Ride Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

Análisis correlacional de competencias matemáticas de pruebas estandarizadas y pre-requisitos matemáticos en estudiantes de nuevo ingreso a Ingeniería en Computación

Correlational analysis of mathematical competences of standardized tests and mathematical prerequisites in students of new entrance to Computer Engineering

Análise de correlação de competências matemáticas de testes padronizados e pré-requisitos matemáticos em novos alunos para engenheiro de informática

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Resumen

El presente trabajo muestra los datos de correlación acerca del razonamiento verbal, lógico matemático, pensamiento analítico y pensamiento funcional, consideradas como competencias matemáticas en pruebas estandarizadas, con respecto al conocimiento matemático inicial que marcan los programas de estudio para alumnos de nuevo ingreso a la carrera de Ingeniería en Computación del Centro Universitario Valle de Chalco, de la Universidad Autónoma del Estado de México, en el 2017, provenientes de diferentes instituciones educativas de nivel medio superior del Estado de México. Se tomaron los resultados del examen de ingreso a licenciatura (EXANI II) del CENEVAL, de Planea para la localidad de Valle de Chalco y de PISA, y se correlacionaron con un instrumento diagnóstico de 29 ítems que incluye los prerrequisitos que marcan los programas de estudio de las materias de primer semestre del área de matemáticas; se evaluaron conocimientos básicos de aritmética, álgebra, geometría analítica y cálculo diferencial; se consideró a 50% de la población de alumnos de ingeniería. Existe una diferencia significativa entre los conocimientos en matemáticas que se requieren para ingreso a ingeniería y los contenidos en el EXANI, valorados por medio de una correlación de Pearson y la comparación de medias por t de student. En todos los instrumentos se obtuvo un bajo nivel operativo de los estudiantes en el área de matemáticas, lo cual indica que las estrategias aplicadas en la trayectoria académica del alumno hasta el nivel medio superior no han favorecido su desarrollo; en ese sentido, se recomiendan actividades didácticas empleando tecnología diseñadas con la intención de favorecer el aprendizaje significativo y conceptual, para fomentar un desempeño más acorde con las características de la carrera profesional.

Palabras clave: competencias, estudiante universitario, ingeniería, matemáticas.

Abstract

The present work shows the correlation data about verbal reasoning, mathematical logic, analytical thinking and functional thinking, considered as mathematical competences in standardized tests, with respect to the initial mathematical knowledge that mark the curricula for students entering the race again of Engineering in Computing of the Centro Universitario Valle de Chalco, of the Universidad Autónoma del Estado de México, in 2017, coming from different educational institutions of middle level superior of the State of Mexico. The results of the CENEVAL undergraduate entrance exam, from PLANEA for Valle de Chalco and from PISA, were taken and correlated with a 29-item diagnostic tool that includes the prerequisites of the curricula of the subjects of the first semester of the area of mathematics; basic knowledge of arithmetic, algebra, analytical geometry and differential calculus was evaluated; 50% of the population of engineering students was considered. There is a significant difference between the knowledge in mathematics required for entrance to engineering and the contents in the EXANI, assessed by means of a Pearson correlation and a comparison of means by t student. In all the instruments a low operational level of the students in the area of mathematics is obtained, which indicates that the strategies applied in the academic trajectory of the student to the average superior level have not favored its development; in this sense, it is recommended to use didactic activities using technology designed with the intention of favoring meaningful and conceptual learning, and thus to promote a performance more in line with the characteristics of the professional degree.

Keywords: competencies, university student, engineering, mathematics.

Resumo

Este artigo mostra os dados de correlação sobre raciocínio verbal, lógica matemática, pensamento analítico e pensamento funcional, considerados como competências matemáticas em testes padronizados, em relação ao conhecimento matemático inicial que marca os programas de estudo para novos alunos que entram na corrida de Engenharia Informática do Centro Universitário Valle de Chalco, da Universidade Autônoma do Estado do México, em 2017, de diferentes instituições de ensino superior do Estado do México. Foram realizados os resultados do exame de admissão ao curso de graduação (EXANI II) do CENEVAL, do Plano para a localidade de Valle de Chalco e do PISA e correlacionados com um instrumento de diagnóstico de 29 itens que inclui os pré-requisitos que marcam os programas de estudo dos assuntos do primeiro semestre da área de matemática; conhecimentos básicos de aritmética, álgebra, geometria analítica e cálculo diferencial; Foram considerados 50% da população de estudantes de engenharia. Existe uma diferença significativa entre o conhecimento em matemática exigido para a entrada na engenharia e os conteúdos na EXANI, avaliado por meio de uma correlação de Pearson e a comparação dos meios por estudante t. Em todos os instrumentos, obteve-se um baixo nível de operação do aluno na área de matemática, o que indica que as estratégias aplicadas na trajetória acadêmica do aluno até o ensino médio não favoreceram seu desenvolvimento; Nesse sentido, as atividades didáticas são recomendadas usando a tecnologia projetada com a intenção de favorecer a aprendizagem significativa e conceitual, para encorajar uma performance mais adequada às características da carreira profissional.

Palavras-chave: competências, estudantes universitários, engenharia, matemática.

