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¿Cómo desarrollar competencias de creatividad e innovación en la educación superior? Caso: carreras de ingeniería del Instituto Politécnico Nacional

How to develop creativity and innovation competences in higher education? Case: Engineering careers of the National Polytechnic Institute

Como desenvolver competências de criatividade e inovação no ensino superior? Caso: carreiras de engenharia do Instituto Politécnico Nacional

Yasmín Ivette Jiménez Galán
Instituto Politécnico Nacional, México
yjimenezg@ipn.mx
https://orcid.org/0000-0003-0575-7283

Resumen

Esta investigación se centró en el desarrollo de las competencias transversales *creatividad* e *innovación* para la solución de problemas planteados a los estudiantes de educación superior del Instituto Politécnico Nacional, concretamente en las carreras de ingeniería. En tal sentido, objetivo planteado fue diseñar un modelo para desarrollar dichas competencias a lo largo de la malla curricular de los planes de estudio de las 34 ingenierías que oferta la mencionada institución. El modelo desarrollado enfatiza el trabajo interdisciplinario del colectivo docente de las cuatro áreas formativas y de los cinco niveles de formación correspondientes al modelo educativo institucional; con esta iniciativa se pretende que los egresados de esas carreras valoren la creatividad como fórmula para solucionar problemas en sus respectivos campos laborales. Este modelo constituye una innovación educativa para el instituto, por lo que se espera que incida en sus cursos de formación docente.

Palabras clave: competencias transversales, creatividad, innovación, investigación educativa, solución de problemas.

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Abstract

This research focuses on the development of transversal competences: creativity and innovation in the solving problems raised in higher education students of the National Polytechnic Institute, specifically in engineering careers; It's objective was to design a model that allows developing the competences along the curricular grid of the 34 engineering careers that the National Polytechnic Institute offers. The developed model emphasizes the interdisciplinary work of the teaching group of the four training areas and in the five levels of training corresponding to the institutional educational model; it´s expected that graduates of National Polytechnic Institute engineering careers value creativity as a way to solve problems in their respective fields of work. The developed model represents an educational innovation for the National Polytechnic Institute and it´s expected to have an impact on the teacher training courses offered by the institution.

Keywords: transversal competences, creativity, innovation, educational research, solving problems.

Resumo

Esta pesquisa centrou-se no desenvolvimento de competências interdisciplinares de criatividade e inovação para a solução de problemas colocados a estudantes do ensino superior do Instituto Politécnico Nacional, especificamente em carreiras de engenharia. Nesse sentido, o objetivo foi desenhar um modelo para desenvolver essas competências ao longo da grade curricular dos currículos dos 34 projetos de engenharia oferecidos pela referida instituição. O modelo desenvolvido enfatiza o trabalho interdisciplinar do grupo de ensino das quatro áreas de formação e dos cinco níveis de formação correspondentes ao modelo educacional institucional; Com esta iniciativa, pretende-se que os graduados dessas carreiras valorizem a criatividade como uma fórmula para resolver problemas em seus respectivos campos de trabalho. Esse modelo é uma inovação educacional para o instituto, que deve impactar seus cursos de formação de professores.

Palavras-chave: competências transversais, criatividade, inovação, pesquisa educacional, resolução de problemas.

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Introduction

Competency-based education (EBC) is an educational approach that seeks to raise the quality of learning to achieve relevance and formative relevance (Unesco, 2007). Its inclusion in educational models has forced universities to provide instruction located in the socioprofessional context of each degree (Quiroz, 2007; Tejada and Ruiz, 2013), which implies the development of a diversity of learning that requires future professionals to perform successfully in an increasingly demanding work environment.

In this context, the educational model by competencies conceives the results of learning as observable performances at a conceptual, procedural and attitudinal level (Beneitone, Esquetini, González, Maletá and Suifi, 2007). With this it is tried that these skills are configured as authentic tools that allow the students to think and act with criteria and autonomy before decisions of personal, professional and social nature (Villarroel and Bruna, 2014). Thus, within the EBC, competition is linked to the integral formation of the citizen in the cognitive (knowing how to know), the psychomotor (knowing how to do) and the affective (knowing how to be and knowing how to live together) (Beneitone et al., 2007).

