

The Environmental Management Discipline Of Chemistry Course At Faculty Of Natural Sciences In Agostinho Neto University And The Entrepreneurship Guidance

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Abstract:

Background: Nowadays, the inclusion of entrepreneurship-related topics in curricula is very important. Alongside the curricula of different specialties, it is crucial that university students understand how they can contribute to the development of the society not only as specialists but also as entrepreneurs. That is, they should learn how to create small businesses related to their field of specialization or related areas; how to think in multidisciplinary work teams; how to implement sustainable work practices and procedures; and how to comply with national and international legislation related to their area of specialization and the environment, among other aspects. But what to do when curricula do not include entrepreneurship or topics that guide entrepreneurship? This scientific article shows, through a case study, how a professor overcame this gap in the curriculum by using the content of an Environmental Management discipline to guide entrepreneurship. In this way, professors and students have been designing businesses for different regions of Angola for several years, using various local products, taking into account the preservation of culture and religion, and the creation of sustainable environmental development (natural, economic, social, and political).

Materials and Methods: In the teaching and learning process of the subject, the professor used an active teaching methodology through the development of projects where students, through observation of social problems in their areas of residence, vote on one of the themes for the joint development of the project.

Results: What has been observed in the last three years was: a greater interest in the discipline of environmental management (primarily legislative), a higher number of students passing their courses, and students graduating with an understanding of how to develop a project to solve a social problem.

Conclusion: By using this active teaching methodology project-based learning, it is possible for the 4th year chemistry students to finish the course with an understanding of what means to develop a project, thus making them feel the need to continue investing in their training as future entrepreneurs, which will not only help to address the unemployment problem that many face but also contribute to the country's development.

Key Word: Environmental management, Project development, Entrepreneurship, Curriculum in Higher Education.

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I. Introduction

With the development of societies, technological innovation, and the increase in resulting products, citizens are increasingly becoming part of non-state enterprises. What we see today is people with state jobs who, after normal working hours, dedicate themselves to working in some family business. Over time, many end up leaving their state jobs and moving to the private sector; there are other cases in which citizens started working very early in the public sector and, upon retirement, use their savings to create their own enterprises. The curious thing about this is that in many developed countries, this activity on the part of their citizens is observed.

It therefore becomes important for societies to promote a whole set of knowledge, at the most diverse levels of education, related to knowing how to be an entrepreneur and contributing to sustainable development. In 2001, Dornelas stated that "it is entrepreneurs who are eliminating trade and cultural barriers, shortening distances, globalizing and renewing economic concepts, creating new labour relations and new jobs, breaking paradigms and generating wealth for society." (Dornelas, 2001)

Nowadays, it is observed that there are students who manage to get jobs within their field of specialization and are often called upon to undertake ventures within the companies where they work; if they are unable to do so, they turn to teaching their field of specialization, or if they are unable to teach, they are left without anything to do after specialization. And there lies the great dilemma for many of them.

To address the lack of employment after specialization, nothing is better than helping these students to become entrepreneurs in activities they enjoy and were, in one way or another, they can apply the scientific knowledge acquired in the different years of schooling.

At this point, it is worth highlighting the importance of university professors in identifying which students have the desires and abilities to be entrepreneurs, knowing how to guide them as such, or referring them to training centres such as business incubators linked to universities. Therefore, it is up to the university professor to recognize in their students characteristics such as: dedication to study, not giving up in the face of mistakes, identifying real issues that need solutions and seeing them as opportunities for social development, knowing how to lead, knowing how to defend ideas, working efficiently and with quality, being a good communicator, not being afraid of risks, knowing how to set goals and achieve them, knowing how to work independently, taking initiatives, seeking results, not mixing professional and personal life, among others. (Guimarães et al, 2016).

Entrepreneurship has a great deal to do not only with the curricular or extracurricular training plans carried out by Higher Education Institutions (HEIs), but also with the cultural, economic, political, social, natural resource characteristics, and even religious beliefs of the society where it is to be developed.

Angola is a country where, in recent years, a whole series of entrepreneurial activities have been observed among citizens, and where public policies include funds to support entrepreneurial projects for innovation and social development. Many training centres have begun to focus on entrepreneurship, and HEIs include, in certain specialties, curricular and extracurricular subjects that, in one way or another, guide and support entrepreneurial actions, such as: scientific research methodology, research and development project, social entrepreneurship, strategic planning, business management, leadership, marketing, among others.