Fecha Recepción: Enero 2017 **Fecha Aceptación:** Julio 2017

Introduction

One of the main objectives of education is to train autonomous students who are able to direct their own experience to generate learning, but the reality is generating a paradox, in which the student complains that the classes are uninteresting and encouraging and, On the other hand, the teacher complains about lack of interest and knowledge of the student (Narváez, 2005). In January 2008, the Undersecretary of Higher Secondary Education of the Public Education Secretariat of Mexico published the documents "Generic Competences and Graduate Profile of Higher Secondary Education", in which they establish the characteristics that a graduate of the average system must have, indicating that they must have a series of "competences that contribute to the development of their capacity to deploy their potential, both for their personal development and for that of society", which is why it is essential to have a constructivist approach based on competencies (SEP, 2008).

This educational policy that guides upper secondary education runs into disappointing results when the knowledge of students at that level is evaluated in standardized tests at a national and international level, such as the recent results of the Planea test (2017).), which as expressed by the SEP "are higher standards than the previous tests, in line with the goals proposed by the new Educational Reform in Mexico" (National Institute for Educational Evaluation [INEE], 2017). The INEE indicates that these results are not comparable with the Planea 2015 and Planea 2016 tests. Although PLANEA 2017 is, like the two previous ones, a standardized test, with multiple choice reagents aimed at the students who attend the last semester of the baccalaureate in In the school modality, this instrument introduced a new grading scale and new cut-off points to categorize the results into four more stringent performance levels than those previously used, obtaining again results below the expected ones. In this way, the test explores a greater number of areas of knowledge than in the past and its assembly, application and qualification schemes were also transformed. In Language and Communication, the national average reached in 2015 by the students evaluated was 496 points, while in 2017 it was 500; that is, an improvement of 4 points was registered (the scale is from 200 to 800 with an average of 500 points). Also, in the case of Mathematics, the average score in 2015 was 498 and in 2017 500 points, with an increase of two points (INEE, 2017).

The data from the PLANEA 2017 test show that upper secondary students in the field of Communication and Language are distributed homogeneously in the first three levels of achievement (33.9% in level I, 28.1% in level II , 28.7% in level III and 9.2% in level IV); while this does not happen in mathematics, where about two-thirds of students concentrate on the lowest level of performance. This indicates a generalized problem of low levels of learning, according to the standards of the test (INEE, 2017).

Something similar happens with the evaluation of PISA 2015, where the performance of Mexico is below the average of the member countries of the Organization for Economic Cooperation and Development (OECD) in sciences (416 points), reading (423 points) and mathematics (408 points). In these three areas, less than 1% of students in Mexico achieve excellence levels of competence (level 5 and 6). On average, performance in mathematics improved by 5 points for every three years between 2003 and 2015, but the 2015 average is below that of 2009 (419 points). Students in Mexico declare high levels of interest in science, which is identified through their expectations of having a professional career in this area, in the importance of scientific research, or their motivation to learn science; however, these positive attitudes are weakly associated with the performance of students in mathematics (OECD, 2015).

On the other hand, the OECD's Panorama of Education 2017 report, which presents figures up to 2016, shows that the proportion of young adults who finished their high school education increased from 20% to 25%, and the proportion that completed education higher was increased from 17% to 22%. This indicates that the policy of raising compulsory education at the high school level decreed in the 2012-2013 school year caused the State to acquire the obligation to "offer a place to study those who, having the typical age, had completed basic education" (INEE, 2015), which led to a greater increase in coverage and inclusion, since educational attention was provided to almost 5.5 million students, which resulted in a total coverage rate of 82%. Only in the school modality, in the last four school years, coverage increased 10.7 percentage points, from 65.9% to 76.6%. On the other hand, in higher education, between 2012 and the 2016-2017 cycle, the increase in total coverage was 5.2 percentage points, from 32.1% to 37.3%; as well as technological and engineering careers were encouraged (OCDE, 2017).

According to the OECD, "it is considered that Tertiary Education plays an essential role in the promotion of knowledge and innovation, both fundamental to maintain economic growth. Several governments of the OECD countries have placed special emphasis on improving the quality of education in science, technology, engineering and mathematics, reflecting the importance of these disciplines to boost economic progress, support innovation and lay the foundations for a true prosperity. In addition, advanced scientific skills and competencies such as critical thinking, problem solving and creativity are considered fundamental to success in the labor market, regardless of the final occupation of the students "(OECD, 2017). Although each institution per country determines the entry mechanisms at the university level, most agree to contemplate the results of a general entrance examination and the academic record of the senior high school aspirant.

At the Autonomous University of the State of Mexico, the entry mechanism at the higher level is the EXANI II, a test of academic aptitude that assesses intellectual skills and specific knowledge, considered basic and essential to begin higher education studies. It is applied to applicants to enter the level of higher education in institutions that have hired the services of CENEVAL, and does not apply to individual applicants. For the purpose for which the instrument was designed, approximately 50% of its contents assess intellectual skills (SEP, 2017). Derived from the skills that are sought to develop in students of the career in Computer Engineering, interest is related to mathematics. At first, since the way of reading and interpreting the questions in the area of mathematics requires translation, interpretation and solution processes. While in the second moment, corresponds to knowledge and skills that are of special interest for engineering, so it is included: rational thinking, analytical thinking, functional thinking and two specific modules of mathematics and physics.