Logically, to develop them in the students - that is, to achieve effective performance in problematic situations - it is required that these be addressed through the curricular mesh and by levels of complexity in two types of competences: professional or specific and transversal or generic. The former are closely linked to the disciplines or areas of knowledge that distinguish one profession from another, while the latter are related to the set of skills applicable to a wide variety of situations that students will face, which is why they are common to most of professions and beyond the limits of disciplines or areas of knowledge (Beneitone et al., 2007).

These transversal competences, paraphrasing Quiroz (2007), transcend the knowledge of the students, because they respond to know-how (psychomotor dimension), to know how to be and know how to be (affective dimension) and to know what and why (cognitive dimension). In addition, according to Villa and Poblete (2007) and Tejeda (2016), these seek to promote the following ideals:

- Link the school with the problems of society.
- Promote an interdisciplinary and transdisciplinary vision for the solution of problems.

- Allow students to broaden their critical vision of the problems that affect humanity, so that they are able to contribute to change if necessary.
- Help to make better complex decisions promoting the integral formation of the student.

In accordance with the above, the aforementioned authors point out that the two characteristics of transversal competences are the following: multifunctionality, because they are activated in a wide range of personal, professional and social demands, hence requiring greater mental complexity that involves the activation of the know-how and the know-how of the students; and multidimensionality, because they mobilize perception (discrimination of the relevant and irrelevant), normativity (selection of contextualized meanings) and cooperation with other people to offer solutions to problems. Therefore, it can be said that transversal competences are those that mainly contribute to forming autonomous people, capable of making personal and professional decisions, based on systemic visions when making value judgments.

However, in the Tuning Latin America project 27 transversal competences were agreed upon for graduates of higher education, which were classified into three major groups (Beneitone *et al.*, 2007; Villaroel y Bruna, 2014):

1. Instrumental: Capacities, abilities and skills that materialize in tools to achieve goals or objectives, such as the ability to analyze and synthesize, effective communication, autonomy, information management, decision making, creative thinking, the solution of problems, among others.
2. Interpersonal: Individual and social skills that allow cooperation and integration into work teams to achieve conflict management and negotiation, interdisciplinary teamwork, assertiveness and adaptation to the environment.
3. Systemic: Ability to assess how the parts of a whole interact, which implies other competences, such as the application of knowledge and experience in practice, creativity, project management, self-motivation, initiative and spirit innovative.

These competences, as mentioned, exceed the limits of a discipline, hence they must be cultivated by teachers in all the learning units of the academic programs. For this reason, competency-based training should be considered at the curricular level, establishing a graduation profile whose focus is on the performance of the students upon graduation, as well as favoring the

integrated work of the academies, research and extension based on strategies of teaching and learning that preferably allow work in interdisciplinary teams or the development of transdisciplinary projects (Martínez, Báez, Garza, Treviño and Estrada, 2012, Tejeda, 2016).

Due to this, several researches report that the teaching-learning process by competences requires both teachers and students to acquire a new role. On the one hand, teachers must place learning as the center of the educational process by implementing activities based, for example, on project development, teamwork, seminars, case studies, essays, problem posing or evaluation interviews, which will allow to promote the trinomial think-act-think about its performance. On the other hand, the student must be able to self-regulate their learning and self-evaluate their development (reflection in the action) to transcend the grade obtained in a course (Quiroz, 2007, Tejada and Ruiz, 2013, Villa and Poblete, 2011).

However, it is also worth mentioning that on these cross-cutting competences multiple problems have been detected related to the scarce formation that teachers have to articulate the teaching-learning process by competences (Martínez et al., 2012), the evaluation of these (Jiménez , González and Hernández, 2016; Vega, Figueroa and Del Real, 2017; Villa and Poblete, 2011) and the effectiveness of situated teaching (Díaz, 2006).

Explaining the above, it can be indicated that the interest of this research has focused on three transversal competences: problem solving, creativity and innovation.

Problematic situation

Creativity (located within the instrumental competences) and innovation (included within the systemic competences) are two of the most decisive faculties to successfully face the innumerable challenges of any profession (Adriansen, 2010; Valqui, 2010; Ya-Hui , 2009). However, several authors have shown that these are still a fertile field of inquiry and promotion, given that they have little presence in the plans and programs of study (Martínez et al., 2012; Tena, 2010), despite the fact that creativity For example, it is a human ability of a higher order that allows the traditional understanding of problems to be overcome in order to offer alternative solutions, which are directly linked to innovation, an indispensable faculty to achieve original results of high quality and applicability (Adriansen, 2010, De Bono, 2015). This means that students must first develop creative thinking and then the innovative spirit (López, 2017; Swanger, 2016).

