be carried out from the levels of biodiversity.

Consequently, the philosophical side relies on the Marxist-Leninist conception of knowledge, and their dialectic-materialistic approach, as a general methodology of science, which provides an approximation to the essence of environmental education in biodiversity. The dialectic-materialistic philosophical conception favors the interpretation of current relevant social needs, and the prospects for environmental education that grant professionals the theoretical comprehensive framework of orientation in the complex system of cognitive, economic, political, and ideological interactions, that includes the loss of biodiversity as a present-day problem.

The sociological background is assumed from the process of socialization of the professionals-to-be. Their pertinence depends on the degree of response to shortages and conflicts faced by society, economically and politically, scientific and technological, and environmental, always from a community standpoint. Sociologically, sustainable development and endogenous development are suggestions; they contribute with theoretical, methodological, and practical elements that facilitate this endeavor.

Endogenous development is set on increasing production, using local resources, improving the habits of consumption, and satisfying basic needs. Sustainable development focuses on maintaining basic ecological processes, maintaining biological diversity, stabilizing human populations, the sustainability of resources, the reduction of pollution, and satisfaction of basic needs. Both models benefit biodiversity, including social and cultural biodiversity.

These are basic contents in terms of environment, clearly corresponding to the reality faced by students. Therefore, environmental education “contributes to comprehensive and sustainable development of the society”. (Bolivarian University of Venezuela [UBV], 2015, p.6), and it is intended to improving the quality of university education, which must respond to the social and environmental needs.

The psychological side is backed by the essential practical activity in their relation with cognitive, assessment, and communicative functions of the personality. Accordingly, the psycho-pedagogical standpoint considers that to achieve environmental education, all the educational processes must be reinstated, with new approaches, methods, contents, and new relationships among the different educational agents.

This means that the pedagogical process of these specialists is set on their interaction with the social context. Awareness on knowledge of education, knowledge on behaving, knowledge on doing, and knowledge on living together, open new spaces for discussion, interaction, mutual acknowledgment, collective freedom, and social knowledge applicable to knowledge and defense of biodiversity. These aspects were defined by Vygotsky (1987), in his historical and cultural approach, and it has become an important psychological assumption by conceiving the development of the personality of the future professional as conditioned by their social interaction. In other words, it means the integration of activity, and the communication of the educational process, the relationship between education and development, and the union of the affective and cognitive sides.

Emphasis is placed on the affective aspect, which relies on the pedagogical principle of the union between the cognitive and the affective aspects, since the cognitive operations must carry a favorable emotional content to meet the educational objectives.

Besides, the principle of unity and activity, communication and personality, where the success of the pedagogical work lies, is in the quality of the activities done by students with their teachers to acquire a topic, and fluent communication established by both, and the students. Therefore, the pedagogical process becomes binding to students’ surroundings, nature and its relation with transversality of biodiversity.

Although humans interact with biodiversity on an everyday basis and in different ways, its meaning has not created sufficiently clear images to distinct social sectors and groups. Its implications have not been understood in all their extent, and handling them is confusing, which has limited the social contribution in setting public policies in this regard. This is a complex concept that goes beyond the living degrees, from the genes to the communities, and in all the scales of space and time, which creates difficulties in stating and conscious interpretation in relation to educational and communicational strategies. (Savard 2000)

(Velásquez, Romero & Jardinot, 2015) (Yli-Panula, E. et al., 2018).

Therefore, the efforts made by institutions should embrace research and extension to rescue and disseminate the phenomena like the loss of biodiversity, as a response to the large amount of affected bioregions and ecosystems in Latin America, the ones with the highest diversity in the world.

For instance, “South America not only has 40% of world biodiversity, but also 25% of forests, and 26% of fresh water reservoirs. This huge natural richness has also made this region one of the most vulnerable,

as the target of world capitalism. Only 12 countries of the more than 170 in the world treasure 60-70% of biodiversity that includes all the animal and plant species inhabiting the planet. The sum of all the territories of these countries comprises less than 10% of the earth's surface (Movement of Green Ecological Union [MGEU], Data- August 18, 2015, email: mueve2003@yahoo.com). This richness is frequently unknown by the inhabitants of these countries.