In this way, the results related to these tests will be analyzed: Plan, PISA and EXANI II, related to new students entering the career of Computer Engineering, and later the specific requirements that mark the study plans of the subjects of First semester mathematics: Analytical Geometry, Algebra, Probability and Statistics and differential and integral calculus, to correlate results.

Development

The learning process will depend on each one as an individual and on the processes themselves to focus, process, internalize and recall information to develop new academic skills; This dynamic will depend on the type of education that is determined, where the student can be a passive or active entity and face cognitive challenges (Aparicio, 2004, García, 2002, Lejter, 2000, Bruno, 2006). There are a large number of references, from a couple of decades ago, which indicate that the learning sought in the student is constructivist, that learns from their own experiences (Padilla, 2003, Aristegui, 1999) solving their own problems and face different challenges through their abilities to achieve a type of learning that has meaning in the process of cognitive development, and is related to other particular biopsychosocial factors of the individual (Narváez, 2005; Padilla, 2006; Viera, 2003).

PISA

This concern for the skills of students embodied in the teaching of mathematics has been around for many years and is a problem at the international level; in fact, PISA since 2007 defines mathematical competence as "the ability of an individual to identify and understand the role of mathematics in today's world, to make well-founded judgments and to use them and to commit to them in a way that can meet the needs of the life of the subject as a constructive, committed and reflective citizen "(INEE, 2012). The mathematical competence of PISA is not limited to the mastery of terminology, data and mathematical procedures, or the ability to perform various operations and implement certain methods; Mathematical competence involves a combination of these elements in order to respond to demands that arise in real contexts. It implies having the ability to pose, formulate and interpret problems through mathematics in a variety of situations and contexts that range from the simple to the complex (INEE, 2012).

Hence, international standardized tests, such as PISA, seek with the evaluation to determine if students can reproduce what they have learned, but also examine how they can extrapolate what they have learned and apply that knowledge in unknown circumstances, both inside and outside of the school; that is, if they acquire mathematical competence. In Mexico, this concept has been handled as competition and defined as "a complex system of action that encompasses intellectual abilities, attitudes and other non-cognitive elements, such as motivation and values, that are acquired and developed by individuals throughout life. their lives and are indispensable to participate effectively in diverse social contexts "(INEE, 2012). This approach reflects the fact that modern economies reward individuals not for what they know, but for what they can do with what they know. The conclusions of the PISA studies (2015) allow policy makers around the world to measure the knowledge and skills of students in their own countries compared to students from other countries, set educational policy goals with reference to measurable objectives achieved by other educational systems and learn from the policies and practices applied elsewhere. The processes that the student must perform correspond with three degrees of complexity:

1. In the processes that PISA calls reproduction, it works with common operations, simple calculations and problems of the immediate environment and the daily routine.

2. Connection processes involve mathematical ideas and procedures for the solution of problems that can no longer be defined as ordinary but still include family scenarios; they also involve the development of models for solving problems.

3. The third type of processes, those of reflection, involve the solution of complex problems and the development of an original mathematical approach. To do this, students must mathematise or conceptualize situations.

In these processes, as formulated by the INEE, students are required to "recognize and extract the mathematics contained in the situation" (OECD, 2009). The contents of the mathematical competence assessment cover problems of quantity, space and form, change and relationships and probability. The mathematical problems that arise are located in different contexts or situations. In this case, there are four different situations: personal situation, related to the immediate context of the students and their daily activities; educational or work situation, related to school or work environment; public situation, related to the community; the scientific situation, which involves the analysis of technological processes or specifically mathematical situations (OECD, 2009).

To carry out the evaluation in the area of mathematics, six levels of competence have been established both in the combined scale and in the subscales that refer to the particular components: quantity, space and form, change and probability relations. The levels of the combined scale are defined as follows:

- Level 6 (more than 668 points). Students who reach this level are able to conceptualize, generalize and use information based on their research and in their elaboration of models to solve complex problems. They can relate different sources of information. They demonstrate advanced mathematical thought and reasoning. They can apply their knowledge and skills in mathematics to face novel situations. They can formulate and communicate their actions and reflections with precision.

- Level 5 (from 607 to 668 points). At this level students can develop and work with models for complex situations. They can select, compare and evaluate appropriate strategies for solving complex problems related to these models. They can work strategically by broadly using well-developed reasoning skills, association representations, and symbolic and formal characterizations.

- Level 4 (from 545 to 606 points). Students are able to work effectively with explicit models for specific complex situations. They can select and integrate different representations, including symbols and associating them directly to real-world situations. They can use well-developed skills and reason flexibly with some understanding in these contexts. They can construct and communicate explanations and arguments.

- Level 3 (from 483 to 544 points). Those who are at this level are able to execute clearly described procedures, including those that require sequential decisions. They can select and apply simple problem-solving strategies. They can interpret and use representations based on different sources of information, as well as reason directly from them. They can generate brief communications to report their interpretations.

- Level 2 (from 421 to 482 points). At the second level, students can interpret and recognize situations in contexts that require only direct inferences. They can extract relevant information from a single source and make use of only one type of representation. They can use algorithms, formulas, conventions or basic procedures. They are able to make literal interpretations of the results.

