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Original article

Methodology for educational guidance in the teaching-learning process of engineering

Metodología para la orientación educativa en el proceso de enseñanza-aprendizaje de las ingenierías

Metodologia para orientação educacional no processo de ensino-aprendizagem da engenharia

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ABSTRACT

In the 21st century, new challenges for engineering training are emerging, given the evolving technological, economic, and social developments. The comprehensive training of these professionals constitutes the social mandate of the university. Based on this, it is necessary for university professors to prepare for the guidance they perform within the discipline they teach in the training process. Taking this into account, the objective of this article focused on developing a methodology for educational guidance in the engineering teaching-learning process. Theoretical, empirical, and mathematical-statistical research methods were used, which enabled the design and implementation of the methodology. The proposal enables educational guidance actions closely linked to the didactic components of teaching activities. Its implementation helped minimize the shortcomings identified

in the assessment and revealed positive impacts that can be seen in significant transformations in the educational guidance provided by teachers in the teaching-learning process of the Mechanical Engineering program at the Technological University of Havana "José Antonio Echeverría", validated through the pedagogical experiment.

Keywords: engineering; methodology; educational guidance; teaching-learning process.

RESUMEN

En el siglo XXI se develan nuevos retos para la formación de ingenieros, dado el desarrollo tecnológico, económico y social que evoluciona en la época. La formación integral de estos profesionales constituye el encargo social de la universidad. A partir de lo anterior, es necesario que los profesores universitarios se preparen para la labor de orientación que realizan desde la disciplina que imparten en el proceso de formación. Al tener en cuenta este particular, el objetivo del artículo se centró en elaborar una metodología para la orientación educativa en el proceso de enseñanza-aprendizaje de las ingenierías. Se utilizaron métodos de investigación teóricos, empíricos y matemático-estadísticos, que posibilitaron el diseño y aplicación de la metodología. La propuesta posibilita realizar acciones de orientación educativa en estrecho vínculo con los componentes didácticos en las actividades docentes. Su implementación permitió minimizar las carencias detectadas en el diagnóstico y reveló impactos positivos que se aprecian en transformaciones significativas en la orientación educativa que realizan los profesores en el proceso de enseñanza-aprendizaje de la carrera Ingeniería Mecánica de la Universidad Tecnológica de La Habana "José Antonio Echeverría", validados a través del experimento pedagógico.

Palabras clave: ingenierías; metodología; orientación educativa; proceso de enseñanza-aprendizaje.

RESUMO

O século XXI apresenta novos desafios para a formação em engenharia, diante da evolução tecnológica, econômica e social. A formação integral desses profissionais constitui o mandato social da universidade. Diante do exposto, é necessário que os professores universitários se preparem para a orientação que realizam na disciplina que lecionam no processo de formação. Diante disso, o

objetivo deste artigo foi desenvolver uma metodologia para a orientação pedagógica no processo de ensino-aprendizagem em engenharia. Foram utilizados métodos de pesquisa teórica, empírica e matemático-estatística, que possibilitaram o desenho e a aplicação da metodologia. A proposta possibilita ações de orientação pedagógica intimamente ligadas aos componentes didáticos das atividades de ensino. Sua implementação contribuiu para minimizar as deficiências identificadas na avaliação e revelou impactos positivos, que podem ser observados em transformações significativas na orientação pedagógica realizada pelos docentes no processo de ensino-aprendizagem do curso de Engenharia Mecânica da Universidade Tecnológica de Havana "José Antonio Echeverría", validadas por meio do experimento pedagógico.

Palavras-chave: engenharia; metodologia; orientação pedagógica; processo de ensino-aprendizagem.

INTRODUCTION

In the 21st century, new challenges for engineering training are emerging, given the evolving technological, economic, and social developments. In the teaching-learning process (PEA) of engineering students, the following are identified as essential objectives in the engineering profile that society demands: the development of analytical skills, effective communication, the design and conduct of experiments, project management, lifelong learning, and teamwork.

For some years now, the demand for engineers with skills such as creativity, empathy, communication, and teamwork has begun to grow. Within the framework of the 4.0 Revolution, these are referred to as transversal competencies that must be enhanced in all disciplines of the engineering training curriculum (Echeverría and Martínez, 2021).