Taking this idea as a reference, the National Polytechnic Institute (IPN) is one of the institutions that has modified its educational model to introduce "teaching methodologies that give priority to innovation and creativity" (IPN, 2004, p.55). In this university 81 study programs are offered in three areas of knowledge: Engineering and Mathematical Physics Sciences (ICFM); Biological Medical Sciences (CMB) and Social and Administrative Sciences (CSA). The distribution of registered enrollment for the 2017 cycle is shown in Table 1.

Tabla 1. Distribución de alumnos inscritos en el IPN en 2017

Rama	**Total por área de conocimiento**	**%**
ICFM	67 142	64.04
CMB	17 487	19.29
CSA	20 231	16.67
Total	104 860	100

Fuente: IPN (2017)

Table 1 shows that more than 64% of the enrollment is grouped in the ICFM area, which consists of 36 programs (34 engineering and two undergraduate). However, in an initial exploration it was found that of all the engineering programs, only four explicitly state creativity competence, in five innovation competition appears, while the two only appear in six programs.

In addition to this, it can be indicated that two researches focused on the performance of teachers -cases of study in an academic unit of the IPN of the branch of ICFM (Jiménez et al., 2013, 2016) - have served to demonstrate that while the professors of this area have a favorable perception of the EBC, in practice they do not evaluate that the solution of proposed problems is based on creativity and innovation, and they do not know how to articulate this educational approach in their practice.

This research, therefore, aimed to design a model for the development of transversal competences, particularly those related to the solution of problems, creativity and innovation in engineering careers of the IPN.

Teaching competencies

According to Tobon (2009), the process of structuring competencies in students responds to the meeting of four concepts:

1. Training: Stimulates the integration of the four knowledge to enable the development of a new human being.
2. Development: In competencies there are processes that go from a state of differentiation (knowing, doing, being and being) towards the harmonious integration of these.
3. Acquisition: The competences have components that are acquired in practice and may or may not be a priori in the nature of students
4. Construction: The competences are built with subprocesses acquired and developed previously.

This means that the EBC is the responsibility of the teachers, who must work in the construction of these components so that the students perceive how the articulated integration of the know-how should be produced (knowing, doing, being and being). In this sense, teachers are committed to structuring their classes (methods, strategies, techniques and activities) (Arias, Giraldo and Anaya, 2013), so that graduates can offer creative and innovative solutions to complex problems they will face in the future. work world.

To this end, some of the teaching methods that best promote competencies and favor the transfer of what is learned in school to real life are the development of projects, problem-based learning and case analysis, since all are trying to promote an active learning

According to Díaz (2006), a professional, unlike a novice, is one who masters the qualities of knowledge, which implies being dynamic, self-regulated, reflective and strategic. In other words, for students to graduate with a professional performance they need teachers to face real situations that are specific to their respective fields of work. In this way, learning can be configured as a constructive, proactive, intentional, active and conscious practice that includes activities that involve intention-action-reflection.

Instrumental competences

As the name implies, these are grouped those that serve as an instrument to achieve a specific purpose. According to the Tuning Project, these could be classified into four subgroups: cognitive (related to the development of analytical, divergent, synthetic and critical thinking), methodological (linked to time management, learning for life, decision making). and the solution of problems), technological (associated with the handling of ICT) and linguistic (referring to effective communication) (Villa y Poblete, 2007).

Problem solving

The solution of problems, classified as transversal instrumental competence, can be defined as one that allows the student to identify, analyze and define the significant or critical elements that constitute a problem to solve it effectively (Iriarte, 2011; Villa and Poblete, 2007). Regarding this competence, teachers must be aware that first level students do not usually have the knowledge to face and solve complex problems, so they must establish proficiency levels with their respective indicators of gradual development (Llanos et al., 2016; Valqui, 2010; Villalobos, 2009).

From this perspective, the problematic situation must be understood not as an algorithm, but as a complex situation that requires interaction between the subject that analyzes and the context in which the problem is presented. This interaction, obviously, must be guided by reflection and continuous assessment, elements that give shape to the solutions proposed. This process is not usually linear, because in reality it has a strategic nature (Iriarte, 2011).