- Level 1 (from 358 to 420 points). Students are able to answer questions that involve family contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and develop routine procedures according to direct instructions in explicit situations. They can carry out actions that are obvious and follow them immediately from a stimulus.

- Below level 1 (less than 358 points). These are students who are not able to perform the most elementary math tasks that PISA requires.

In the PISA reports, on average in the OECD countries, almost one in four students (23%) does not reach the basic level of competence (Level 2) in mathematics. Students who do not reach this level can from time to time perform routine procedures, such as arithmetic operations in situations where all instructions are given to them, but have problems identifying how a (simple) real-world situation can be represented mathematically (for example, compare the total distance between two alternative routes, or convert prices to a different currency). The proportion of Mexican students who do not reach the minimum level of competence remained stable between 2003 and 2015 (PISA, 2015). In this 2015 report, the assessment focuses on basic school subjects in science, reading and mathematics. The capacities of the students in an innovative field are also evaluated (in 2015, this area was the collaborative problem solving).

PLANEA

Inscribed in the National Apprenticeship Evaluation Plan designed by INEE, the Planea Media Superior (Plan MS) 2016 test is intended to inform society about the state of education, in terms of student learning achievement. , in two areas of competence: Language and Communication (Reading Comprehension) and Mathematics. The test is aimed at students throughout the Mexican Republic enrolled in schools that show interest in participating in the application of Planea MS with an annual periodicity. Students must complete their last cycle of baccalaureate (semester, semester, year, etc.) in school mode, in the different subsystems and modalities of High School (EMS). Institutions can be both public and private support. It is an individual diagnostic evaluation consisting of 110 multiple-choice items, the result of which is used for feedback purposes and allows knowing the level of proficiency of the supporter in competence indicators associated with the areas that the test evaluates. MS Planning is a test that focuses on a limited set of knowledge and skills that a group of experts considers sufficient and representative indicators of the basic disciplinary competences that, ideally, should dominate the supporters (INEE, 2016).

The pedagogical approach by competences recognizes that to the solution of each type of mathematical problem correspond different knowledge and skills, and the deployment of different values and attitudes. Therefore, students must reason mathematically, and not simply respond to certain types of problems by repeating established procedures. This implies that they can take the applications of this discipline beyond the classroom. Of the eight competences of the Competency-Centered Model for Mathematics, the following six were chosen:

- Interprets mathematical models through the application of arithmetic, algebraic, geometric and variational procedures for the understanding and analysis of real, hypothetical or formal situations.
- Solve mathematical problems, applying different approaches.
- Interprets the data obtained through mathematical procedures and contrasts them with established models or real situations.
- Analyze the relationships between two or more variables of a social or natural process to determine or approximate their behavior.
- Quantifies and mathematically represents the magnitudes of space and the physical properties of the objects that surround it.
- Read tables, graphs, maps, diagrams and texts with mathematical and scientific symbols.

The Mathematics Test of Planea MS evaluates the ability of an individual to identify, interpret, apply, synthesize and mathematically evaluate their environment, making use of their creativity and a logical and critical thinking that allows them to solve quantitative problems with different mathematical tools. The mathematical capacity that evaluates the test is crystallized in reagents associated with arithmetic, geometric and algebraic contents that are considered the minimum indispensable for the supporters at the end of the baccalaureate and that are categorized in: quantity, space and form and changes and relationships, with the cognitive processes of reproduction, connection and reflection. These categories are similar to those of PISA. Four levels of domain are established (CENEVAL, 2016):

1. Students who are at this level of achievement demonstrate deficiencies in the development of knowledge and skills related to the basic disciplinary skills expected of graduates of upper secondary education; In addition, they still have difficulty performing the tasks indicated in levels 2, 3 and 4, since they only show ability to solve direct problems that require basic operations with integers and identify graphic elements.

2. Students who are at this level of achievement are able to apply simple arithmetic and geometric procedures to understand different situations similar to those studied in the classroom, in addition to the identification of spatial relationships. They carry out operations with fractions, percentages or with signs of grouping; graphically represent series of numbers, or describe the behavior of numerical sequences and the relationship between them. They transform mathematical models of algebraic or geometric nature when they enunciate an algebraic expression in a common language and vice versa, as well as solving two-dimensional and three-dimensional geometric problems that involve transformations and the management of the elements of the figures. They solve systems of equations and identify the combination of procedures necessary to solve different exercises. However, they still show a poor command of the tasks indicated in levels 3 and 4.

3. In addition to mastering the knowledge and skills of level 2, students who are at this level of achievement are able to analyze the relationships between two or more variables of a contextualized problem to estimate or obtain a result. They solve problems related to social or natural processes that involve variables and physical units, and perform calculations with reasons and proportions. Solve mathematical problems by applying different approaches, whether they require the posing of equations, the application of the Pythagorean theorem or concepts such as the least common multiple and the greatest common divisor, or require estimating solutions for arithmetic, geometric or variational problems. In addition, they extract information from tables or graphs to solve problems that involve operations. However, they still show a poor command of the tasks indicated in level 4.