All of these aspirations are embodied in the E curricula of engineering programs. Reference is made to engineers being able to express critical judgment and recognize errors in a timely, appropriate manner, to contribute to the good of themselves, the community, and society. Furthermore, they must be able to demonstrate adequate communication skills, facilitate decision-making, develop independent, responsible, and creative action to solve the problems they will face, and demonstrate the ability to integrate multidisciplinary teams; all of which must be considered in the PEA. For this reason, the PEA of engineering programs needs to be transformed from a linear and technical

conception to a more systemic and collaborative one with the help of other educational sciences (Padrón and de la Rúa, 2013).

The organization of work in Cuba is governed by important principles; one of them is active worker participation. This principle gives workers greater agency in the design, scheduling, and evaluation of the tasks to be undertaken. It fosters the integration of tasks within companies, thereby coordinating performance with decision-making and exchange with others.

It is argued that, faced with these new demands, engineers cannot continue to solve problems only from a technical perspective; their jobs require a blend of technical, human, and organizational knowledge. It is therefore necessary to pay special attention to the interpersonal relationship between instructors and students, to ensuring satisfaction and security in a climate that fosters dialogue and knowledge sharing. This emphasizes the need to further explore avenues and proposals from the PEA (Educational Planning) that contribute to developing engineering students in the modes of action they will later need in their professional careers in business and in society at large.

The comprehensive training of students to achieve these goals is an important consideration in the design of the educational process at universities. The development of professionals with intellectual potential and personal resources that enable them to interact in the society in which they live becomes a necessity to be addressed in the conception of educational guidance.

However, young people arrive at university with shortcomings that must be addressed in their educational process, where educational guidance plays a very important role. A lack of responsibility in their study activities, poor development of independent study skills, insecurity that leads to shyness, a lack of cooperation and knowledge of self-regulation techniques, as well as communication difficulties, are behaviors that generally characterize first-year students.

Educational guidance plays a significant role in diagnosing these problems and providing individualized care. It allows the problem to be transformed into an opportunity for personal growth for each young person, geared toward meeting current demands in professional training.

Guidance, as a relationship of helping one or more people, has existed since the dawn of humanity. Human needs to feel fulfilled, to plan for the future, to guide education toward a goal, among others, are associated with guidance by the very social essence of human beings. In the specialized

literature, there is consensus that guidance emerged as an important area of study in the sciences at the beginning of the 20th century (Vélaz-de-Medrano *et al*., 2023).

Throughout its evolution, educational guidance has been conceptualized by different researchers, who have provided theoretical and methodological foundations that constitute starting points for the development of guidance programs and actions. Based on the analysis and systematization of studies carried out by authors such as: Calviño (2002), Vieira and Vidal (2006), Alfonso and Serra (2016), Da Silva and Pereira (2021), Echeverría and Martínez (2021), Torrecilla-Sánchez *et al.* (2022), Allueva (2022), Vélaz-de-Medrano *et al*. (2023), Viñuela and Vidal (2023), González *et al.* (2024), Bertolín *et al*. (2025), several reflections emerge that constitute the core axes to be considered in the present research:

- Educational guidance has moved away from its remedial conception to give way to a more preventative and personal development approach.
- Educational guidance is considered a helping relationship.
- Guidance is seen as a planned process, taking into account the needs of students.
- The teacher is considered an important educational agent in educational guidance.
- Guidance actions, as a means of providing educational guidance, are becoming increasingly relevant in the proposals analyzed.
- The group constitutes an important space for carrying out educational guidance.
- The need to take into account the specificities of professional training in planning educational guidance is raised, and it is added that this should prepare students to assume a critical and transformative position in society.
- Educational guidance is given the character of a system and an advisory function within the educational process.
- The class is recognized as a fundamental cell for educational guidance.
- The PEA has begun to be perceived as an important space for educational guidance and for achieving results in this regard.

Various studies maintain that guidance in the PEA is an area with sufficient foundation of its own (Paz *et al.*, 2016; López *et al.*, 2023; González *et al.*, 2023). These authors consider that the PEA constitutes a process with sufficient theoretical and practical foundations, which allow educational guidance to be assumed within it.