Systemic competences

These involve skills related to the ability to analyze and understand how the parts of a whole interact, so they are grouped into three groups: organization, entrepreneurship and leadership. Within the competences of entrepreneurship is creativity, which presupposes the ability to respond in an original way to the demands of a problematic situation, while at a higher stage is innovation, understood as the ability to respond effectively to the needs personal, organizational and social changes in processes, procedures or results (Villa and Poblete, 2007).

Creativity and innovation

According to Adriansen (2010) and Llanos et al. (2016), creative people are usually characterized by maintaining a position of openness to discovery, affinity for the unknown, perseverance, divergent thinking and security in their actions; whereas innovative people usually have a great determination, drive, non-linear mental processes, ability to transfer, autonomy, entrepreneurship and discipline.

In the same way as other transversal competences, creativity and innovation allow transforming not only the context, but also the students, since creativity offers them the opportunity to generate new ideas, while innovation enables them to choose a concrete idea and apply it successfully in the corresponding field (Arias *et al.*, 2013; Díaz, 2006; Iriarte, 2011).

Although these two faculties can be developed in varying degrees depending on the circumstances and cognitive particularities of each person, in all cases they will always need students to take an active role, hence they must change the phrase "the teacher teaches me" by the "I learn what I need to develop" (Arias, 2013).

But for this transformation to happen teachers must provide opportunities to cultivate them and to sensitize students that a high percentage of personal success depends on the implication that they show with the proposed training activities (Montero, 2009; Villa y Poblete, 2011; Villalobos, 2009).

Developing

The proposed model for the development of transversal competences was based on three articulated elements:

1. The characteristics of the educational model and the exit profile of the IPN.
2. The academic model of the IPN and the curricular redesign.
3. Transversal competences: creativity, innovation and problem solving.

Characteristics of the educational model

The IPN educational model has four essential ideals: 1) promote high-quality comprehensive training; 2) combine in a balanced way the development of knowledge, attitudes, skills and values; 3) provide a solid formation that facilitates autonomous learning; and 4) express

itself in flexible and innovative educational processes. Also, try to promote the following generic exit profile (IPN, 2004):

> The graduates of the IPN will have a solid integral formation, with general scientific and technological knowledge, so they will be able to perform in different fields, as well as to combine theory and practice adequately in their professional field. They will have developed the necessary skills to function in inter and multidisciplinary work environments, work as a team and leadership. All graduates will have received training based on ethical values, responsibility, which will make them aware and open to change, that respond to the needs of society and the sustainable development of the nation. (pp. 89-90).

Academic model and curricular redesign

The educational model is flexible and incorporates professional competences in each of the study plans. These are structured by levels in four training areas, the objective of which is shown in Table 2.

Tabla 2. Áreas de formación de los planes de estudio del IPN

Área de formación	**Objetivo**
Institucional	Desarrollar las competencias básicas para que los estudiantes desarrollen la capacidad de aprender a aprender, lo cual contribuye sustancialmente a aprender a ser, a convivir, a respetar y a emprender.
Científica básica	Construir las bases de conocimiento para un conjunto de programas de una misma rama. Corresponden exclusivamente a las ciencias que proporcionan los fundamentos de un determinado campo del saber científico y son indispensables para, posteriormente, comprender un campo específico de la realidad.
Profesional	Desarrollar los conocimientos, habilidades, actitudes y valores necesarios para el desempeño de una actividad profesional.
Terminal y de integración	Preparar al estudiante para su egreso del ámbito académico. Brindar experiencias de aprendizaje que le permitan integrar los contenidos curriculares desarrollados en etapas previas de formación privilegiando la participación en proyectos.

Fuente: Elaboración propia

Professional competences

In the IPN the notion of human competence for development is incorporated (synthesis of the understanding and action between necessity, conscience, skill and values, and reasoning), which will allow students to transform their environment and undertake projects. This is defined as "the professional performance that integrates knowledge: knowing, doing, being and being; promoting comprehensive training and high scientific, technological and humanistic quality based on the autonomous learning of students "(IPN, 2003, p.69). This knowledge materializes in three components:

1. Disciplinary: Includes the fields relevant to the disciplinary training and the field of basic and applied knowledge. Generic competences involving knowledge and attitudes are associated with this component, which are translated into the capacity for analysis, synthesis, understanding and evaluation (IPN, 2004).
2. Professional: It covers those aspects that distinguish one profession from another, such as its normative frameworks, identity, means, language and distinctive instruments. Associated to this component are the particular competences related to the field of specific activity of a discipline (IPN, 2004).
3. Practical-productive: It incorporates the optimal performances of activities in which the basic skills are expressed so that the individual has a willingness to work, adaptability, intervention and transformation; includes specific competences associated with knowing how to be and knowing how to be of students (IPN, 2004).