4. In addition to mastering the knowledge and skills of levels 1 and 2, students who are at this level of achievement are able to assess the environment and integrate the data obtained through different mathematical procedures, to contrast them with established models or real situations . They read and interpret tables, graphs and textual information when they solve contextualized problems that require estimates, conversions, analysis of graphic information or successions. They quantify and mathematically represent the magnitudes of space to solve problems involving the handling of plane and three-dimensional figures, as well as the geometrical properties of incomplete figures. Additionally, they perform calculations from two linear or quadratic functions that are displayed independently and through numerical, textual, graphic or tabular representations.

In the 2016 results of Planea MS for the municipality of Valle de Chalco, where the institutions of the study subjects and part of the sample belong, it is found that 72% are in level 1, 20% in level 2, 8% in level 3 and none at level 4. These results agree with those obtained at the national level where 49.2% is at level 1, 30% at level 2, 14.4% at level 3 and 6.3% at level 4. Since its conception, the test is useful to know the strengths and areas of opportunity that students exhibit in what was defined operationally as part of the evaluation in Mathematics (CENEVAL, 2016).

EXANI

In another different context is the EXANI II, a standardized test of national academic aptitude that evaluates the intellectual skills and the basic and essential knowledge to initiate higher education studies. Being a service that higher education institutions hire CENEVAL, the results are confidential for each school in order to establish the level of potential of an individual to achieve new learning; although the results are provided individually to each participant with the intention that they estimate the areas of opportunity that they must attack for a good performance in the university environment. In the case of admission to any career, the following competences are considered: Mathematical thinking (PM), Analytical thinking (PA), Language structure (EL), Reading comprehension (CL), Written language (LE) e English (IN), while for the particular case of Computer Engineering, two more modules are added: Mathematics (MOD01) and Physics (MOD02). For the purposes of this study, we will concentrate on: Mathematical thinking, analytical thinking and mathematics, to get closer to the indicators of the competences of the other standardized instruments (PISA and Plan).

The EXANI II evaluates the ability of knowledge and identification of information and specific contents; also, the capacity for systematization and integration through the use of formulas, rules or theories, contemplating synoptic diagrams or charts or, alternatively, the classification, ordering or grouping of information; Finally, it also investigates the competence of interpretation and application through situations that require finding an appropriate strategy to make inferences, draw conclusions and solve problems. In particular, the Mathematical Thinking area explores the competence to understand and solve situations that involve the use of arithmetic, algebraic, statistical and probabilistic, and geometric reasoning strategies. That is, it covers the set of knowledge and skills of the mathematical field that should have been learned and mastered in higher secondary education (EMS). In the area of analytical thinking the applicant must demonstrate his competence at an intermediate level to integrate and analyze textual and graphic information; he must also be able to understand and interpret logical relationships and patterns, as well as recognize and analyze coincidences in the spatial representation of objects in different planes. The Language structure area evaluates the ability to identify and apply elements of the language that allow the creation and organization of meaningful messages. The reading comprehension area demands to understand explicit and implicit information in narrative and informative texts, as well as its purpose, characteristics and language.

Finally, for the areas of Written Language, English, Mathematics and Physics they evaluate the level of performance of the candidates to recognize, understand and solve approaches in which they must apply the knowledge and skills acquired in the subjects of the EMS (CENEVAL, 2017). It is feasible to observe that what PISA and Plan specifies as Mathematical Competences correspond to what the EXANI II is establishing as analysis categories. The EXANI does not establish performance levels but hits scores for a total of 200 items, distributed as follows: PM (19), PA (67), EL (7), CL (7), LE (30), IN (20)), MOD01 (35) and MOD02 (15).

In this context, and also emphasizing the need to develop certain mathematical competencies in upper secondary students, as marked by the National Council of Mathematics (NCTM 1989), the stages are determined to take a math student of this level from basic to advanced thinking, from concrete to abstract thinking. In this regard, Cuevas and Pluvinage (2017) establish the following stages of basic mathematical thinking from the cognitive point of view:

- Arithmetic thinking, which corresponds to the knowledge of numbers and basic arithmetic operations (Kjeldsen and Petersen, 2014, Mouhayar and Jurdak, 2016).
- Advanced arithmetic thinking (proportions), which refers to more advanced numerical knowledge; that is, from the basic arithmetic operations the proportions and the handling of fractions are developed, including also the knowledge of magnitudes and elements of logical reasoning (Pluvinage and Cuevas, 2006).
- Algebraic thinking, which includes recognizing and analyzing patterns, studying and representing relationships, making generalizations and analyzing how things change. It also contains Mathematical Signal Systems (SMS); the resolution of equations and the handling of expressions that include variables and parameters. It is convenient to point out that the acquisition of this thought would facilitate the understanding of abstract symbolism and work with algebraic relationships (Filloy, Puig and Rojano, 2008, Lagrange, 2014, Seeley, 2004).

- Functional thinking, which is defined as a cognitive activity that allows establishing relationships of functional dependence, beyond the arithmetic and algebraic relationships that can be applied to various contexts and that is not related to the application of formulas. Even more, it is considered that to be able to interact in the current world and be able to develop in any of the diverse disciplines or sciences as basic, natural or social, functional thinking is required (Pluvinage y Cuevas, 2006).

