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La mecánica de sólidos como unidad de competencia del currículo de los programas de estudio en Ingeniería

The mechanics of solids as a unit of competence of the curriculum of engineering study programs

A mecânica dos sólidos como uma unidade de competência dos currículos dos programas de estudo em Engenharia

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Resumen

La actualización curricular de los programas de estudio en las instituciones de educación superior (IES) actualmente se enfoca en la oferta de una educación basada en competencias, como la propuesta por el Gobierno de México (2017), en lugar de una instrucción sustentada en desempeños sociales. En tal sentido, es indispensable que las modificaciones realizadas a los planes de estudio sean pertinentes y permitan que los profesionistas en formación tengan mejores alternativas de inclusión o mejora laboral, aun cuando no puedan continuar sus estudios. En las revisiones curriculares, la propuesta para crear opciones de salida laterales cuando los estudiantes no pueden continuar sus estudios no ha sido formulada de forma apropiada ante las instancias dedicadas a la gestión, planeación y diseño curricular en las IES. Por ello, en el presente trabajo se expone el análisis realizado para intentar ofrecer alternativas de profesionalización de los saberes parcelados de una disciplina desde la perspectiva de la competencia laboral, con fundamento en la experiencia del diseño de una estrategia de enseñanza desarrollada a partir del análisis de los contenidos académicos de las asignaturas relacionadas con la cátedra Mecánica de Sólidos (MS). Los resultados obtenidos muestran la posibilidad de ubicar la MS como una viable unidad de competencia a favor de la formación profesional de un estudiante de Ingeniería. También se observó que un bloque de asignaturas de los semestres iniciales de un programa de estudios en Ingeniería concurre como requerimientos previos para cursar la materia MS. Por lo tanto, se identificó que a partir de la enseñanza instruccional de esta asignatura se genera la oportunidad para adquirir destrezas que propician una habilitación laboral pertinente (Morin, 1999) con las actividades del control de la calidad, lo cual le permite al educando-aprendiz formarse para trabajar como analista de propiedades mecánicas de los materiales metálicos en estado sólido, actividad con alta demanda en el sector empresarial de la industria metalmecánica y de construcción a nivel nacional e internacional.

Palabras clave: actualización curricular, competencia, desempeño, diseño mecánico, mecánica de sólidos.

Abstract

The curricular update of the study programs in Higher Education Institutions (IES), are currently oriented to the offer of a competency-based education proposed by the Government of Mexico (2017) and not in social performances proposed by CONALTE (1991). Therefore, it is essential that the modifications made to the study plans be highly relevant and allow the professionals in training to have better alternatives and opportunities for inclusion or work improvement, even when they can not continue their studies. In curricular reviews, the proposal to create lateral exit options when students can not continue their studies has not been formulated in a relevant manner before the instances dedicated to management, planning and curricular design in HEIs. Therefore, the present work exposes the analysis carried out in favor of the alternatives of professionalization of the parceled knowledge of a profession from the perspective of labor competence. Based on the experience of designing a teaching strategy developed from the analysis of the academic content of the subjects related to the subject of Solid Mechanics (MS) and its educational objective. The results obtained show the possibility of locating the MS as a viable Competency Unit in favor of the professional training of an engineering student of Higher Education Institutions. It was also observed that a block of subjects of the initial semesters of a program of studies in engineering concur as prerequisites to study the subject of MS. Therefore, it was identified that from the instructional teaching of the MS the opportunity is generated to acquire the skills that favor a pertinent labor qualification with the activities of the control of the quality. From the perspective of the labor qualification of the job position "Analyst of mechanical properties of metallic materials in solid state". Activity with high demand of the business sector of the metal-mechanic and construction industry nationally and internationally.

Key words: curriculum update, competence, performance, curriculum, mechanical design, solid mechanics.