However, despite the fact that the PEA is the space where teachers and students interact the most, making it the ideal process for educational influences, it is not used as desired to carry out educational guidance actions in engineering training. Interaction between teachers and students to achieve direction in the PEA will contribute to meeting guidance needs through teaching activities.

Based on the above, university professors are required to prepare for the guidance role within the discipline they teach, and thus be able to fulfill the important role assigned to them by the university and society in the 21st century. Professors must ensure a teaching structure that fosters education through content acquisition; it is their responsibility to demonstrate their role as facilitators in a process that contributes to the humanistic development of engineers.

It can be argued, then, that the practice of educational guidance can be based on a didactic foundation that allows engineer-teachers to carry it out, according to the needs of their students and in accordance with the requirements of the PEA and the context in which they are inserted.

Based on the above approaches, the objective of this study is to develop a methodology for educational guidance in the teaching-learning process of engineering, which contributes to the comprehensive development of engineering students, with a view to successful performance in society.

MATERIALS AND METHODS

The dialectical-materialist and historical method was used to conduct this research, combining quantitative and qualitative aspects. To achieve this objective, theoretical, empirical, and mathematical-statistical methods were used. Analytical-synthetic and inductive-deductive theoretical methods enabled conclusive syntheses in the study of theories and trends related to engineering training needs, and they also determined the potential of educational guidance to contribute to improving the training process.

In order to be able to carry out educational guidance work in engineering teaching activities by the closest educational agent, the teacher, educational guidance is defined in the PEA as a helping relationship that, through the interpersonal link between the teacher and the students, the joint diagnostic intervention and the stimulation and development of the potential of each student and the group in teaching activities, contributes to personal growth.

The systemic-structural-functional method allowed us to configure, in a logical and integrative manner, the methodology for educational guidance based on the given definition.

The empirical level methods used were interviews with teachers and students, as well as scientific observation of teaching activities. Both methods aimed to explore perceptions and practices regarding educational guidance and its connection to the didactic components of the classroom.

The sample consisted of 20 professors and 62 second-year students of the Mechanical Engineering program, belonging to the Technological University of Havana "José Antonio Echeverría", in the 2022 academic year.

Source triangulation was used to analyze the results. This approach took into account the manifestations of five categories (Table 1).

Table 1. Categories for the analysis of the information obtained

Category	Particularity
A	Determining the orientation objective linked to the teaching-learning objective
B	Determining resources and techniques for educational guidance
C	Interaction to offer the necessary assistance in teaching activities
D	Expression of students' self-determination in teaching activities
E	Updating the students' diagnosis, according to the proposed objective.

To measure each category, a scale from 1 to 5 was designed (Table 2).

Table 2. Scale of values for the categories

Scale	Quality
1	It is not done, it is not planned
2	It is done, but not planned
3	It is planned, but not carried out
4	It is planned and carried out with little systematicity.
5	It is planned and carried out systematically

To validate the methodology. The sign test was used as a statistical method to verify the significance of the differences between the initial and final states in the application.

RESULTS

Proposed methodology for educational guidance in the teaching-learning process of engineering

The methodology for educational guidance in the PEA of engineering is defined as a proposal of phases and methodological procedures that allow for carrying out the action of educational guidance in the PEA.

Guidance actions will enable educational guidance to be implemented in the engineering PEA. They are defined as the dialectical interrelationship of operations that, when executed in accordance with the PEA, allow for the establishment of a supportive relationship between the teacher and the student, where diagnosis, intervention, and follow-up are energized to meet the demands of the professional model. Actions can be planned within the PEA or emergent.

The objective of the methodology is to enable the teacher to carry out educational guidance actions in the PEA of engineering, so that students cooperate in meeting their guidance needs.

The methodology consists of five phases, each of which corresponds to the operations of the action that characterizes it. In each phase, the methodological procedure is explained and the methods and methods used to carry out the educational guidance action are specified.

Phases and methodological procedures for implementing the educational guidance action in the PEA of engineering

Phase 1. Needs identification

In this phase, an internal model must be projected, based on the teacher's and students' awareness of their own teaching practices and the need for assistance. Both teachers will determine the need for educational guidance based on the diagnosis previously conducted.