Similarly, authors, such as García (2014), indicate that "... engineering is a reflexive-pragmatic discipline that tends to leave the theoretical foundation of the knowledge resources it uses to be developed by other disciplines, such as case of mathematics ".

So that in this broad context and to standardize the analysis, the four types of thinking will be established as units of analysis through an instrument that includes 29 items and was applied to 50% of the total number of new students entering the race of Computer Engineering at UAEM University Center Valle de Chalco; The results obtained were compared with the PISA, Plannea and EXANI II data for analysis.

Pretest

In order to evaluate school performance at the higher level in the first year university subjects: Analytical Geometry, Algebra, Probability and Statistics and differential and integral calculus, of the Computer Engineering degree, an evaluation instrument was designed to assess what these subjects mark as prerequisites in their study plans, forming 29 items divided according to the categorization of the four basic mathematical strata taken from the previous classification (Cuevas and Pluvinage, 2017): arithmetic, advanced arithmetic, algebraic and the functional These strata determine the basic knowledge (mathematical requirements) that a student must master considering his level of studies and his degree of maturity. For the analysis, each question was assigned a value of 1 (correct), 2 (incorrect), 3 (no answer) and 4 (another solution). This instrument has evolved over several years of application and feedback since 2006 and has been subject to validity and reliability tests (Martínez, Soberanes and Castillo, 2016). The results for the group taken as a sample will be presented immediately and compared with the results of the standardized tests.

Method

The concern to analyze the mathematical competences of the students that graduate from the high school level and enter the superior is shared by a broad community; It is possible to find in different forums the studies that different institutions carry out in order to have a starting point for university teaching. For example, Rico (2007) makes an interesting analysis of the competences specified in the PISA test of 2007 and that have been maintained and enriched over the years; for this reason, in this study the competences specified in the three standardized tests PISA, EXANI and Plannea were resumed, to show their similarity. However, they do not provide a common framework for analysis, so they were included in the levels of Arithmetic Thought, Algebraic Thought and Functional Thought.

In the same sense, the concern to measure the mathematical competences through the national entrance exams, that determine a place in the universities, is generalized. For example, we find studies such as those of Larrazolo, Backhoff and Tirado (2013) that measure 45 mathematical competences of the Skills and Basic Knowledge Examination (Exhcoba), used in the admission processes of 2006 and 2007 for the state universities of Querétaro, Nayarit , Sonora, Guanajuato and Baja California, where the results confirm that the students: have a very low utilization; they do not understand the basic concepts of mathematics; they do not have the skills to solve numerical problems of medium complexity and the acquired knowledge is related to the memorization of algorithms. Therefore, in this study we took additional indicators extending this type of studies, relating PISA, Plan MS and EXANI II and a diagnostic pretest of the new admission group, to correlate results.

On the other hand, Villalón, Medina and Bravo (2015) carry out a study to determine the previous mathematical competences of the students of ten Engineering in the Technological Institute of Celaya, comparing the demand of desirable previous competences in the new students with the competences that they really possess, with the intention that the information serves as an input to measure the average distance between an income profile closer to reality and the educational level requested by the institution. The authors elaborate an examination of 20 questions that considers the necessary mathematical competences of the aspirants, applied to 200 students of high school level who seek to enter the Technological Institute of Celaya; the exam is based on the contents proposed by Ceneval for the EXANI II that apply for the selection of applicants to enter the institution; the authors found that the students lack the level of previous mathematical competences, so they proposed a pre-calculus workshop in the upper middle levels to attack this problem. So, following this line of exploration, in our study we developed the Pretest with the intention of measuring the mathematical competences, but from the conceptual framework of the levels of thought as a measure to homogenize between what Planea MS, PISA and EXANI requests as Mathematical competences

The results of the EXANI II, entrance examination of CENEVAL, of new students to the Computer Engineering career of the Valle de Chalco University Center of the Autonomous University of the State of Mexico for the period of 2017 were taken. The students are graduates of different educational institutions of EMS of the municipality of Valle de Chalco and the metropolitan area, of which the results of the application of Planea MS 2016 are had. These results were correlated with the instrument called Pretest, which consisted of 29 items and which evaluated the basic knowledge of arithmetic, algebra and functional relationship; the answer options for each item were classified as correct, incorrect and no answer or other solution, 50% of the population of Computer Engineering students was considered. The correlation calculation was made through Pearson's statistician to measure the level of correlation of each of the categories contemplated in EXANI II and Pretest, to determine if the same contents are being evaluated. In addition, a comparison of the means with a student's t is made to determine the level of relationship of the contents of both tests and in this way support the conclusions about the discrepancy or similarity; both statistics are made through statistical software SPSS.

Results

Table 1 represents the grades obtained from the graduates of the upper level of the exam performed by CENEVAL, EXANI II, by areas of competence: Mathematical Thought (PM), Analytical Thought (PA), Language structure (EL) and Mathematics (MOD01); and Pretest results in its modules of: Arithmetic Thinking (PPA), Algebraic Thinking (PPAL) and Functional Thinking (PPF), according to their indicators, on a scale of 1 to 10.

Tabla 1. Calificaciones del EXANI II.

