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Didactic strategies for the development of competences and complex thinking in university students

Estrategias didácticas para el desarrollo de competencias y pensamiento complejo en estudiantes universitarios

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Abstract

The present investigation starts from the logical and theoretical framework of the development of competences and complex thinking in the world university system. In this sense, the research aimed to demonstrate the effects of the application of didactic strategies for the development of competences and complex thinking in the Systems Engineering degree at a public university in Lima provinces. The research was of an applied type, explanatory level, we worked with a pre-experimental design. The population was made up of 325 students from the professional career of Systems Engineering, and the sample was taken non-probabilistically by 23 students of the X cycle. The level of development of competences was 74% in percentage terms and 64,25% in complex thinking. It is concluded based on the three didactic strategies used (problem-based strategy, collaborative learning strategies, and the incorporated strategy of information and communication technologies) with a significance level of 5% and a (p-value: 0,006 < 0,050) that competences and complex thinking have been favorably developed in the students of the Professional Career in Systems Engineering at the National University of Cañete, Lima, Peru.

Keywords

Didactic strategies, development of competences, complex thinking, problem-based strategy, collaborative strategy, incorporation of ICT.

Resumen

La presente investigación parte del marco lógico y teórico del desarrollo de competencias y el pensamiento complejo en el sistema universitario mundial, en ese sentido la investigación tuvo como objetivo demostrar los efectos de la aplicación de las estrategias didácticas para el desarrollo de competencias y pensamiento complejo en la carrera de Ingeniería de Sistemas en una universidad pública de Lima provincias. La investigación fue de tipo aplicada, nivel explicativo, se trabajó con un diseño pre experimental. La población la conformaron por 325 estudiantes de la carrera profesional de Ingeniería de Sistemas, y la muestra fue tomada no probabilísticamente por 23 estudiantes del X ciclo. El nivel de desarrollo de competencias fue porcentualmente del 74% y del pensamiento complejo el 64,25%. Se concluye en base a las tres estrategias didácticas utilizadas (estrategia basada en problemas, estrategias de aprendizaje colaborativo, y la estrategia incorporada de las tecnologías de información y comunicación) con un nivel de significancia del 5% y un (p-valor: 0,006<0,050) que se ha desarrollado favorablemente las competencias y el pensamiento complejo en los estudiantes de la Carrera Profesional de Ingeniería de Sistemas en la Universidad Nacional de Cañete-Lima, Perú.

Palabras clave

Estrategias didácticas, desarrollo de competencias, pensamiento complejo, estrategia basada en problemas, estrategia colaborativa, incorporación de las TIC.

Introduction

The excessive and massive expansion of university higher education in the world and specifically in Peru according to Brooks, Waters and Pimlott-Wilson (2012); Yeom (2016) have made the offer of graduates in all professional careers increasingly broad and diversified, and thus there is greater competition in applying for a job.

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This definitely has an impact on employability, according to Figuereido, Biscaia, Rocha, and Teixeira (2017), as it has been evidenced in certain mismatches in the skills, abilities, and competences required by the labor market, as well as by those formed in the university.

In this perspective as pointed out by Guzzomi, Male and Miller (2015); and Medland (2016) to become a good professional it is not only necessary to have mastery of the cognitive component and the technical/operational skills of the specialty, but also, nowadays, is required to develop the social skills, soft skills and complex thinking skills needed in the workplace.

In the occupational market, for Kalyuga, Renkl and Pass (2010); and Oliveri and Markle (2017) "The ability to solve problems, to think critically and to communicate properly are some of the skills most needed by employers who are becoming increasingly selective and restricted in their choices. Morales and Zambrano (2016) argue that, while these skills are part of the declared graduate profiles of most universities, they do not have adequate tracking of trajectories and achievements of the graduates in a properly systematized in an information system".

Likewise, today due to the accreditation and licensing policies of the universities and professional careers in the country, in large part of both public and private universities, undergraduate programs have moved towards a competence-based model, as said by Knight (2011); Manzanares and Santamaría (2016). Although their advantages are related to more dynamic and practical educational processes, for Pavié (2011); and Tobón (2013) they seek the integral formation of students and the evaluation of learning at the time of their graduation, it has been found that among the main difficulties of its implementation is the limited modification of the evaluation processes.

On the one hand, according to Ampuero y Casas (2013), there is no coherence between higher education institutions around what competency assessment involves and, on the other hand, according to Möller and Gómez (2014), there is a lack of coherent and relevant assessment tools to measure complex thinking.

From this point of view the research problem is formulated:

What are the effects of the application of didactic strategies on the development of competences and complex thinking in students of the Systems Engineering Degree at the National University of Cañete?