However, the harm to this biodiversity is severe, and the university should be up front to revert this situation. In agriculture, there is a need to emphasize on the integration of the potential of ecosystemic services of agrobiodiversity. (Parrado, Carrión & Castro 2017).

To achieve this, higher education is required to offer broad environmental training, and transversal treatment of biodiversity in terms of research and professional education, as another area of knowledge, and substantive part of their social functions; besides being an urgent need due to the growing loss of regional, national, and global biodiversity.

Characterization of state in environmental education on biodiversity

Periodical checks made at the BUV, Barinas, and Portuguesa venues, in the 2010-2015 period, showed insufficiencies and potentials for development of this important work.

The analysis of the existing situation in the treatment of biodiversity in the Program of Postgraduate Training in Environmental Management used instruments like pedagogical tests to students, surveys to students and teachers, interviews to syllabus coordinators, and class observations to check the evolution of the environmental education process. A population of 155 students received intentional samples N=96 in the survey, and N=47 in the pedagogical test. Teacher sampling was N=20 (100% of the population), whose education was provided to industrial engineers, sociologists, integral teachers, nurses, and teachers of biology. The following indicators were considered:

- Knowledge of biodiversity by students and teachers.
- Mastery of biodiversity in the location, and different types of environmental responsibility.
- Student and teacher attitudes toward protection of biodiversity.
- Participation of students and teachers in actions related to biodiversity and its preservation.
- Activities developed in that direction throughout professional training.

This helped disclose the lack of knowledge of local endemic species in the plains and at the basis of the Andean Mounts, with difficulties to state proper definition of biodiversity, as well as measures to preserve and protect species. Similarly, there were little accurate responses on the activities that may affect biodiversity, no mastery of major concepts, like ecological niche, environmental education, population, and species. Only a fourth of the samples acknowledged some contribution to fight back the loss of biodiversity within its scope of action.

Teachers recognized their limitations in biodiversity treatment. No activities were held in that direction. Most considered that the training received for this job was inadequate. The subjects did not recognize the levels of biodiversity, though they did understand the importance of endemism, climate change, and deforestation, and attributed the occurrence of this problem to the development model.

Only a fourth of the subjects provided the right response, just cognitive elements, in terms of the methodological actions made by teachers to help preserve biodiversity. This coincides with studies done at the University of Valencia, which noted "more cognitive-centered educational activities, and little education in skills and attitudes, as negative" (Aznar et al., 2014 p.145). Various tasks including contents in biodiversity, though transversalization was not observed in dealing with this topic. However, they acknowledged the importance of transversal work.

Hence, several insufficiencies were observed in the treatment of biodiversity, at the local, country, region, and global levels. No identification of local threatened species (endemic or native), little mastery of processes involved in species variety. Finally, the developmental model is not always associated to this problem. Research done by Martín et al. (2015), showed similar limitations in students at the Department of Biology, University of La Plata, Argentina.

Although the importance of developing education and consciousness in that direction, no participatory action or social work was observed to favor biodiversity. Accordingly, there was no adequate understanding of the repercussions brought about by the loss of biodiversity. This has been corroborated in both students and educators with teaching expertise in various professions, as shown in the sample.

Transversal treatment of biodiversity

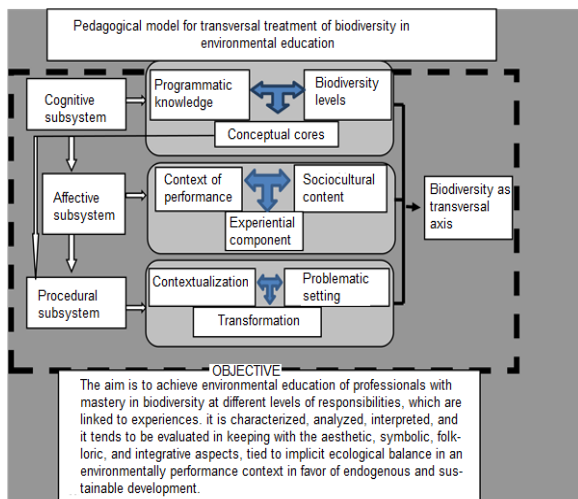
The pedagogical model designed for transversal treatment of biodiversity stems from the data collected from the actual diagnostic, the experience of authors, and critical analysis of the sources consulted, particularly, Méndez (2010), Guerra (2011), and Cardona, Díaz & Vera (2013). Three