The Chemistry Course at the Faculty of Natural Sciences of Agostinho Neto University (FNC-ANU) does not include in its curriculum any subject that directly guides students towards entrepreneurship. Nor is this subject presented as an optional or extracurricular subject.

The professor responsible for this case of study is a professor in the Department of Chemistry, supervising undergraduate and master's level final year projects in the research areas of natural products and environmental pollution. Among other subjects, the professor teaches Environmental Chemistry (EQ - 3rd year) Environmental Management (EM - 4th year).

When professor took over teaching these two subjects, founds that the passing rates were unsatisfactory, with students enrolling below 50%. For the first subject (EQ), the difficulty lay in understanding environmental phenomena and solving environmental problems in light of all the chemistry students had learned up to that point, namely: organic, inorganic, analytical, physical chemistry; as well as physical and mathematical principles, contributions from biology, geology, among others; knowledge acquired throughout their many levels of education. In other words, the difficulty lay in understanding the importance of ensuring that no knowledge is left behind and then beginning to understand that many environmental problems cannot be solved unilaterally, but require the collaboration of specialists from other areas of science, ideally working in a multidisciplinary, transdisciplinary, or even interdisciplinary way.

Understanding the second subject (EM) was even more difficult because it deals with content that is not usual for chemists, such as national and international environmental legislation, which supports assessments of human intervention in the environment.

The problems here were: how to see a logic in the sequence of content from the two subjects and, above all, how to make content that deviates from the normal content of chemistry into content that is easy to understand and recognize its applicability in solving problems that these same 4th year students face in their daily lives? And What was the way the professor organized her Teaching and Learning Process (TLP) to respond to the problem and allowed her students to begin to glimpse how one can be an entrepreneur in Angola.

II. Material And Methods

Throughout the centuries, methods of education and teaching have evolved, and the perception that the teacher was the main figure in the Teaching-Learning Process (TLP) has dissipated until, in the 20th century, the discussion by various thinkers resulted in the idea that TLP involves creating greater autonomy in the student, largely based on the use of ICTs, the flexibility of face-to-face teaching in the use of hybrid teaching, and bringing the problems experienced by the student in their social environment into the understanding of the content. (Lovato et al, 2018)

The success of Teaching and Learning Process (TLP) is largely based on the type of methodology applied in the transmission, analysis, acquisition, and application of knowledge. Therefore, special attention is given to so-called active methodologies, which are simply ways in which TLP is developed using real or simulated situations to solve societal challenges in the most diverse areas of knowledge. In these methodologies, theory and practice are correlated; the student is at the centre of the entire process, and the

teacher, based on the students' prior knowledge, is responsible for stimulating discoveries, reflection on them, reorganization, adaptation, and construction of a new cognitive structure. It is up to the teacher to guide the interactions between: student and teacher, classmates, student family, student community for greater autonomy and maturity. (Barbosa et al, 2013, Newman, 2005)

Several active methodologies are used in HEIs. Among them, the following stand out: the flipped classroom, problem-based learning, project-based learning, case study and peer learning.

Project-based learning was proposed by John Dewey, who defended the assumption that students learn by doing, that is, students acquire knowledge through problematic situations that, for their resolution, involve curricular content and that are developed through a specific plan with a defined objective, and must be executed in a certain period of time, in a delimited geographical area, for a specific group of beneficiaries. Projects developed in this way can be constructive whenever they involve innovation, investigative whenever they involve the discovery of new knowledge, or didactic whenever they are focused on the whys of things. (Lovato et al, 2018; Sobrosa et al, 2018).

In this case study, the 4th year students of Chemistry Department on Faculty of Natural Sciences were all involved in the project structure. Each year one class of 15 students were engaged making a total of 45 students.

The environmental management discipline is a first-semester course in the 4th year of chemistry program at the Faculty of Sciences in Agostinho Neto University. In this first semester of the fourth year, students take the last set of "common core disciplines" of the aforementioned course. From here, they enter the specialties of Inorganic Chemistry, Organic Chemistry, Analytical Chemistry, and Physical Chemistry.