The investigation is justified in so far as it was not possible to know its justification in the following components:

- Convenience, this aspect is fundamental, since addressing the topic of research study is convenient for this time and space, as

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it was useful to know the levels of attainment of competences and complex thinking in the study sample.

- Social relevance, research is justified to the extent that managers, teachers and students improve their social and moral conscience, and this serves as a starting point for the subsequent accreditation of the professional career, which will result in a better society.
- Practical implications, such as the development of competences and complex thinking of university students was measured in two moments before and after the implementation of teaching strategies; this application has been favorable for students of the professional career of Systems Engineering.
- Theoretical value, the information gathered and processed within the university system, will serve as theoretical support for this and other research purposes, as it will enrich the theoretical framework and/or body of knowledge that exists on the subject in question.
- Methodological utility, because all the stages and/or phases of the scientific method were followed in its achievement.

Regarding the literature review, we have the contributions of Villarroel and Bruna (2019) who propose an authentic evaluation in university higher education. Learning assessment tools, traditionally used at university, have major weaknesses in measuring students' in-depth knowledge. On the other hand, authentic evaluation provides relevance by linking what happens in the classroom with real and working life, measuring knowledge in real contexts.

Also, Tapia and Luna (2010) presented the Research "Validation of a Thought Skills Test for Fourth and Fifth High School and First Year College Students", where they conclude that the process of validation of the test involved an analysis of the validity of content through evaluation by judges and psychometric evaluation carried out in two phases, the first with a pilot sample of validation to determine the reliability of the test through the analysis of difficulty of the items, the correlation item-test and the estimation of the Cronbach coefficient. As a result of this analysis thirteen items were invalidated, of which four were definitely deleted. The second phase consisted of re-evaluating the nine invalid items, after review and improvement, in a sample of the student group for standardization. A fundamental aspect of the psychometric evaluation was the Factor Analysis that allowed to base the theory on which the instrument

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is based. Three underlying factors were identified: deductive and inductive logical inference, analog classification, generalization and reasoning.

Barberousse (2007) in his research "Theoretical Foundations of Edgar Morin's Complex Thinking", concludes that in the face of what he considered the crisis of the western paradigm of simplification and disjunction, based on the reduction and separation of knowledge, Morin posed the emergence of a new paradigm of complexity, which would attempt to articulate and contextualize scientific cultures, humanities cultures and artistic cultures. To further this purpose, it was based on the integration of ideas, concepts and notions from various theoretical sources.

And Gonzáles (2002) in his research "The Educational Loop: Learning, Complex Thinking and Transdisciplinarity", where he concludes that learning as a complex system denotes various facets and ways of presenting itself in educational metacomplexity. A student, before learning as a unique moment in his life, must face an intersubjective spiral where detachment and re-learning are two components of learning individually and socially. Learning is the complexity of what the subject wants to "learn".

In the theoretical-scientific bases, we will first analyze the independent variable referring to didactic strategies. According to Ordóñez et al. (2011) the structure proposed in the different works seeks to modify the process that is regularly carried out in a classroom in order to achieve the development of complex competences and thought of students. The reformulation of teaching strategies under the approach of competence development and complex thinking consists of reviewing those that we have already used as they are: problem-based learning, collaborative learning and the incorporation of ICT in the learning process of university students.

The most pertinent is that, once the complex competences and learning to be achieved have been defined, it is necessary to design the teaching-learning process for its development and achievement. Educational research has proposed that complex learning and competences are achieved when students face situations that require their application.

Various authors have proposed and demonstrated the importance of working with problems, cases, projects and integrative tasks. Based on the review of specialized literature, we have the support of three didactic strategies to work with, considered as dimensions of the independent variable:

- The Problem Based Learning Strategy (PBL).
- The collaborative learning strategy (CLS).
- The incorporation of Information and Communication Technologies (ICT).

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It will begin by analyzing the first strategy, which was initiated at the University of Mcmaster Ontario, Canada, introducing problem-based learning (PBL) at the School of Medicine in 1969. Its purpose was to improve the quality of medical education, to transform the curriculum from a set of topics to an organization around real-life problems that requires the integration of different areas of knowledge to solve problems.

For Ordóñez et al. (2011) the problem-based strategy is a an instructional and curricular student-centred approach that encourages them to research, integrate theory with practice, and apply their knowledge, skills and attitudes to develop a solution to a specific problem. However, this proposal has been complemented by contributions made by different researchers on instructional design, such as Gagné, which shows the importance of motivating students, informing learning objectives, recovering previous learning, present content, provide learning guides, practice application or implementation, provide feedback, evaluate performance and promote retention and transfer; Merrill also emphasizes that learning is achieved by solving real-life problems, when previous learning is activated to generate new knowledge and learning, when new learning is shown to the student, when the student can apply the new knowledge and learning, and can integrate new knowledge and learning into his real world.