From the above it can be inferred that the professional component corresponds to the development of the particular skills of each profession, while the transversal competences, common to all areas of knowledge, should be developed taking as axis the disciplinary and practical productive components. The effective performance in each of the competences - associated with these components - requires the integrated mobilization of three types of subcompetences: technical, methodological and participatory social; while the proportion of the four types of knowledge will vary according to the specific competence analyzed. Specifically, Table 3 presents the disciplinary and practical productive components, which are closely associated with transversal competences.

Tabla 3. Componentes, áreas de formación y subcompetencias asociadas

Componente	Área de formación	Subcompetencia y saberes que necesitan movilizarse para dar solución a las problemáticas
Disciplinario	**Institucional Científica básica**	• Competencia técnica (saber referencial): Conocimientos de los diversos campos disciplinarios. • Competencia metodológica (saber hacer): Saber aplicar los conocimientos a situaciones profesionales concretas, solucionando problemas con autonomía. Habilidad para transferir las experiencias adquiridas a nuevas situaciones. • Competencia participativa (saber estar): Conjunto de actitudes y habilidades interpersonales que permiten a la persona interactuar en su entorno laboral y desarrollar su profesión. • Competencia personal (saber ser): Características y actitudes personales hacia sí mismo, hacia los demás y hacia la profesión, que posibilitan un óptimo desempeño de la actividad profesional.
Práctico-productivo	**Terminal e integral**	

Fuente: Elaboración propia

Cross-cutting competences: problem solving, creativity and innovation

The operationalization of the constructs referred to the competences solving problems, creativity and innovation was made based on the approaches of Villa y Poblete (2007), Villalobos (2009), Llanos *et al.* (2016) y Valqui (2010) (tabla 4).

Tabla 4. Competencias *solución de problemas*, *creatividad* e *innovación*, y sus estadios de desarrollo

Competencia	Definición operacional	Competencias asociadas	Estadios de desarrollo
Solución de problemas	El estudiante identifica, analiza y define los elementos significativos que constituyen un problema para resolverlo con criterio y de forma efectiva.	• Pensamiento analítico. • Pensamiento reflexivo. • Pensamiento crítico. • Pensamiento sistémico. • Capacidad de síntesis. • Capacidad de investigación.	I. Identifica y reconoce los problemas hasta plantearlos de forma coherente. II. Relaciona nuevos conocimientos en el planteamiento de los problemas ampliando su visión para solucionarlos. III. Analiza los problemas planteados siguiendo una metodología apropiada que le permita desarrollar una visión sistémica. IV. Transfiere los conocimientos adquiridos a diferentes ámbitos para solucionar problemas.
Creatividad	El estudiante genera ideas nuevas y originales planteando soluciones alternativas a un determinado problema.	• Solución de problemas. • Pensamiento divergente. • Autoestima. • Autonomía. • Imaginación.	I. Genera ideas o soluciones nuevas y es capaz de comunicarlas con eficiencia. II. Genera ideas originales de calidad susceptibles de ser puestas en práctica. III. Aporta ideas y soluciones originales, así como prácticas eficientes, efectivas, complejas y flexibles trascendiendo los marcos habituales de trabajo. IV. Valora la creatividad como forma para solucionar problemas para el mejoramiento de la calidad de procesos y de la vida.
Innovación	El estudiante consigue resultados originales, efectivos y aplicables al resolver demandas personales, organizacionales y sociales.	• Creatividad. • Espíritu emprendedor. • Toma de decisiones. • Trabajo en equipo. • Liderazgo. • Negociación.	I. Introduce nuevos procesos y acciones para responder mejor a las limitaciones o problemas detectados. II. Encuentra nuevos métodos y soluciones ante problemas. Analiza riesgos y beneficios de una gama de soluciones. III. Diseña y aplica los nuevos procesos y métodos en proyectos o soluciones a problemáticas.