The guidance objective, linked to the teaching-learning objective, is determined here. There should be no dichotomy between the two intentions. Dialogue between the teacher and students is feasible

in this approach, where both parties' requests for educational guidance are heard. The teacher must use scientific observation and oral interviews as methods and techniques that facilitate and make this phase effective. It can begin at the beginning of the activity, from the moment the teaching-learning objective is reconciled, if the educational guidance action is planned. If the action is emergent, it is carried out at the precise moment the need is to be addressed.

Phase 2. Determining resources and techniques for educational guidance

To determine the personal and methodological resources, as well as the techniques to be used, the starting level established in the previous phase must be taken into account, so that a forecast of what can be achieved can be established.

In this phase, the exchange between students and between them and the teacher predominates. Students have a role in managing group dynamics. It is feasible to propose guidance techniques to students and facilitate their decisions regarding their individual or group use, since the teacher, as an education professional, is familiar with the internal characteristics of the techniques. The techniques that can be used are related to influence techniques (support, persuasion, suggestion), information techniques (questioning, restating or repeating, summarizing and clarification), group reflection, and problem-solving, among others.

When the application of educational guidance actions becomes systematic in teaching activities, students will be able to make decisions about using one technique or another based on their personal experience with it.

At this point, guidance resources and techniques will become procedures for the teaching-learning method to be used in teaching activities.

Any time during class is a good time to carry out this phase, provided it has been preceded by an awareness of the need for guidance that will be addressed. This phase is very important because it fosters decision-making at the group level, paving the way for the transition to self-determination.

Phase 3. Interaction to offer the necessary assistance

It is necessary here to specify the joint intervention that has been planned in the previous phases, but which has only been related to student awareness and self-determination in the formation of the

guiding basis for action. Once the techniques and tools have been determined, the content of the educational guidance need anticipated from the needs identification is addressed.

The teacher carries out the procedures corresponding to the guidance technique or instrument determined jointly with the students and emphasizes the use of teaching aids that can facilitate exchange, which is facilitated by coordinating group dynamics. By placing educational guidance in the PEA, the teacher as a counselor opens up the possibilities for the student to make decisions.

The levels of support will allow for adjustment, modification, and decision-making regarding the student's or group's responses, facilitating diagnostic confirmation for joint diagnostic intervention. The levels of support that can be provided to the student and the group can be:

- First level of support: alerts. You can highlight important elements of the task or express motivating ideas, such as: "Look carefully, what do you need?" This will allow the student to act independently, without feeling pressured. Allowing the student to reflect and make their own decision minimizes resistance and anxiety in the process of receiving support and issuing a response.
- Second level of support: reminders of similar situations. This helps students gain confidence by taking on the path they've taken in previous situations. It simultaneously generates independence and satisfaction from the help they've received.
- Third level of support: a more detailed explanation of the situation to be resolved and suggestions for ways forward, allowing the student to act independently. In this case, the student can be helped to re-establish awareness of the objective and methods determined in order to rethink their course of action, be told that it is important to set a goal, be offered clues to solve the problem, among other options. Even at this level, the student can demonstrate independence and confidence in what is happening.
- Fourth level of help: Execution of part of the solution to the problem or situation the teacher wants to implement, where a demonstration may be implicit; the student continues with the execution. At this level, it is necessary to assess the student's fears and insecurities, as they may have the resources to complete the task and not do it out of shyness.

The levels of support are adjusted to the student's and group's assessment; they are provided in stages, starting with the first. The student's and group's actions are enhanced as they respond to the level provided, thereby achieving greater awareness of their actions and independent behavior.

As can be seen, the movement between each action and the reflection is continuous and unstoppable, requiring considerable creativity on the part of both the teacher and the students.

Phase 4. Expression of students' self-determination

The teacher should provide opportunities during teaching for students to express their level of self-determination, always in accordance with the development of their personal resources, the satisfaction of their guidance needs, and the use of their resources to solve problems, all of which can be observed from the support provided. The selection of techniques and resources by the group and the teacher in teaching activities will also be taken into account. When stress arises during teaching activities, alternatives can be used to control it.