The Murray Problem Based Learning Strategy (1995) is one of the most widely used strategies for integrating knowledge, skills and attitudes and developing and transferring skills for problem solving. One of the most important contributions to this strategy is McMaster's problem-solving heuristics, which is summed up in six steps: committing, defining, exploring, planning, doing and evaluating.

The problem-based learning proposal also emphasizes the development of group skills learning, the proposition of alternatives and presentations. Students are faced with the search for alternative solutions and the theoretical support for them.

Problem-based learning according to Ordóñez et al. (2011) allows students to discover for themselves the relationship of theory with the proposed problematic situation and the teacher coordinates, clarifies and emphasizes the important aspects of these relationships. The challenge of solving a problem and the difficulties they overcome strengthen the learning, participation and leadership of the "teams".

The design of a subject with a problem-based teaching strategy will allow all theoretical topics to be covered through practical application. Problem-based learning, according to Ordóñez et al. (2011) includes several phases:

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- Problem Statement. "The problem is proposed by the teacher and discussed with the students. A deadline is given to complete said work".
- Appropriation of the problem. "The problem is open, can be solved by different approaches and students must make assumptions, selection of parameters to justify. The application of independent criteria leads to different solutions".
- Planning. "Students can organize themselves into groups to investigate the theoretical aspects that support the solution of the problem and solve it with the appropriate tools and techniques for the problem".
- Solution of the problem. "The solution includes the evaluation and discussion of the obtained results, which are compared with previously determined criteria and communicated to the students".
- Preparation of "a report, which can be presented individually or in groups. "The following sections are generally included: introduction, general and specific objectives, problem approach and solution methodology, obtained results and their discussion, conclusions and recommendations, bibliography".
- Presentation of results to the group. "The purpose is for students to enhance the competence of group work, so that they can clarify their doubts in their own language, that they themselves are their own guides in the group and that they internalize the studied subject. The competence to publicly present the results, defend and discuss them and present them in written form as is customary in an investigation report is also encouraged".

This type of strategy according to Ordóñez et al. (2011) promotes:

- "The learning of knowledge in the subjects covered by the course, its integration with the general theme and its application to particular cases of problems in engineering majors and professions at the end".
- The development of "group working competence and the written presentation of the results of both basic and applied research".
- The development of the "oral presentation, defense of results and public speaking" competency.
- Problem-based learning under the complexity approach can be reformulated by considering the implications of solutions in social, economic, environmental and ethical contexts. The

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arguments and criteria for selecting the best alternative are included in the "defense of the results".

The second proposal, the collaborative learning strategy CLS), according to Ordóñez et al. (2011) the CLS favours the development of skills, not only in the specific field of the subject, but also in the ethical field (responsibility and solidarity), communicative (debates, support and argumentation), emotional (positive interdependence, interaction leading to results, support, mutual help, overcoming weaknesses, achieving results, etc.) and attitudinal (sharing knowledge, continuous improvement, permanent self-assessment, etc.).

For a methodology to acquire the connotation of collaborative it is essential that five basic principles are met according to Ordónez et al. (2011):

- The "first principle, is positive interdependence, considered as the strategy in which students assimilate that they are intertwined with others in the sense that, if any member of the group is harmed, the group is damaged and if each member of the group reaches a goal is the achievement of the whole group, that is, either everyone wins or everyone loses".
- The "second principle is that face-to-face interaction between students is promoted. This face-to-face interaction occurs when students help each other, assist each other, motivate and collaborate in each other's efforts to learn. Students can promote the learning of each other through oral explanation of how to solve problems, discussing among themselves the nature of the concepts and strategies learned, sharing their knowledge and explaining the connections between past and present learning".
- The "third principle, is individual responsibility, exercised when evaluating the performance of each member of the group and the obtained results allow feedback to the group and the individual. It is essential that the members of the group know who needs the most assistance to complete the assigned work and harm the work of others. A common method of structuring individual responsibility is to assign tasks to the group or an individual task to each student and to randomly select one student to represent the efforts of the whole group".
- The "fourth principle is social formation, groups cannot function effectively if students do not have or exercise leadership, decision-making, truth-building, communication and

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conflict management. These elements of formation should be taken entirely as academic purposes".

- The "fifth principle is the group process, determined by ensuring that the groups work as such, achieving their goals and maintaining an effective working relationship among their members".

And the third didactic proposal was the incorporation of Information and Communication Technologies (ICT) in teaching and learning processes, for Ordóñez et al. (2011) With the introduction of ICT into training programs, the transformation of content-based training into broad-based concepts and the strengthening of basic principles has been envisaged, which requires new pedagogical strategies for the learning process.