subsystems are identified in the model: cognitive, affective, and procedural.

The cognitive subsystem is mediated by conceptual cores as an element that articulates and reveals the levels of biodiversity periodically and systematically of programmed contents. Consequently, the components of this subsystem are the system of programmed knowledge, the levels of biodiversity, and the conceptual cores.

Hence, programmed contents are the ones present in each chapter of curricular units, throughout the curricular professional training process. Likewise, the levels of biodiversity correspond to steps of biological hierarchies pooled according to their arrangement. This subsystem in particular basically considers the molecular level in its genetic variety, organisms and population, species variety, and community, regarded as ecosystem diversity.

Figure 1. The Pedagogical Model.



The conceptual cores are expressed by a system of essential concepts (high generality) that contribute to the articulation of biodiversity levels with programmed contents, and which must be broadly known by teachers and students.

Actions for transversal treatment

The cognitive subsystem in terms of programmed knowledge, is articulated and it focuses on conceptual cores of high generality present in the programs of curricular units of basic, social, philosophical, technological, and environmental sciences of syllabi. Some examples of disciplines with such potential are, Ecology, Environmental Systems, Globalization Communication and Culture, Legislation, Biogeochemical cycles, Territorial Arrangement, Environmental Law and Integrated Management of Natural Resources, etc. The affective subsystem defines the context of environmental performance as the community space where community culture is associated to the way of knowing, included in the programs of different curricular units, which allows for acquisition, understanding, and characterization

of biodiversity and its interrelations. In that order, the social and cultural contents show the need to reveal students and teachers the relationship between the loss of biodiversity with the loss of not only life, but also harmony, identity, and culture. Moreover, the significance of popular and artistic knowledge to educate in biodiversity preservation, supported by Guerra & Hernández (2015), is also significant. In that subsystem, experience means taking advantage of the best acquisition expertise, and the meaning that nature shows man in their relation with it.

It is important for students to make biodiversity as part of their identity during their education, living in an inclusive society, where nature is seen as an inseparable part of their existence. Hence, the social and cultural message with other subsystems and components, because man knows about biodiversity in the form of experiences; they characterize it, analyze it, interpret it, and tend to value it. It comprises harmony and joy of the arts and aesthetics, the symbols, the folklore, integration, and their balance, explicitly given but not used within the context of environmental performance by students.

In the context of environmental performance, the ecological trail, as the way to signal outstanding environmental elements, is significantly articulated with the subsystem. It allows re-signaling as a space with some level of biodiversity, which offers the by-walkers certain experiential meaning of nature.

The procedural subsystem is conceived as the main actions generated in the broad context of environmental performance made by the community surroundings, where students are educated with the experience of the ecological trail. It is assumed as a route with certain qualities of biodiversity present in that area, which help bring new meaning to the innate features of subsystems cognitive and affective.

Thus, the procedural subsystem is the one that shapes the community performance stage of undergraduate professionals, where the issues of biodiversity are contextualized, aiming at identifying and suggesting solution alternatives to improve or transform an undesired environmental situation.

Generally, the procedural subsystem is focused on building education that arises from understanding and searching for solutions to already identified problems.

All this leads to strengthening necessary concepts that will be used later in practice.

Accordingly, student evolution can also be attained through transversalization of biodiversity. This involves the three subsystems, demands more flexible contents and a more experiential treatment of biodiversity, assumed as a cultural message assimilated and internalized on the trail, mainly, as part of the context.