Fuente: Elaboración propia

Results and Discussion

For graduates of IPN engineering careers to value creativity as a strategy to solve problems in their respective fields of work and implement new, original and efficient methods -transferring their professional and transversal competences in effective actions-, a model was developed for the interdisciplinary work of teachers in the four training areas and the five levels of training (IPN, 2004), since it was considered that teachers have the main responsibility for future professionals to be competent to perform successfully in the workplace, which implies the work around the cognitive, psychomotor and affective capacities (Beneitone et al., 2007, Tejeda, 2016). In this sense, it can be said that the model developed in this research has internal consistency not only because it is derived from the educational model of the IPN and the conception of professional competence, but also because it is applied through the curriculum of the engineering careers offered at the institute.

In other words, the model considers the process of structuring students' competences (Tobón, 2009) based on formative levels and training areas (table 5), to which creativity and creativity are later integrated harmoniously. the innovation for solving problems.

Tabla 5. Nomenclatura utilizada para desarrollar el modelo

Niveles formativos	Áreas de formación
1	Científica básica (1.CB)
	Institucional (1.I)
	Profesional (1.P)
2	Científica básica (2.CB)
	Profesional (2.P)
3	Profesional (3.P)
4	Profesional (4.P)
	Terminal y de Integración (4.TyI)
5	Terminal y de Integración (5.TyI)

Fuente: Elaboración propia

Based on these elements, it is proposed to develop the solution of problems with didactic methods that emphasize a situated teaching (Díaz, 2006). For this, teachers, in a collaborative work, should evaluate not only knowledge, but also the way in which students apply them, as well as

knowing how to be and knowing how to be, since creativity and innovation belong to the group of Systemic competencies that support the transfer of learning and academic development. This is fundamental because if the evaluation process is not modified to include these aspects (Llanos et al 2016, Tobón, 2009, Villalobos, 2009), the institute will not be able to fully comply with its graduation profiles. Table 6 shows the interdisciplinary work proposed by area and educational level.

Tabla 6. Desarrollo de las competencias genéricas a través de la malla curricular del IPN

Competencia	Definición operacional	Competencias asociadas (área formativa y nivel)
Solución de problemas	El estudiante identifica, analiza y define los elementos significativos que constituyen un problema para resolverlo con criterio y de forma efectiva.	• Pensamiento analítico (1.CB) (2.CB) (1.P) • Pensamiento reflexivo (2CB) (2.P) • Pensamiento crítico (2.CB) (desde 1.P hasta 4.P) • Pensamiento sistémico (1.CB) (2.CB) (desde 1.P hasta 4.P) • Capacidad de síntesis (2.CB) (desde 2.P hasta 4.P) • Capacidad de investigación (1.I) (desde 1.P hasta 4.P) • Trabajo individual (1.CB) (1.P)
Creatividad	El estudiante genera ideas nuevas y originales planteando soluciones alternativas a un determinado problema.	• Solución de problemas (desde 1.P) (1.I) • Pensamiento divergente (desde 2.P) (desde 4. TyI hasta egreso) • Autoestima (1.I) (desde 3.P) • Autonomía (1.I) (1.CB) (desde 3.P) • Imaginación (1.I) (desde 3.P) • Trabajo en equipo (1.I) (2. CB) (desde 2.P)
Innovación	El estudiante consigue resultados originales, efectivos y aplicables para resolver las demandas personales, organizacionales y sociales.	• Creatividad (1. I.) (desde 3. P) (4.TyI hasta egreso) • Espíritu emprendedor (desde 2.P.) • Toma de decisiones (desde 2.P) (4.TyI hasta egreso) • Capacidad de transferencia a otros contextos (desde 3.P) (4.TyI hasta egreso) • Liderazgo (1.I) (desde 3.P) (4.TyI hasta egreso) • Negociación (desde 3.P) (4 TyI hasta egreso)
Egresados de las carreras de ingeniería del IPN que valoran la creatividad como forma para solucionar problemáticas en sus respectivos campos laborales e implementan métodos o procesos nuevos, originales y eficientes, transfiriendo sus competencias profesionales y transversales en actuaciones efectivas.		