ICTs contribute to the implementation of third-generation education supported by the use of new methods, techniques, strategies and means for comprehensive training. ICTs provide tools and resources through learning objects, which provide an enabling environment for collaborative learning and enhance the development of self-learning attitudes and information search, selection, assessment and organization skills. University training institutions are using these technologies as a teaching resource for the development of the contents of each subject, and as a tool for making learning-teaching environments more flexible.

In the pedagogical activities, according to Ordóñez et al. (2011) ICTs offer a broad spectrum of resources, which seek to facilitate the meaningful and personalized learning of complex concepts, as well as the construction and confrontation of knowledge, in interactive, dynamic and highly eye-catching environments. According to Trigos (2001), there are three criteria to consider in order to achieve online learning processes:

- It must be "networked, allowing the immediate updating, storage, retrieval and distribution of content and information"
- It should be "delivered through a computer using Internet technological standards".
- "It should focus on the broader vision of learning solutions that go beyond traditional training paradigms".

The incorporation of ICT into teaching and learning processes allows, *inter alia*, the following activities:

- Establishment of "a permanent channel of communication with students through a virtual platform".

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- Development of "subject support materials by teachers and their placement on a platform".
- Review of "support tools for the learning process developed in other universities for online use by the student".
- Development of "learning objects for virtual environments that allow students to conduct online learning activities without the presence of teachers".
- Design "of online self-assessment and evaluation systems".
- Design "of materials and tools for the independent study of students with different levels of learning".
- Provision "of alternatives for flexible learning in time and route".

The dependent variable called competence development and complex thinking will now be analyzed.

The concept of competence has been so thoroughly adapted the professional world that it has been incorporated into the university horizon as a catalyst for curricular models since the 1990s, taking on different names: competence-based training, curricula based on the competence-based approach, educational proposals based on competences, all with a view to becoming an academic training option.

There is considerable consensus in justifying this decision, which can be summed up mainly in the main characteristic of the time we lived in. For Manríquez (2012) this is a time of exponential changes of all order and magnitude, which is causing a shift in the center of gravity of university education, historically charged with training professionals for the labor market, whose structure is increasingly oriented towards the tertiary level. As a result, the content of various occupations is changing rapidly, creating new demands for skills and knowledge.

All this in the context of globalisation and the new information technologies that are constantly evolving, according to Brunner (2003).

One of the problems with the assessment of competences is that they are necessarily the product of a sequenced process; the assessment should aim at establishing the achievement or not of a competence, which can hardly be determined by a single method. To set out ideas, we will refer to the so-called Miller's Pyramid, a model for assessing competences proposed since the 1990s by Miller (1990) in the field of university education and presented in Figure 1:

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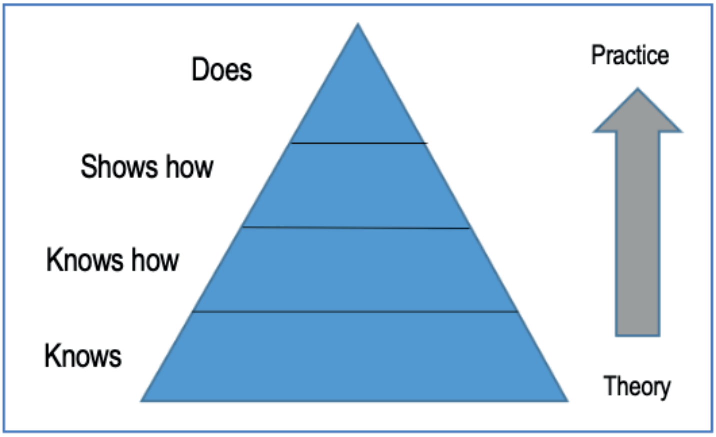
Figure 1
Miller's Pyramid



The figure clearly shows the stages that must be scaled in order to develop a competence. The first two stages (base) are obviously related to the cognitive and the two upper ones to the behavior. It is relatively obvious that the levels called knowing and know how, could be evaluated through traditional instruments in the context of a model that tries to certify the mastery of topics treated by the teacher in classes, with emphasis on paper and pencil tests and that in some manner reinforce converging thinking.

For Manríquez (2012) in a competences approach, this practice would correspond to the scope of what is defined as capacity -a specific component that is part of a competence- defined in terms of actions on content carried out around tasks that make sense as long as they are within a context of the very capacity that is intended to be demonstrated. This implies the restriction that the constructs, in this scenario, measure generic knowledge, that is, they would point towards general competences and not necessarily in an appropriate context. The latter is not minor: let us suppose that the task is being evaluated to *measure height*; this task should be in the context of an action that is connected with professional competence, beyond the experimental application of scientific method in general.

Regarding the complex thinking Peña (2018) considers that, the theory of complexity and complex thought tries to articulate disciplinary domains in favor of the teacher of the future, broken by the divisive thinking and who aspires to multidimensional knowledge.