The program content of this discipline is:

1. Instructional Objectives

Understand what:

- . Environmental Management is;
- . An Environmental Impact Assessment is and the methods used to carry it out;
- . Environmental Audits are and what types exist;
- . Eco-products, Labels, Tags, Eco-balance sheets and Standardization Processes are;
- . the different ISO Standards are;
- . a Life Cycle Analysis is and how it indicates factors of environmental sustainability;

2. Educational Objectives

- . Leading the student to develop the understanding that companies and societies will be more sustainable from an economic, social, and environmental point of view if they promote environmental management systems;
- . Awaken in the student the awareness that in order to develop environmental management systems, these systems must be evaluated at all stages of implementation;
- . Making the student aware that the problems of one are the problems of all, and therefore the need to comply with national, regional, and international laws.

3. The Program

- . Chapter I - Introduction to the concept of Environmental Management (Environmental Sustainability; Economic Activities and Environmental Pollution; Environmental Management; Evolution of Environmental Management Systems; Reasons for Implementing an EMS; Difficulties in Implementing an EMS; Steps for implementing an EMS);
- . Chapter II - Environmental Impact Assessment (Introduction: environment and environmental impact; Environmental Impact Assessment: objectives, governing principles, stages; Methods of Environmental Impact Assessment; Environmental Assessment Systems);
- . Chapter III - Environmental Audits (Introduction; Eco-audits: legal and methodological aspects of an environmental audit; Waste audit);
- . Chapter IV - Eco-products (Eco-products; Product labeling; Establishment of eco-balance sheets; Environmental standardization at the international level);
- . Chapter V - Quality Standards and Environmental Management (ISO 14000 series standards; ISO 14001 - Environmental Management System: specifications and guidelines; ISO 14004 - Environmental Management System: general guidelines concerning principles, systems and implementation techniques; ISO 14010 - Environmental Audits: general guidelines and principles; ISO 14011 - EMS Audits; ISO 14012 - Qualification criteria for Environmental Assessment; ISO 14031 - Environmental Management, Efficiency Evaluation, Technical Reports, Guidelines; Other tools for managing the environment);
- . Chapter VI - Life Cycle Analysis (Introduction; Development of an LCA, ISO 14040 and 14041 standards; quality, standardization, control, certification, environmental indicators).

4. The Teaching Resources: Use of Data Projector, Graphs, Tables, Images, PowerPoint; Different types of existing bibliography.

5. The Teaching Methods: Expository, Demonstrative, Interrogative, Independent Work, Collaborative Elaboration, Group Work.

As one can see, all of this content deviates somewhat from what is usual in chemistry courses, but it is important and relies on the contribution of chemists, such as environmental legislation regarding polluting substances, their toxicological properties, and handling. Perhaps because of this, the pass rate in this subject was very low. The question was: what to do to make this subject more "attractive"?

Undoubtedly, the content of the six chapters of this subject would have to be known, understood, and above all, seen in its practical application. Only with these three stages of grasping reality would students be ready to analyse, synthesize, and evaluate any problem they might encounter later.

Due to the aforementioned delay, the lesson plan always took into account, in each chapter, theoretical and practical work, as can be seen in table n°1.

Table No. 1 – Distribution of Workload

CHAPTER	THEME	THEORETICAL CLASSES (h)	THEORETICAL AND PRACTICAL CLASSES (h)	TOTAL HOURS
1	Introduction to Environmental Management	6	4	10
2	Environmental Impact Assessment	6	4	10
3	Environmental Audits	6	6	12
4	Eco-Products	4	6	10
5	Quality Standards and Environmental Management	4	6	10
6	Life Cycle Analysis	3	5	8
TOTAL (h)		29	31	60

Source: the author

NOTE: 4 hours are still reserved for 2 partial exams.

Procedure methodology

In the professor's first year of teaching, the class carried out the usual continuous assessment activities (classes with presentation of the content and debate about its relationship with the social reality of each student and the country; group work with analysis of case studies and presentation in plenary; two tests: one only to consolidate the content and its importance to society in general; the second test, in addition to consolidating the content, had 1/4 of the grade related to the interpretation of a video; where groups of 5 met after 1 hour and 30 minutes of individual tests and, for another half hour, analysed different case studies and verified, in the light of what they had learned, whether the application methodologies were correct and whether any assessment had been neglected.

However, there comes a point where it is not feasible to study the topic based solely on case study analyses. As the course curriculum did not include guidance for entrepreneurship, the professor decided to start preparing some social development projects with her students, based on what concerned them in their communities. In other words, professor moved towards what is now called Project-Based Learning (PBL).

