

Research Article

Advantages in Propaedeutic Cycles University Technological and Engineering Programs for the Development of Formative Research on Solar Projects*

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Abstract The following work treats the strength of the investigation process in university programs by propaedeutic cycles, framed in an experience of a project restored in the first cycle of formation in Mechanical Technology in the solar energy area and complemented by a second project of degree in the cycle of deepening in Mechanical Engineering, in the Curricular Project of Mechanics of the Technological Faculty of the Distrital University Francisco Jose de Caldas in the city of Bogota, Colombia. The experience demonstrates a qualitative way to start an investigation process from the first semesters framed in the works of degree of students, and offers one better participation and one better appropriation of the concept and greater relevance in the processes of the surroundings oriented to obtain good work and a first step in the investigation related to solar energy systems. The constructivism is used as a pedagogical model within this work, allowing that the student advances an effective process of construction of knowledge showing the advances until the first semester of 2011.

Keywords solar energy education; processes of investigation; propaedeutic cycles; degree projects; formative research; collaborative processes

1 Introduction

In technological and engineering programs, where the students must project studies in a sense that dictates the labor supply, loss of personal interest frequently appears in front of the appropriation of knowledge. Before this situation, it becomes necessary that the university orients its research processes towards direct linking students in the development of projects that contribute to first experience

of responsibility. This experience offers significant tools that direct towards a personal growth that complements the educative development. The main idea is to take advantage of all what is said before and to guide towards the development of the research on solar energy projects and systems.

Within the structuring of the technological and professional programs, the Ministry of National Education of Colombia, through Law 749 of 2002 [3], has adopted similar mechanism so that the students can attain by growth stages the development of a professional degree, through the option of propaedeutic cycles. The cycles are interdependent, complementary, and sequential units; whereas the propaedeutic component refers to the process by which it prepares a person to continue in the process of formation throughout life, in this particular case, the professional degree. In consequence, a propaedeutic cycle can be defined as a phase of the education that allows students to be developed throughout their professional formation following their interests and capacities. In that order of ideas, it is advisable to comment that the propaedeutic cycles in professional degree formation organize the Superior Education in three stages: flexible, sequential, and complementary. This means that students can initiate their studies with a professional technical program (2 or 3 years) and a journey towards the technological formation (3 years), soon to reach the level of university professional degree (5 years).

The Curricular Project of Mechanics of the Technological Faculty of the Distrital University Francisco Jose de Caldas in the city of Bogota (Colombia) offers a program of Mechanical Engineering by propaedeutic cycles made up of a first denominated cycle, Mechanical Technology, and a second cycle of deepening to earn the title of mechanical engineer. It is pertinent to say that many of the students in this program have special social and cultural conditions that force them to alternate their studies with paid work related to areas different to academic research.

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Taking as a basis the performance of a group of students of technology through a research experience, we try to demonstrate the potentiality that has the development of a degree program by cycles in the process of formative research in the student, compared with engineering programs that do not present cycles of formation.

This work shows two developed research experiences; the first one is related to the study and planning of an air-conditioning application taking advantage of geothermal energy stored just a few meters in the surface layer of the earth in the city of Bogota (Colombia), highlighting the importance of involving and promoting the role of participatory students from the first semester trying to convey the relevance that sustainable energy systems possess. The second experience is related to solar dish and stirling engine to evaluate the possibilities of generating energy in Bogota. This exercise promotes the interaction between the solutions proposed by students and their environment. The students themselves propose, discuss, and conclude during the process and make it through the construction of their grade work. This strategy is framed in a constructivist teaching model through which it is intended that the mechanical knowledge in the student focus on their past experiences and new mental constructs [8]. The construction of knowledge occurs when the students interact with the object of knowledge (Piaget), when this is done in interaction with their peers (Vygotsky) and when it is significant to the students (Ausubel) [8].

2 Development of degree work

It is proposed to use the fact of having a first education cycle, so that it begins and stipulates a degree work framed in an institutionalized research project; this feature offers the advantage of having a mentor who guides the works that are generated. This experience encourages the student to initiate discussions on the development of professionals in early stages of its formation. The work to be specified at this stage should continue in the cycle of deepening of the curricular program, thus avoiding the student's looking so disoriented. Development issues for the graduation project must be submitted to complete the deepening stage for the same student or others who continue with the work.

2.1 First experience: earth-air heat exchanger

Following this reasoning, the aim is to work with two students in an observable need for issues of thermodynamics: "controlling the temperature of the environment or working spaces using the thermal inertia of the ground." The temperature variation is produced by domestic energy sources, such as gains or losses to the outside causing variations in the sense of comfort. Initially, take the classrooms of the University Technology Office as a test station; the study focuses on the application of a passive conditioning system using air-to-air heat exchangers through buried pipes.

In equatorial countries like Colombia, mostly in developing situation, climatic conditions have a relatively flat thermal sine wave excitation, with yearly mean temperature values depending on the location of places with respect to sea level. This creates a situation of energy demand for air conditioning constantly and regularly in specific towns for high values of yearly average temperature. The energy demand increased by the widespread acquisition of conditioning equipment, creating a tendency to purchase air-conditioning units, which still have not reached their peak.