Hence Morín (2003) indicates that complex thinking "is the ability to interconnect different dimensions of the real. It promotes a transdis-

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ciplinary and holistic approach, without abandoning the notion of the constituent parts of the whole" (p. 5).

The theory of complexity captures reality as a complex system, in its various connections, mediations and conditionings. That is why it does not establish antithetical relations between order and chaos, uncertainty and certainty, between the parts and the whole. If it does not assume it with awareness that they are antithetical, each separately, but at the same time unifies them, without making them a whole, each element retains its identity and unity.

University training towards transformation, however, requires specialized approval, possibly of a pedagogical nature. Since institutional policies, quality assurance that enhances those that promote professional development in universities, throughout their career, given that universities must now develop a scenario aimed at enhancing pedagogical training and professional development as a key strategy for improving the quality of education. The teacher in his daily practice, integrates different knowledge from this perspective, the teaching knowledge is formed by a more or less coherent mix of curricular and experiential knowledge.

These considerations, according to researchers such as García (2007), point out that "Teaching practice is not only an object of the knowledge of the sciences of education but also an activity that theorizes various forms of knowledge that can be called pedagogical, which are presented as doctrines by educational practice" (p. 57). Broadening the term, personal and normative reflections lead to the system, more or less coherent in pedagogical knowledge representing educational activity in the university system.

Based on the review of specialized literature, the investigation has had as objective to demonstrate the effects of the application of didactic strategies for the development of competences and complex thought in the students of the Major in Systems Engineering in a public university of Lima. And the hypothesis the application of didactic strategies produces significant effects in the development of competences and complex thinking in students of the Systems Engineering Major at the National University of Cañete.

Materials and method

The research was of the applied type and explanatory level. As a general research method, we used the scientific method and as specific methods, the experimental method, the statistical method and the hypothetical deductive method.

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In this regard, Ávila (2001) states that "applied research is interested in the application of knowledge to the solution of an immediate practical problem, seeks to know how to do, to act, to build, to modify, is concerned about the immediate application on a concrete reality" (p. 38).

According to Pardinas (2004), "the scientific method consists of the succession of steps we must take to discover new knowledge or, in other words, to test hypotheses that explain or predict behaviors of hitherto unknown phenomena" (p.72).

The study population consisted of 325 students duly enrolled in the 2019-II cycle, all of them belonging to the Professional Career of Systems Engineering of the National University of Cañete.

The study sample was not taken probabilistically and was made up of 23 students from the 10th cycle of the university.

After having selected the appropriate research design that was the pre-experimental according to the study problem and objectives, the scheme is shown below:

GE: 0_1 X 0_2
Where:
GE: unique experimental group.
0_1: Application of the Pre-test.
0_2: Application of the Post-test.
X: Manipulation of the independent variable.

Various research instruments have been designed, which were objective/essay-type pedagogical tests to measure the cognitive component of competences, a rubric to measure the procedural component and an attitude scale to measure the attitudinal component, as well as the inventory to measure complex thinking, the same ones that previously passed the Reliability criteria (Cronbach's Alpha = 0.964) and Construct Validation (Confirmatory Factor Analysis = 0.992) Then we proceeded to collect data, for this we first proceeded with the letters of informed consent to the members of the specified study sample to proceed with the practical execution of the research. Pablo (2007).

Analysis and results

Before implementing the three didactic strategies mentioned above (problem-based strategy, collaborative learning strategies, and the embedded ICT strategy), the following results were achieved:

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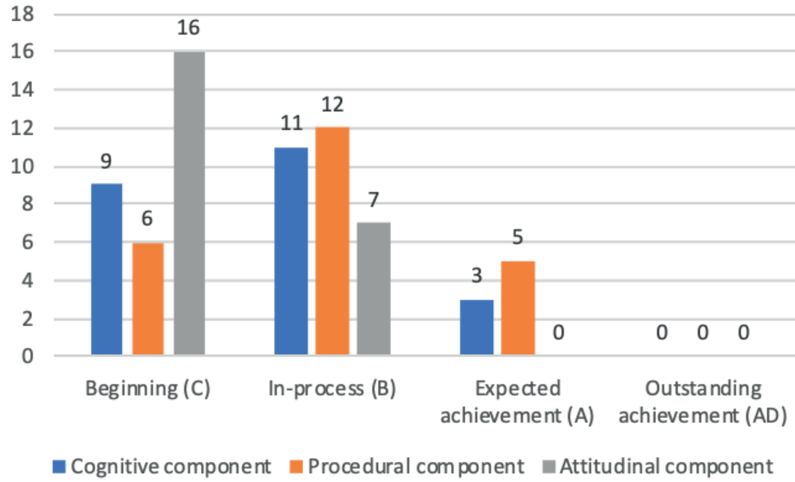
Figure 1
Pre-test development of competences



Source: Database of researchers.