The aim of these actions include transversal treatment of biodiversity, systematicity, transformation, and comprehensiveness, in order to guarantee student learning, the development of attitudes, skills, and values, as a conclusion of understanding the culture of biodiversity.

These actions are set into three directions: diagnostic and planning, implementation, and evaluation.

I. Diagnostic and planning of contextualized and problem-solving actions in concert with the professional training program contents.

Objectives:

-To corroborate particularities and regularities in transversal treatment of biodiversity within the syllabus.

-To plan contextualized and problem-solving activities based on present particularities, the trail conceived, and the community, aided by local specialists.

During this stage, as part of checking regularities, teachers apply instruments, such as certain dimensions and indicators, according to the social and environmental realities of the context surrounding education.

Moreover, it will take into account planning of activities with contradictory situations, which are perceived in the regional and national surroundings (CITMA 2016), and perform local assessment based on a contextualized and problem-solving character. Hence, students must apply the system of knowledge, skills, and values incorporated, and therefore, lead to a positive behavior of students toward biodiversity, namely, environmental ethics, social sensitivity toward the environment, and scientific criteria about man-nature relationship.

In this direction, the actions to be implemented are,

- The application of instruments to check particularities and regularities in the treatment of biodiversity.
- Determination of the community potential in environmental education in biodiversity.
- Design of the ecological trail based on the existing local biodiversity.
- Design of activities that associate students to class contents, review of several sources, and the reality of the local biodiversity.

II. Implementation and development.

Objective: To perform actions and activities planned.

The links between contents of the curricular units will be set up as a way to establish a relationship with conceptual cores, as well as the system of values promoted. Then integration links will be established among the cognitive, affective, and

procedural subsystems, determined in the model of biodiversity treatment.

Consequently, the activities below can be done to link the related curricular units to studies in biodiversity.

- Orientation and discussion of exercises and assignments, based on the knowledge acquired on biodiversity at different levels, and their relationship with curricular units.
- Contextualization and problem-solving in topics like,
 - Biodiversity degrading elements.
 - Problems related to biodiversity preservation.
 - Solution of problems affecting biodiversity.
 - Development of planned process activities.

III. Evaluation of contents acquired by students in environmental education, a culture of biodiversity.

OBJECTIVE: To check individual and collective student progress in knowledge, skills, and actions, as a results of grasping and acquisition of a culture of biodiversity.

The evaluation of knowledge, skills, and attitudes acquired by students during their educational process is done by corroborating biodiversity acquisition, behaviors, and assessment of the commitment to this problem.

Throughout that stage, teachers may carry out actions like,

- Planned activity follow up included in the set objectives.
- Application of systematic monitoring through visits to the community surroundings and the trail.
- Assessment of research activities on the trail and the community through the drafting of a report.

Assessment may vary. Hence, various activities can be assessed, including workshops, which can show student acquired knowledge, skills, and attitudes, through schematics, monographs, papers, narrations, stories, songs, drawings of the reality, maps, poetry, legends, and other cultural manifestations. All of it must be constructed with the elements of biodiversity elements realized as a trail or environmental visits, spots where professional education takes place. In other words, to engage and foster manifestations of favorable expressions and conducts contributing to the preservation of biodiversity.

The above mentioned pedagogical actions should be deployed along the curricular units or subjects that have a potential, making emphasis on the ones more closely related to professional environmental

education. For instance, topics like Ecological Basis of Environmental Systems, Biodiversity and Socio-diversity, and Environmental Law, in syllabus Environmental Manager, which are ideal to design actions favoring the association of students to interactions with nature, to disclose the close relationship, and assessment between socio-cultural variability and biodiversity, and discover that there is a conduct guide within a broad legislation in effect. Regarding Cuban universities, the curricular strategy set up in terms of environmental education would be the way to incorporate these actions (Pérez & García, 2013), which favors its implementation.