Thus, the teacher began to organize the teaching and learning process as follows: right at the beginning of the year, after presenting the subject: its objectives, chapters, and skills to be developed, professor introduced an activity that everyone should carry out and that would constitute the second test of the subject, which would be defended before a jury (two more teachers) and which would be "Planning an ecological project to solve a social problem" which would be based on the content under study but also other aspects related to them. For this second test, they would have to present a written work with all the rules of scientific writing work accompanied by the respective PowerPoint presentation. It means, all of them have to work on a specific aspect of project, even though some need the work of the others (for example, the student who works on the budget for workers cannot do so without knowing the company's organizational chart) and they all only move forward after the opinion and approval of the whole class. In the organization of the Teaching and Learning Process (TLP) for this subject, time must be reserved to discuss the progress made and, as a general rule, at the end of each chapter, the students and the professor return to the work of creating the project to see how the content and the project are related. As time progresses, more class time should be reserved for its creation, and before defending, there is a whole rehearsal on the joint presentation of the project to the jury.

On the day of the defence, although the other jurors may ask questions and even give their opinions on the evaluation, the final grade for this exam rests mainly with the professor who, throughout the process,

evaluated: each student's dedication, responsibility, understanding of time, respect for others' ideas, way of working with diverse opinions, defence of points of view, among other aspects.

But ultimately, what are the topics to be developed by students for the creation of a project without neglecting the content of the environmental management discipline?

III. Result

Initially, students begin by brainstorming, that is, conducting basic research on the problems in their area of residence or country that require a solution, which should involve a chemical component and contribute to environmental preservation.

After presenting the different solutions, the majority decides which problem is most urgently needed by the population. It is worth noting that, preferably, they should not repeat enterprises that other colleagues have already created in the course in previous years.

In three different years, students planned 3 projects that were:

- . 1st: An enterprise for sorting and recovering Municipal Solid Waste (MSW) called Kiazele Angola;
- . 2nd: An enterprise manufacturing sorghum flour called Ossema Finde;
- . 3rd: An enterprise selling eco-friendly cell phones called Kuango Angola.

Related with distribution of the tasks, the students started for designed a leader and determinate a theme. After that, they organise a table (table n°1) that among other contents had:

Table n°2: Aspects of the enterprises project to be developed by the students of the class

TASKS	RESPONSIBLE
Theme, Problem, General and Specific Objectives	
Hypotheses	
Background (3 bibliographies – APA style) and Justification (National Development Plan)	
Object and Scope Action	
Specific objectives for execution and research.	
Tasks for each specific objective and expected results.	
Project Life Cycle	
Logical Framework Matrix	
Activity Schedule	
Organizational chart	
Risk Mitigation Table	
Budget	
National Legislation for the Sector	

Source: the author

The students also determinates:

- . the location through the use of Google Earth;
- . the name to be given to the company taking into account the native language spoken in the region;
- . the company logo and the possible product label;
- . its architectural structure (roughly a drawing showing the main infrastructures of the enterprise: offices, sales area, raw material collection area, cafeteria, medical post, etc.)
- . the organizational chart;
- . the national and international laws that would have to be complied with (from environmental laws to trade or industry laws, among others);
- . the company's implementation plan based on the Deming cycle;
- . the company's working conditions (from personal protective equipment, health plans, cafeterias, transportation, among others);
- . the awareness actions to be carried out about the enterprise and its products, whether with workers, suppliers, consumers and populations neighbouring (encompassing everything from lectures, brochures, signage, regulations);
- . the product life cycle / the production process / eco-balance sheet;
- . the initial budget needed to purchase (ecological) materials and equipment;
- . the monthly budget for supplies, salaries, and raw materials;
- . the sales value of the product produced or service provided and the time horizon for possible investment recovery;
- . the type of prior audit carried out before the enterprise's implementation;
- . the type of certification they wish to achieve for the enterprise, the necessary dossier, and the time horizon;
- . the company's social purpose;
- . the company's implementation schedule;

The students also learn that all projects can face some risks and previously one should think about it. A brief analyse could be done throw table n° 2.

Table n°3: Table of Risks Mitigation

RISK MITIGATION TABLE				
	Risks	Probability	Impact	Mitigation Strategy
	Naturals			
	Technological			
	Materials			
	Financiers			
	Gestion			
	Humans			
	Other risks			

Source: the author

IV. Discussion

Project-based learning is an active teaching methodology that allowed students to develop a certain autonomy in their work, contextualize knowledge to their own reality by involving real-world problems, develop skills and abilities relevant to comprehensive education, engage in participatory and collaborative learning, and develop a final report on the company's product. Throughout this process, the teacher acted as a mediator and facilitator.