Regarding the achievement of competences, in the pre-test, of the 23 students of the Systems Engineering Major, in the cognitive component, there are 9 students at the beginning level (C), 11 at the level of process (B), and 3 in the expected achievement level (A), in the outstanding achievement level (AD) there were no students. In the procedural component, there are 6 students at the beginning level (C), 12 at the in-process level (B), and 5 at the expected achievement level (A), and at the outstanding achievement level (AD) there were no students. And finally, in the attitudinal component, the scores are even lower, since there were 16 students at the beginning level (C), 7 at the in-process level (B), and no student at the expected achievement level (A) or Outstanding Achievement (AD), which was very concerning.

Now, the results will be appreciated in the dimension complex thinking.

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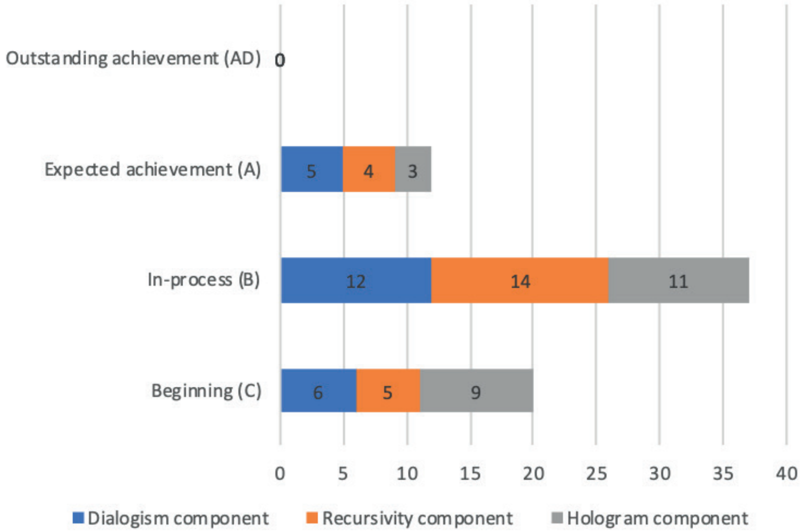
Figure 2
Pre-test development of complex thinking



Source: Database of researchers.

Regarding the levels of achievement of complex thinking, also in the pre-test before the application of the three didactic strategies, it was found that, of the 23 students of the Systems Engineering Major, in the dialogism component, there were 6 students in the beginning level (C), 12 in the in-process level (B), and 5 in the expected achievement level (A), in the outstanding achievement level (AD) there were no students. In the recursivity component, we had 5 students in the beginning level (C), 14 in the in-process level (B), and 4 in the expected achievement level (A), and in the outstanding achievement level (AD) we did not have any students. And finally, in the hologram component we had 9 students at the beginning level (C), 11 at the in-process level (B), and at the expected achievement level 3 students, and at the outstanding achievement level (AD) no students.

Let us now look at the results of the post-test, after the implementation of the three didactic strategies (problem-based strategy, collaborative learning strategies, and the strategy of incorporating information and communication technologies), planned in 15 learning sessions during the 2019-II cycle, the results of which are shown below:

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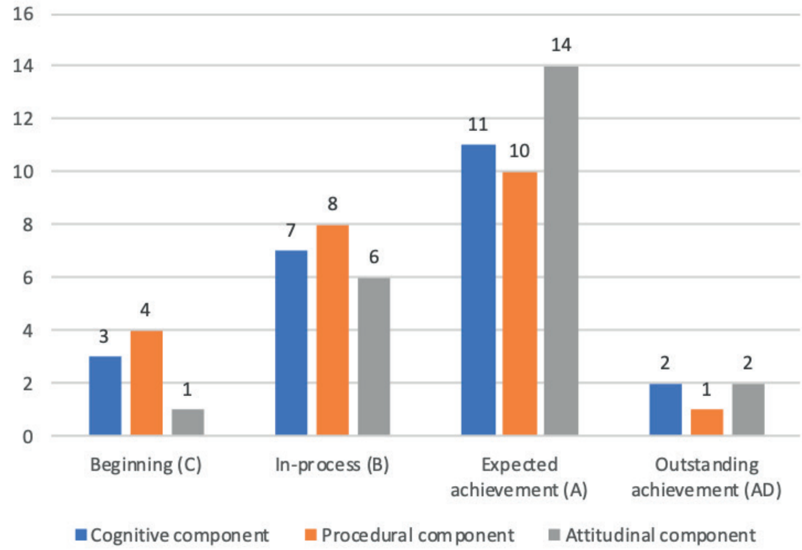
Figure 3
Post-test development of competences