Fuente: Elaboración propia

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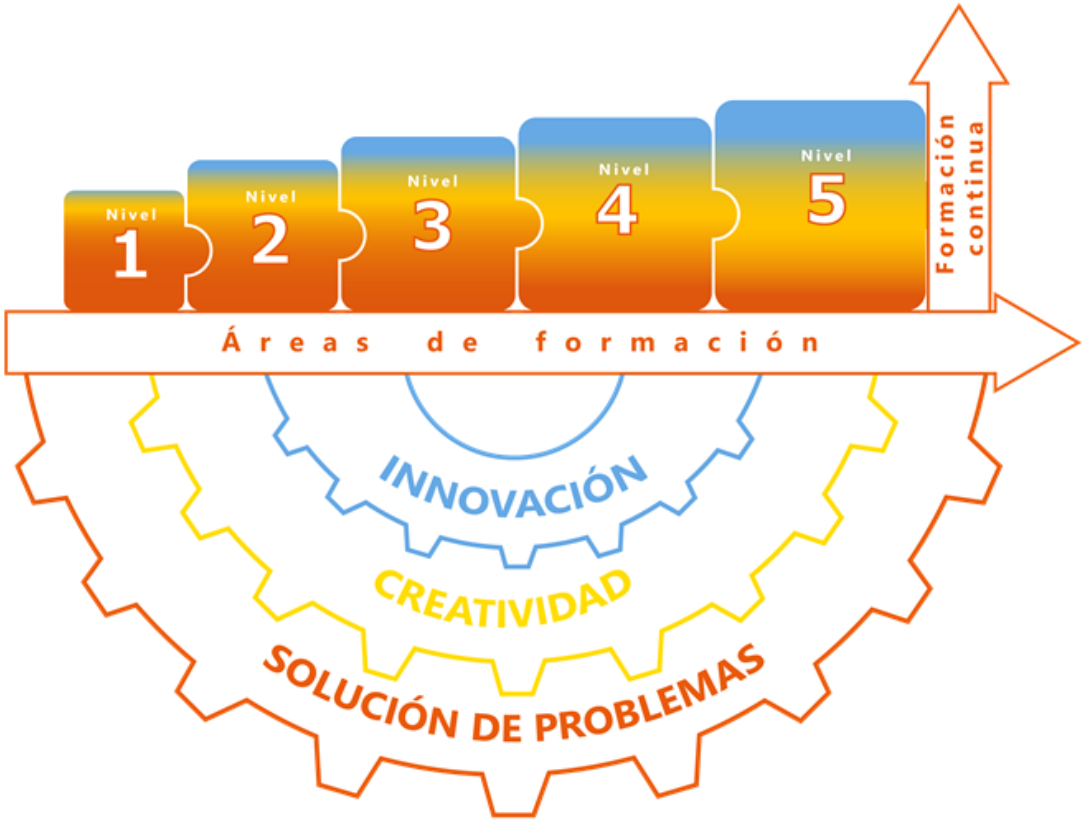
This means that graduates will be able to master the qualities of professional knowledge and transfer it dynamically and strategically (Díaz, 2006). The proposed model is shown in figure 1.

Figura 1. Modelo de desarrollo de las competencias de solución de problemas con creatividad e innovación



Fuente: Elaboración propia

At the educational level 1 it is important to promote individual work among students (Valqui, 2010), since this will lay the foundations for later teamwork, which is recommended from level 2. It is important to emphasize that the problems that The students must solve the problem. They do not refer to algorithm solutions, but to approaches that will vary in intensity and will go from being semi-structured to open.

Subsequently, it is proposed to continue with the stimulation of creativity in the solution of problems; for this, at the beginning students should be encouraged to transcend what they have been taught, for which they should propose ideas different from traditional ones (Adriansen, 2010,

Arias et al., 2013, De Bono, 2015) and make transfers between different learning units taken. In short, the determining factor is to develop imagination, divergent thinking and lateral thinking (De Bono, 2015, Rasmussen, 2009, Swanger, 2016). Then, from level 3 you can continue with the work of the components associated with innovation.

Regarding the limitations of this model, it is worth emphasizing that this was developed for the 34 engineering careers of the 18 academic units of the IPN, so that the areas of medical-biological and economic-administrative sciences of the institute would have to propose one own, which could take as a reference the one suggested in this investigation.

Even so, and unlike the model developed by Martínez et al. (2012) and the curriculum proposal of Montero (2009), the present model has two strengths: on the one hand, it fosters creativity and innovation together, and, on the other, it teaches in a structured way how transversal competences are developed through its different associated components.

Conclusions

The model developed in this document allows teachers from different training areas to understand how they could collaborate to promote creativity and innovation, which constitutes an advance for the construction of competence-based education knowledge. This model, in addition, represents per se an educational innovation for the IPN, which is expected to affect the teacher training courses offered by the institution to improve quality.

Finally, it is recommended that more research be developed to focus teaching-learning strategies, as well as the evaluation of these competencies in order to provide teachers with more tools to improve their performance from the competency model.

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