	Mínimo	Máximo	Media	Desviación típica
Pensamiento Matemático (PM)	4.00	9.20	6.3107	1.18123
Pensamiento Analítico (PA)	4.00	9.10	6.2733	1.22275
Estructura del Lenguaje (EL)	2.00	8.40	4.9000	1.52157
Matemáticas (MOD01)	3.00	8.70	5.9767	1.29792
Pensamiento Aritmético (PPA)	1.43	10.00	4.7497	1.99137
Pensamiento Algebraico (PPAL)	1.11	8.89	4.2035	1.85630
Pensamiento funcional (PPF)	0.00	6.15	2.7442	1.45664

Fuente: Elaboración propia.

As can be seen in the EXANI II, there is a barely approving trend in PM, PA and MOD01. In PM, arithmetic reasoning is included with the management of basic operations and decimal and fractional numbers; proportionality relations; algebraic reasoning of operations with monomials and binomials, first and second degree equations, systems of equations and graphical representation of functions; statistical and probabilistic reasoning and geometric and trigonometric reasoning. In PA, the integration of information is handled from texts, graphs, maps, tables; interpretation of logical relationships; recognition of patterns through successions; spatial representation of figures and objects. In MOD01 arithmetic is included by problems with real numbers, scientific notation and management of proportions in intermediate level, algebra, linear and quadratic equations and operations with exponents and radicals, geometry, similarity management, areas, equations and slope, calculation corresponds to operations with functions, limits, derivatives and integrals.

On the other hand, for the similar contents that are contemplated in the Pretest, lower values are observed: the modules that contemplate algebra and arithmetic PPA and PPAL are close to 5, while the functional thinking PPF does not reach 3 and functional thinking is well below the scale.

Thus, to be able to relate all the contents are established in the three types of thinking: Arithmetic (PPA), Algebraic (PPAL) and Functional (PPF), and it is required to compare with the contents that is evaluating the EXANI II, which produces a first contradiction in terms of evaluation scales. If we now analyze the level of correlation between PM, PA, MOD01 with PPA, PPAL and PPF, using Pearson correlation, the results can be seen in Table 2.

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Table 2. Correlación de Pearson.

		PM	PA	EL	MOD01	PPA	PPAL	PPF
PM	Correlación de Pearson	1	**.351***	.119	**.427****	.120	.041	**-.310***
	Sig. (unilateral)		.029	.265	.009	.263	.414	.048
	N	30	30	30	30	30	30	30
PA	Correlación de Pearson	**.351***	1	.125	.198	.064	.098	.085
	Sig. (unilateral)	.029		.255	.148	.369	.304	.327
	N	30	30	30	30	30	30	30
EL	Correlación de Pearson	.119	.125	1	-.003	**.355***	.134	.172
	Sig. (unilateral)	.265	.255		.493	.027	.241	.182
	N	30	30	30	30	30	30	30
MOD01	Correlación de Pearson	**.427****	.198	-.003	1	.224	**-.312***	.095
	Sig. (unilateral)	.009	.148	.493		.117	.047	.308
	N	30	30	30	30	30	30	30
PPA	Correlación de Pearson	.120	.064	.355*	.224	1	.151	.244
	Sig. (unilateral)	.263	.369	.027	.117		.186	.073
	N	30	30	30	30	37	37	37
PPAL	Correlación de Pearson	.041	.098	.134	**-.312***	.151	1	.216
	Sig. (unilateral)	.414	.304	.241	.047	.186		.099
	N	30	30	30	30	37	37	37
PPF	Correlación de Pearson	**-.310***	.085	.172	.095	.244	.216	1
	Sig. (unilateral)	.048	.327	.182	.308	.073	.099	
	N	30	30	30	30	37	37	37

* *La correlación es significativa al nivel 0,05 (unilateral).*
** *La correlación es significante al nivel 0,01 (unilateral).*

Fuente: Elaboración propia.

Table 2 describes the Pearson correlations of each of the categories contemplated in EXANI II and Pretest, in which the little relationship stands out, even though the contents that both are evaluating are explicitly described and which confirms the initial contradiction in terms of evaluation scales. In particular, the only modules of both tests that have a significant relationship are the modules PM and MOD01 of the EXANI II when duplicating the type of content that is evaluating, and both include arithmetic and algebra, but it does not correlate with any module of the Pretest. . On the other hand, there is a minor but existing correlation between PM and MOD01 of the EXANI and PPF PPAL of the Pretest respectively. These results indicate that a deeper analysis of the contents must be developed, in order to establish or deny a true relationship between contents and qualifications, which we will do with the student's t (see Table 3).

Tabla 3. Diferencia relacionada entre el Pretest y el EXANI (categoría PM).

	Diferencias relacionadas Student							
				95% Intervalo de confianza para la diferencia				
	Media	Desviación típica	Error típico de la media	Inferior	Superior	t	gl	Sig. (bilateral)
PensaMat - Aritmética	1.59567	2.18711	.39931	.77898	2.41235	3.996	29	.000
PensaMat - Algebra	2.08900	2.23468	.40799	1.25456	2.92344	5.120	29	.000
PensaMat - Funcional	3.61847	2.02654	.36999	2.86174	4.37519	9.780	29	.000

Fuente: Elaboración propia.