Source: Database of the researchers

Regarding the achievement of the development of the competences, in the post-test, we got that form the 23 students of the Systems Engineering Major, in the cognitive component, there are 3 students in the beginning level (C), 7 in the in-process level (B), and 11 at the expected achievement level (A), and 2 students at the outstanding achievement level (AD), this being a good indicator of achievement. In the procedural component, there were 4 students at the beginning level (C), 8 at the in-process level (B), 10 at the expected achievement level (A), and at the outstanding achievement level (AD), only one student. And finally, in the attitudinal component, it is now even better, since there was 1 student in the beginning level (C), 6 in the in-process level (B), 14 students in the expected achievement level (A) and 2 students in the Outstanding Achievement Level (AD).

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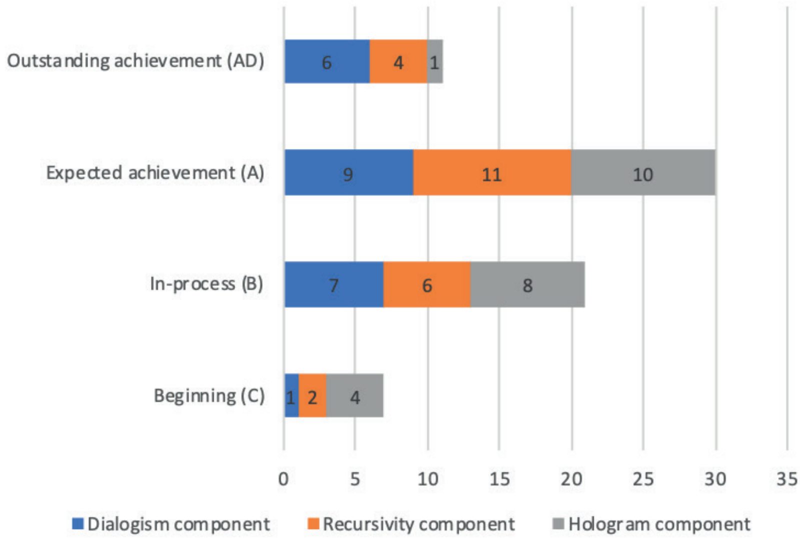
Figure 4
Post-test development of complex thinking



Source: Database of the researchers

Regarding the levels of achievement of complex thinking, also in the post-test after the application of the three didactic strategies, it was found that, of the 23 students of the Systems Engineering Major, in the dialogism component, there was 1 student in the starting level (C), 7 at the in-process level (B), 9 at the expected achievement level (A), and at the outstanding achievement level (AD) there were 6 students, which is very favorable. In the recursivity component, we had 2 students in the beginning level (C), 6 in the in-process level (B), 11 in the expected achievement level (A), and in the outstanding achievement level (AD) we had 4 students. And finally, in the hologram component we had 4 students in the beginning level (C), 8 in the process level (B), in the expected achievement level 10 students, and in the outstanding achievement level (AD) a single student.

However, with regard to the general hypothesis test, the Wilcoxon statistic was used.

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Table 1
Mann-Whitney Test. Ranks

	Group	N	Mean Rank	Sum of Ranks
Evaluation	Pre-test	23	90.64	16315.50
	Post-test	23	270.36	48664.50
	Total	46		

Test Statistics

	Evaluation
Mann-Whitney U	25.500
Wilcoxon W	1315.500
Z	-16.476
Asymp. Sig. (2-tailed)	.006

a Grouping Variable: Group

The contrast of general hypothesis.

Null hypothesis: H_o: The application of didactic strategies does not produce significant effects on the development of competences and complex thinking in students of the Systems Engineering Major at the National University of Cañete.

Alternate hypothesis: H_1: The application of didactic strategies produces significant effects in the development of competences and complex thinking in students of the Systems Engineering Major at the National University of Cañete.

Level of significance or risk: α = 0.05 or 5%

Test statistic calculation: N = 23, Wilcoxon W = 1350

Statistical decision: Since (p-value: 0.006 <0.050), consequently, the null hypothesis (H_o) is rejected and the alternative hypothesis (H_i) is accepted.

Statistical conclusion: It is concluded that the application of the didactic strategies has produced favorable and significant effects in the development of competences and complex thinking in the students of the Systems Engineering Major at the National University of Cañete.

Discussion and conclusions

As can be seen from the statistical tables, three teaching strategies have been used as a independent variable (problem-based strategy, collabo-

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rative learning strategies, and the embedding ICT strategy), it has thus been possible to demonstrate its results in the dependent variable which is the development of competences and complex thinking, the results of which are favorable by comparing the pre and post-test respectively. In this sense, the assessment of learning for Villarroel and Bruna (2019) "is one of the teaching practices that has shown the greatest impact on students' learning. The way in which they are evaluated shapes the quality of the results, skills and competences that apprentices will achieve (p. 501).