This phase must be realized in the teaching process. This is where the teacher must propose an action to the student that will enhance their development. Teaching should encourage exchange, discussion, adjustments, and defense of arguments, thereby encouraging personal growth and developing the engineer's approach. At this point, the student should have a clear idea of their approach; the teacher must provide the opportunity to put it into practice and self-assess their behavior. Peer assessment is also appropriate at this point.

Phase 5. Diagnosis update

Based on the completed tasks, the students' and group's assessment is updated. In the conclusions to the teaching activity, the students express their experience of achieving the objective and their satisfaction with their leading role in the activity. The class conclusions help students corroborate the follow-up and updating of their assessment. Educational guidance at this point is energized through assessment.

This phase, being the final one, is not isolated from the rest. Every action must always lead to the diagnosis being updated, but each phase itself contains a constant update.

The methodology for educational guidance in the engineering PEA was applied according to the phases and methodological procedures outlined in the experiment. The pre-experiment was conducted using the pre-test/post-test methodology, with a single group of students from the Mechanical Engineering program at the Technological University of Havana "José Antonio Echeverría".

In this type of experiment, there is an initial reference point, and the transformation achieved can be assessed until the end.

For the initial measurement (pre-test), the following instruments were applied: interviews with teachers and students, and scientific observation of teaching activities. After the information was obtained, the results were triangulated, yielding the initial diagnosis.

In the final measurement (post-test), the same battery of instruments was applied and the final diagnosis was obtained. The comparative results from one test to the next (Figure 1).

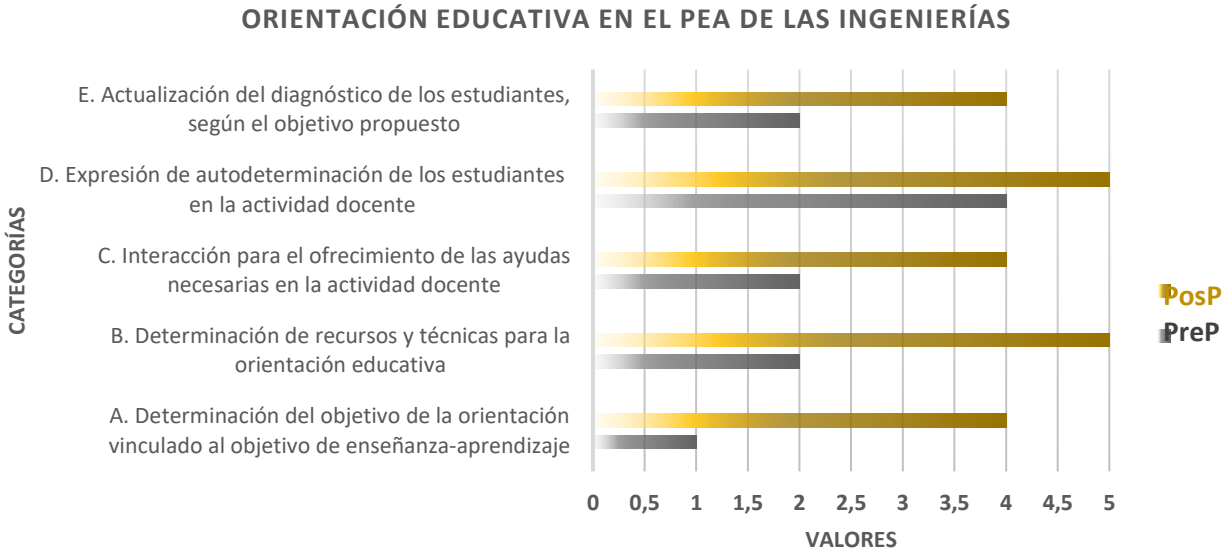

Figure 1. Initial and final values of the behavior of the categories of educational orientation in the PEA of engineering, according to the triangulation of sources
Source: prepared by the author based on information obtained from the research

To test the significance of the differences between the initial and final stages of educational guidance in the engineering PEA, the sign test was applied. N = 5 and x = 0, with a p value of 0.031, which was significant at less than 0.05. A positive relationship was found in favor of applying the methodology for educational guidance in the engineering PEA.