Throughout this study, it can be seen that project-based learning is a powerful methodological tool for university extension and a formative social, political, and ethical strategy. (Rosa et al, 2025)

The proposal to carry out this type of project, immediately after the presentation of the discipline contents, allows the student to be much more focused, because with each piece of content presented, they ask themselves: how does this content help in the creation of our project? In this way, they also get the idea that creating a projec is something that should be thought about, analysed, and questioned with other people besides their classmates, and all of this takes time. It creates the perception of the existence of an evolutionary before and after. A before where they begin to research for the project autonomously and self-taught without having knowledge of the content, and an after when they improve their research in light of the content of the different chapters.

Starting from the problem presented, the students began to think about what they knew about it, observed, saw what could influence its solution, determined the chances of a solution, discussed, debated, argued, and reached consensus positions.

In the end, it was found that the students finished the course knowing how to explain: what Environmental Management is, the difficulties and steps for implementing an Environmental Management System; what an Environmental Impact Study is and its importance; the difference between Auditing in general and Eco-Auditing; what an eco-product and an eco-balance sheet are, and how to evaluate them in light of International Standardization; the different ISO Standards relating to Quality Standards, Environmental Management, and product labelling; and how to interpret a Life Cycle Analysis.

Also, from the interaction with the students, the teacher observed the development of human values resulting from respect for differing opinions regarding the desires of the people for whom the project was written. Regarding the subject matter, it was noted that it contributed to values such as: awareness of the importance of implementing Environmental Management Systems and how a Chemist can assist an Environmental Manager; awareness of the importance of Analysis, Evaluation and Sanction in the Environmental Management process and how a Chemist can assist an Environmental Legislator; awareness of the importance of using International Standards and Norms for Environmental Performance and Preservation and how one can be a Green Chemist; they learned to see to what extent the proposed technological solutions were or were not viable in the country's context; what could be done locally and what would have to be imported, the costs and time this would take and how it was reflected in the activity schedule and the proposed budget.

All these aspects are achievable because this program has a total of 64 teaching hours (16 weeks x 4 hours per week = 64 hours); where 48% were theoretical classes and 52% were theoretical-practical classes, as can be seen from the distribution of the workload.

Projects developed in this way can be constructive whenever they involve innovation, investigative whenever they involve the discovery of new knowledge, or didactic whenever they focus on the whys of things. (Lovato et al, 2018; Sobrosa et al, 2018).

The curious thing about whole this experience was that each year the students (depending on the type of enterprise) bring new contributions to the enterprise's planning.

V. Conclusion

From all this experience in 3 years with the 4th year students of chemistry, it can be concluded that project-based learning is not just about conducting laboratory experiments. Project-based learning has proven to be a student-centred teaching methodology where students are the main protagonists of the teaching-learning process and enhance their entrepreneurial and citizenship learning, structured around the cooperative search for solutions to significant real-world problems, developed amidst adversity and uncertainty.

The creation of a project in this 4th and final semester of common core subjects allowed students to better analyse what to pursue in terms of specialization, both in the second semester of the 4th year and in the 5th year. It also allowed them to understand how the specialization they will pursue can then be continued not only from a laboratory perspective.

In this way, the student developed the conviction that enterprises and societies will be more sustainable from an economic, social, and environmental point of view if they promote environmental management systems; that environmental management systems help to evaluate all phases of enterprise implementation; that the problems of one are the problems of all and, therefore, the need to comply with national, regional and international legislation in the sector in which the enterprise operates, as well as International Standards and Norms for Environmental Performance and Preservation; that analysis, evaluation and sanction, if necessary, are important in the Environmental Management process. And thus, the objectives proposed for this discipline were fulfilled.

The students' satisfaction level in participating in this discipline increased and this was reflected in the percentage of those who passed and will be presented in another article.

In this way, the environmental management discipline associated with the environmental chemistry discipline previous thought (in 3rd curriculum year) is creating in the students of the Chemistry course at Faculty of Natural Sciences of Agostinho Neto University, the awareness of a green chemist and with this, more responsible citizens of their rights and duties towards their country and towards a sustainable world that is desirable to create.

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