Likewise, learning is related to making use of knowledge for something. This can be the understanding of a social phenomenon, the resolution of a disciplinary problem, or the evaluation of the quality or effectiveness of a product.

Definitively, according to Manzanares and Santamaría (2016) the way in which one evaluates students is crucial at the moment of measuring, making an assessment and making decisions, as mentioned.

According to Kerlinger and Lee (2002), in the experience of measuring competence development, the pedagogical test was first used to measure the cognitive component, then a rubric was used for the procedural component, and, finally for the attitudinal component the attitude scale was used. And for the complex thinking sub variable, an inventory was used, all of which compulsorily passed through the reliability and validity criteria prior to their application.

Now, as there was a significant improvement, according to Barberousse (2007), "theoretical production is never an attempt at finished achievement, but rather a process that, in its very transformation, marks a cognitive course in which we are invited to participate" (p. 9). His work must therefore be understood not only in terms of its content, but also of its production process.

From this point of view, there is an urgent need to innovate the evaluation process, but with theoretical support that demands a holistic activity involving all educational actors, which in our case is the National University of Cañete.

Now, while it is true for Murray (1995) "in teaching, the teacher must not develop an intervention characterized by its one-way relationship in which the only voice" to be heard is that of the teacher himself, but must give rise to the student's voice (p.154). This is nothing other than the manifestation of his ability to think and construct meanings, just as in the process of evaluation, the pupil must find a place to express meanings from his own perspective.

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Taking into account this complex process of education and the classroom-mind-social vision as a central element of a new didactic vision of education, which breaks with traditional teaching and learning models, it incorporated a new element, the *educational loop*, that is, the back and forth element of any learning and teaching process. There are processes of variable educational change that lead the student to learn, unlearn and relearn knowledge.

For Gonzales (2002) the classroom-mind-social is in itself a loop, which in educational complexity allows the setting of models of meta complex classroom planning with spiral forms, iconic, circular, double icon, and others. Beyond the simple or reductionist model of conducting a conventional class.

Based on the statistical data there is sufficient evidence to affirm that the use of didactic strategies, have been favorable to promote the development of competences and also complex thinking in the classroom, In this sense, Trigos (2011) concludes that these strategies correspond to the need for transversality in integral learning and formation. Thus, at present, the University of Rosario has common competence programs in the areas of language, logic-mathematics and ethics, which are taught in the first semesters of undergraduate studies through the Rosarist Training Core and Basic Core.

However, it is expected that the subjects that students take throughout their careers will promote and strengthen these initial competences, so that the student will gain in complexity and dexterity over time in the higher cycles. Something similar happened at the beginning, in the Professional Career of Systems Engineering of the National University of Cañete, where the subjects of the 2016 curriculum have promoted and strengthened the general competences of the career profile. In addition, they have helped students of the last cycle to consolidate in their training the complexity and skill with respect to the profile of the graduate in the last cycles of the career.

For Ordoñez, et al. (2011):

> Bringing to the classroom the advances of research on learning, the needs and challenges of current life and the professional field, the questions about the complexity of reality and the use of ICT are some of the elements that have been considered in this project, in addition to proposals for new approaches to evaluation. The contribution of teachers is their reflection on the impact that innovation on their teaching practices has had on the achievement of meaningful learning by tea-

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chers and, at the same time, the explicit process for transferring their experience (p. 205).

Problem-based strategies, cooperative learning and the use of ICT in the university classroom, specifically in the Systems Engineering Career, have had a positive impact, not only in terms of academic achievement, but also in skills and abilities specific to the profession, also without neglecting the attitudinal aspect, added to the holistic training of problem solving, through experimentation itself.

Conclusions

It has been demonstrated with a level of significance of 5%, that the didactic strategies have favored significantly (p-value: 0.0060,050) the development of the competences (74%) and the complex thought (64.25%) in the students of the Professional Career of Systems Engineering of the National University of Cañete in Lima-Peru.

It has been determined that the problem-based teaching strategy has benefited significantly (p-value: 0.0080,050) the development of competences and complex thinking in students of the Professional Career in Systems Engineering of the National University of Cañete in Lima-Peru.

It has also been determined that the collaborative learning strategy has benefited significantly (p-value: 0.0000.010) the development of competences and complex thinking in students of the Professional Career in Systems Engineering of the National University of Cañete in Lima-Peru.

And finally, it has also been determined that, the incorporation of information and communication technologies has favored significantly (p-value: 0.0000,010) the development of the competences and complex thinking of the students of the Professional Career in Systems Engineering of the National University of Cañete in Lima-Peru.

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