For this analysis we considered the level of similarity of the means in the interval [3 - 4], and of inequality in the rest of the range. It can be seen that only the PPA is related to the PM, in terms of content. Table 4 presents the similar study for category MOD01

Tabla 4. Diferencia relacionada entre el Pretest y el EXANI (categoría MOD01).

	Diferencias relacionadas							
				95% Intervalo de confianza para la diferencia				
	Media	Desviación típica	Error típico de la media	Inferior	Superior	t	gl	Sig. (bilateral)
Matema - Aritmética	1.26167	2.11765	.38663	.47092	2.05241	3.263	29	.003
Matema - Algebra	1.75500	2.65474	.48469	.76371	2.74629	3.621	29	.001
Matema - Funcional	3.28447	1.76150	.32160	2.62671	3.94222	10.213	29	.000

Fuente: Elaboración propia.

For this analysis, the level of similarity of the means in the interval was maintained [3 - 4], and of inequality in the rest of the range. It can be seen that only the PPF is related to the MOD01 in terms of content.

From this exercise of analysis between specific contents that are asked in EXANI and Pretest, the disparity of reagents can be deduced, although they belong to the same subjects evaluated, which indicates that the investigation of what EXANI is asking must be done in greater depth. it corresponds to the mathematical competences that the same instrument says to evaluate and to those that are required of a new student of the career of Computer Engineering. In addition, if you include the other results of PISA and Plan, it becomes a sea of information that the teacher must process to start from a certain level of competence of their students, select the most appropriate strategies to reach the competencies they do not possess and achieve the objectives that the different subjects mark as expected learning by the students when concluding a first year university course.

Previously, the studies presented by Larrazolo et al. (2013) and Villalón et al. (2015) had shown that first-year university students, especially those in engineering, suffer from the mathematical competences evaluated in entrance examinations at the university level; with the present study, however, it is further deepened not only in the absence of the competence but in the dissimilarity of what is required as a mathematical competence in a new student and what these tests evaluate; the study is enriched by comparing what is understood in each standardized test PISA, Planea and EXANI as competence; and it is compared with the initial study by Rico (2007) that points out the importance of locating mathematical competences and looking for students to reach them according to their educational level. Therefore, located in this case a stage by levels of thought as shown by Cuevas et al. (2017), this framework serves as the basis for the analysis and design of the Pretest.

Conclusions

From the results of the standardized tests to measure the mathematical competences in upper secondary students, a similarity of scopes is observed. For example, according to the results of Plan 2015 for the Mathematics case, the national average score was 498 and in 2017 500 points, where close to two thirds of the students are concentrated in the lowest level of performance. In the 2016 results of Planea MS for the municipality of Valle de Chalco, where the institutions of the subjects of the sample belong, it is found that 72% are in level 1, 20% in level 2, 8% in level 3 and none in level 4; the same happens if we review the national levels: 49.2% is in level 1, 30% in level 2, 14.4% in level 3 and 6.3% in level 4. Something similar is found with PISA 2015, where Mexico's performance is found by below the OECD average in Mathematics (408 points) and less than 1% of students in Mexico achieve excellence levels of competence (level 5 and 6, from 607 to 688 points). These results are confirmed by the EXANI II, where the vast majority barely passes the mathematical competences. All these instruments confirm what many researches and different news media have published in recent years, that Mexican students do not acquire the necessary competencies for their performance in mathematics.

However, as a teacher a deeper analysis is required, since in the current educational models, students start from a level of students to reach a greater competence, so the reliability of the results of the diagnosis is of the utmost importance. Faced with this enormous responsibility, many professors who teach the subjects of the first university semester end up giving contents of arithmetic in the course of algebra, of algebra and arithmetic in the one of analytical geometry, and of all the subjects in those of differential calculus; what hinders addressing the contents of each subject. Thus, in this work the indicators of arithmetic thinking, algebraic thinking and functional thought (Cuevas and Delgado, 2016) were taken from the different evaluation theories to analyze the type of verbal, logical, mathematical and functional reasoning of the students and seek to correlate the information provided by all the aforementioned instruments.

For this, the instrument called Pretest was designed, which includes the initial mathematical knowledge (prerequisites) that mark the study programs for new students to the Computer Engineering career of the Vale de Chalco University Center, of the Autonomous University of the State of Mexico, in the period 2017, and the data was correlated with the mathematical competences considered in the standardized tests (PISA, Plannea and EXANI), basic knowledge of arithmetic, algebra, analytical geometry and differential calculus was evaluated in 50% of the population of engineering students. Reflecting in particular that the EXANI does not consider the content to determine the mathematical competence of new students entering this career.

The Pearson correlation and the comparison of means by student's t show the lack of concordance in content and, therefore, the scope of each test. In all the instruments a low operational level of the students is obtained. If one starts from the position that these evaluations serve to improve student performance, they are valuable as a starting point to encourage processes and revise concepts with the students that lead them to reach the mathematical competencies described. In this sense, didactic activities are recommended using technology designed with the intention of favoring significant and conceptual learning, as part of an experience by the Academic Body of Applied Computing, in the area of Educational Technology, of the Valle de Chalco University Center, which has been developing for 10 years (Soberanes, Martínez and Castillo, 2016), and thus encourage a performance more in line with the characteristics of the professional career.

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