During the application of the methodology for educational guidance in the PEA of engineering, the main difficulties in the initial diagnosis were:

- The teaching-learning objective does not design the formative intention related to the educational orientation that will be carried out in the class.
- The student does not have the opportunity to identify his or her educational guidance needs, as this is not encouraged by the teacher in class.
- Procedures are used to guide the student, related to needs that arise spontaneously in the class.
- All types of help are provided to the student in class to meet his or her educational guidance needs, but they are not planned by the teacher.
- Teachers plan spaces within the classroom for students to express their independence and self-determination, and they recognize the importance of this action, but it is not carried out systematically.
- Guidance techniques are used empirically, the most commonly used being questions and summarization.
- The updating of the students' diagnoses remains solely within the teacher's knowledge; the student has no participation and it is not planned, as the needs are not stated in the teaching-learning objective.

From the analysis of the data emanating from the final diagnosis, it can be interpreted that the following impacts are manifested:

- The teacher managed to plan the objective of educational guidance linked to that of teaching-learning.
- Educational guidance actions are planned in the PEA using guidance resources and techniques, such as procedures, within the teaching-learning method.
- The teacher learned to plan and use individual levels of support, not only for the learning task, but also to assist the student in decision-making.
- In the evaluation of teaching activities, students were allowed to express their opinions about their learning and the objectives proposed to meet their guidance needs, which enabled students and teachers to update the assessment.

DISCUSSION

The methodology for educational guidance in the engineering PEA overcomes the identified shortcomings that limit educational guidance as a complementary function to teaching. Engineering training requires a humanistic approach that allows future graduates to integrate into teamwork to solve technical problems. Therefore, planning spaces for exchange, communication, and opportunities for critique in the PEA will contribute to the development of skills and qualities that will allow future graduates to lead active professional lives in all spheres of their careers.

The systematization of the theoretical and methodological references of educational guidance in the PEA, focused on the analysis of the studies by Paz *et al.* (2016), Viñuela and Vidal (2023), González *et al.* (2024) and López *et al.* (2024), lead to the establishment of the regularities that are manifested in educational guidance today, and reveal the potential that allows actions to be carried out in the PEA that contribute to satisfying the needs of engineering students.

According to Valle (2012), methodology is related to the actions that must be taken to follow the established path. When referring to methodology, he states that "the proposed objective is not achieved with a single action; a series of them are required... For this to be clear, especially for the person who must carry it out after the first time, this sequence and aspects of the work must be sufficiently explained and clear" (p. 223).

This author defines methodology as a "proposal of how to proceed to develop an activity, it refers to the establishment of ways, methods and procedures to achieve an end" (Valle, 2012, p. 277). The design and application of a methodology for educational guidance in the PEA of engineering, conceived as a proposal of phases and methodological procedures, consistent with what the author has described, to carry out the action of educational guidance in the PEA, contributed to the comprehensive training of engineering students according to the time in which they live.

Previous research, such as that of López *et al.* (2024), reveals, among others, the need to rethink educational guidance in all school spaces; and in turn, the integration of all educators and students themselves, highlighting a preventative and comprehensive development approach. The proposal of a methodology for educational guidance in the PEA of engineering confirms transformations that have occurred in the PEA of the Mechanical Engineering degree at the Technological University of Havana "José Antonio Echeverría". Teachers expand their knowledge of educational guidance, develop skills

in the use of procedures specific to educational guidance, establish interpersonal relationships with students, which enable a favorable climate for communication, both in classes and for diagnosis, and develop skills in planning educational guidance in the PEA.

Considering the dialectical relationship between the PEA and personality development, it is inferred that the methodology contributed to the students' personal growth. The transformation of educational guidance implemented in the PEA favors changes in students' behaviors. The supportive relationship that contributed to students' awareness of their needs and the ways to meet them is highlighted.

The results obtained reflect significant differences between the initial and final stages of the educational guidance and demonstrate the positive influence of the methodology, demonstrating its validity, relevance, and viability. Future research recommends further application of the methodology to other engineering programs to validate and contrast the results obtained, as well as its implementation in other contexts. Similarly, it would be interesting to explore the transformations that occur in students with the application of the methodology and its impact on the work of the entire year group.

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Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.