With the increase in the residential energy consumption in the future, it is essential to work with clean and sustainable technologies that seek to improve the performance of air-conditioning systems, as well as create opportunities that meet the needs in remote areas, including the "non-interconnected" areas with the electricity grid. Such developments should be advanced in the classroom, making students participate to have a vision of opportunities other than the conventional ones, thus multiplying possible technology solutions.

In 2006, a degree work of a technology project entitled "Characterization of thermodynamic properties of heat subsurface transport of the Technology Faculty" ("Caracterización de propiedades termodinámicas y de transporte térmico del subsuelo de la facultad tecnológica") made it possible to define the thermodynamic and transport properties of a specific field energy in which it was planned to install a test facility [4,5].

The project entitled "Evaluation of the influence of variable lengths and diameters in heat exchange pilot ground-air conditioning system at a depth of two meters" ("Evaluación de la influencia de las variables longitud y diámetro en un sistema experimental de intercambio de calor tierra-aire de acondicionamiento de aire a una profundidad de dos metros") continued the study of the first cycle using the values of the properties obtained to calculate and set up a test station of a system of buried pipes exchanging heat between the ground and the air [6,7].

Today three other projects (at the two in technological level and one at the engineering level) work in the same area. The first one is designed for sensor installation and improvement, the second one is designed for connecting the system in a room with uncomfortable evaluation, and the third one is designed for connecting a psychrometric laboratory to an earth-air heat exchanger [1].

2.2 Second experience: solar dish and stirling engine

In the second area of experimental work, the objet of the study is to evaluate and try to generate electric energy in Bogota, with a mean irradiation of 350 W/m^2 , using a solar dish and a stirling engine coupled. In the first propaedeutic cycle, the stirling engine and the solar dish were constructed

and in the next semester the system installation and probes will be started.

In this research area, 5 students have participated and 3 of them have continued with the original work. Two of them did not continue because of work needs, but the new students are quickly updated with the interaction among the original authors.

2.3 Observations and comments

What we see regularly with students in any training cycle is that the realization of the final project is developed in the last two semesters (the first one for the submission of the proposal and the second one a presentation of the work). In most cases there are delays in the completion of these works due to various factors causing the students to use more time than usual to follow the guidelines of the work. In that sense, students who participated in this project became interested in the themes that will be seen in the second cycle, and this gave them the opportunity to attend supplementary classes.

As previously raised, in the deepening cycle the student can continue the work started at the stage of technology, and this is how the two students who developed the first draft, just a continuous engineering cycle, did their work, involved linking a new participant in the research process. There was evidence of this: qualitatively, the student who brought the first trial basis served as a multiplier for updating knowledge on the subject. For the new member, however, it should be noted that the leadership of work always had the senior student.

These two projects, in addition to the works of degree, led to the development of 4 items and 3 meetings, two of which were international. This disclosure of work successfully complemented the process of formative research.

Many sustainable energy projects are actually works in the same way, starting in the first formation cycle and continue it in the second one with improved deep search characteristics. The same study areas are solar collectors, heat pipes for cooling, potential of plants varieties for cooling shadows, and solar water distillation. The last one had a support from investigation and development university center.

3 Weaknesses of the investigation process

In the course of the activity, there were mainly two difficulties related to the delay in the development of the activities and to the motivation on the part of the students:

- (1) Institutional guidelines for the support of this type of processes: although the works were endorsed by a project of investigation approved the university, in many occasions the support for student participation in events or the delay of equipment provision on the part of the university-sponsored project has resulted in delays in students' accomplishment of their work, which negatively affected their commitment to their work.

- (2) The works of the students (away from of academic work) caused distractions to the investigation process.

4 Strengths of the investigation process

Very positive points in the process were observed:

- (1) The knowledge developed through project: "it is constructed by means of the practice, and it is not outside the own actors" [2].
- (2) Interrelation of the concepts learned with the practices of investigation related to the society that surrounds them.
- (3) The possibility of seeing concepts nonregulated in the program, yet necessary for the development of the degree project.
- (4) Participation in professional groups inside and outside the university emphasis on participation in academic events, which, in spite of some administrative problems, nourished the self-esteem of students and fortified their curriculum vitae.
- (5) Applicable points favoring the selection for entering to the cycle of deepening.
- (6) The time and structure of student research are greater than university programs without propaedeutic cycles.
- (7) Property of the work made, which promotes the future development of the investigation.
- (8) Facilitation of processes I + D + I.

5 Conclusion

It is important to take advantage of professional programs in propaedeutic cycles to fortify student formative research framed in degree projects that support investigation projects and have the possibility of being completed through a new project of degree that deepens the initial subject. The development of the works allows to verify that the constructivist model becomes an effective strategy that accepts and impels the autonomy and initiative of students, and uses cognitive terminology such as: to classify, to analyze, to predict, to create, to infer, to deduce, to consider, to elaborate, and to think. Additionally, it allows to research the understanding of concepts that students have on residential power consumption and clean and sustainable technologies.

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