Assessment of transversal treatment of biodiversity

To corroborate the pertinence of the proposition (given the theoretical and practical character of the results), expert criteria was used following assessment of the scientific level, practical experience, and the competence level in environmental and biodiversity education by teachers and university specialists, which enabled determination of possible experts that might assess the final proposal.

The determination of the competence coefficient contributed to the creation of a team (over 0.84 index) of 33 experts. The pedagogical model was assessed by the experts in the “very adequate” category, with a general quality index of 0.953. The actions for implementation were assessed as “quite adequate”. The experts considered that the proposal is useful, necessary, and applicable to the university context, since it is a guide for student acquisition of biodiversity. The analysis made led to assessment, and feedback and re-structuring process of perfecting the suggested model.

In this context, the main content of the model, and the dynamics of action implementation were socialized among teachers and syllabus officials. The participants in this process considered that the proposal was useful, necessary, and applicable to the university context, since it is a guide for student acquisition of biodiversity. Additionally, the statement of some aspects could be improved, some elements that were considered for improvement as part of an iterative process, which led to the current outcome.

The effects of implementing these actions were corroborated by students of the Environmental Management Educational Program, at the Bolivarian University of Venezuela, Municipality of Bolívar, State of Barinas. It was based on an intentional sample consisting of 96 students from the three initial venues; therefore, they are considered related samples. The most commonly used methods were observation guide and the pedagogical test.

The test revealed an increase in knowledge and inferences on biodiversity, as part of the training process in environmental management. An aspect to highlight is the integration of contents in keeping with transversal actions. Observation of teaching activities (theoretical and practical) help corroborate transformations in the cognitive area, the actions, assessments, and procedures shown by students and teachers, under experiential situations linked to biodiversity, thus creating a pedagogically productive rapprochement to nature.

Therefore, the tests and systematic observation led to a comparative analysis of the initial and final situation of students. Furthermore, advances in biodiversity culture were observed in teachers and students. In terms of biodiversity mastery, the gap between theory and practice was closed through field activities. Favorable changes were observed in analyses and actions to address the problems stated. These advances call for practical actions with a transversal approach to biodiversity in environmental education to professionals.

Conclusions

The analysis of theoretical and empirical data, and historical assessment, revealed the existence of advances derived from a gradual assumption of environmental protection as state policy. However, several theoretical and practical weaknesses were evident in environmental education of professionals in general, and particularly, as to the need to continue to perfect the treatment of biodiversity in the process.

Insufficiencies were observed in teachers and students in terms of biodiversity education, resulting from theoretical and methodological shortages that justify the need to make a more transversal treatment.

The pedagogical model of transversal treatment of biodiversity in undergraduate environmental education shows the essential relationships among the elements that compose it. This led to a disclosure of subsystems: cognitive, affective, and procedural, seeking student evolution and the evolution of every participant in general (teachers, officials, and specialists, as well as community members involved).

This transformation is based on the articulation of the three subsystems, where contents have a more flexible character, and biodiversity is more linked to experience, which is assumed as a cultural message. The model is materialized in actions to achieve the dynamics of the process, and reach the goal set.

Theoretical and experimental assessment of transversal treatment of biodiversity in this context indicated a satisfactory outcome, with a significant general index. The pertinence and feasibility of the actions were corroborated, and these results suggest continuous strengthening of works directed to

biodiversity, and to implement more actions in order to achieve greater integration between the contents of education and the global problem of biodiversity. It is more related to tackling the global problem from different levels of environmental responsibility: local, national, and regional, with emphasis on the local level. Contextualizing this proposal in various syllabi should be seen as research, to scientifically assess the results achieved so far, and set new goals to continue to perfect the theory and the actions directed to transversal treatment of biodiversity.

Author contribution

Ludwig J. Gutiérrez Montilla: design and implementation of research, design of the model, experimentation and analysis of the results, redaction of the final manuscript, final review.

Rogelio A. Díaz Castillo: Advisory on the design and implementation of the research, model improvement, update of referents, redaction of the manuscript, final review.

Fernando Bacardí Soler: research planning, model creation, analysis of results, manuscript redaction, final review.

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