Resumo

A atualização curricular dos programas de estudo em instituições de ensino superior (IES) enfoca atualmente a oferta de uma educação baseada em competências, como a proposta pelo Governo do México (2017), ao invés de uma instrução baseada no desempenho. social. Nesse sentido, é imprescindível que as modificações feitas nos planos de estudo sejam relevantes e possibilitem que os profissionais estagiários tenham melhores alternativas de inclusão ou melhoria do trabalho, mesmo quando não puderem continuar seus estudos. Nas revisões curriculares, a proposta de criar opções de saída lateral quando os alunos não podem continuar seus estudos não foi formulada de forma adequada antes das instâncias dedicadas à gestão, planejamento e desenho curricular na IES. Por esta razão, no presente trabalho a análise está exposta a tentar oferecer alternativas de profissionalização do conhecimento parcelado de uma disciplina a partir da perspectiva da competência do trabalho, com base na experiência do desenho de uma estratégia de ensino desenvolvida a partir da análise. do conteúdo acadêmico dos assuntos relacionados à cadeira Solid Mechanics (MS). Os resultados obtidos mostram a possibilidade de localizar a EM como uma unidade de competência viável em favor da formação profissional de um estudante de engenharia. Observou-se também que um bloco de sujeitos dos semestres iniciais de um programa de estudos em Engenharia concorre como pré-requisitos para o estudo do tema MS. Portanto, identificou-se que a partir do ensino instrucional desse assunto gera-se a oportunidade de

adquirir habilidades que favoreçam uma qualificação laboral pertinente com as atividades de controle de qualidade, o que permite ao aprendiz-trainee ser treinado para atuar como Analista de propriedades mecânicas de materiais metálicos em estado sólido, atividade com alta demanda no setor de negócios da indústria metalúrgica e de construção a nível nacional e internacional.

Palavras-chave: atualização curricular, competência, desempenho, projeto mecânico, mecânica de sólidos.

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Introduction

The proposal presented in this document is based on the conception of a relevant education and for work (Candia, Flores, Carmona and Domínguez, 2016), an intrinsic characteristic of dual education (Cámara México-Alemana [Camexa], 2016), which seeks to promote the curricular development of an authentic education.

> "For Dewey, all authentic education is carried out through experience" and an educational situation is the result of the interaction between the objective conditions of the social environment and the internal characteristics of the learner (...). In addition, experiential learning is active and generates changes in the person and their environment, not only goes "inside the body and soul" of the learner, but uses and transforms the physical and social environments to extract what contributes to experiences valuable and establish a strong link between the classroom and the community (Díaz Barriga, 2003, p. 7).

Dual education is an educational system of German origin that emerged at the end of the Second World War as a strategy of technological and economic restructuring. However, although in Mexico it is considered as an alternative to promote the sustainable development of the nation from the philosophy of specialized technical training (Secretariat of Public

Education (SEP), 2017), in practice it has only been adopted at the educational level superior medium (EMS) because the necessary conditions do not exist to implement it in all regions of the country.

For this reason, this paper offers an alternative curricular proposal for the university education of students of engineering careers who aspire to perform as analysts of the mechanical properties of metallic materials in solid state. In this sense, the analysis of the curriculum of the study programs of a higher education institution (IES) (Benemérita Universidad Autónoma de Puebla [BUAP], 2007) covers the evaluation of the subjects related to the mechanics of solids during the first four teaching cycles (semesters) of careers such as Civil, Mechanical, Industrial, Mechanical and Electrical Engineering, and Mechatronics, to name a few, where priority is given to the Solids Mechanics I and Solid Mechanics II courses as a common element, even when these are they are declared with a different name.

Specifically, this proposal has been raised from the hypothesis of an exploratory analysis that seeks the following: to address the curricular update of the engineering study programs of Higher Education Institutions, with teaching instructions from the perspective of labor competencies (DUAL education and KNOWING) that promote employment qualification. It is then possible to propose lateral exits to the curricula of the undergraduate studies that enable students who leave their studies with a work occupation.

To achieve this, the principles of dual education have been taken as a basis, which focuses on a practical training that systematically combines processes of conscious learning (through formal instruction) and unconscious processes (through the memorization of previous knowledge), as well as the support of the basic foundations of situated teaching, the motivation based on the acquisition of work experience and personalized management. For these reasons, it is considered that it is possible to make a proposal that places the Solid Mechanics subject as a unit of competence within a curriculum in the Engineering career.

Likewise, the paradigm of situated cognition represents one of the most representative and promising current trends in sociocultural theory, since it is linked to different concepts, among which the following stand out:

> "Located learning", "communities of practice" and "legitimate peripheral participation" (...), as well as cognitive learning or artisanal learning (...). [Likewise], in the field of instructional application, the model of reciprocal teaching, learning communities and technological literacy stand out (Díaz Barriga, 2006, p. 18).

This means that the participant must be considered as an educator-apprentice, which is characterized because within the higher educational level is enrolled in a program of engineering studies, with the following specifications (table 1):

Tabla 1. Características de la enseñanza situada

Semestre	**4.°**
Núcleo de formación profesional	Ciencias de la Ingeniería
Competencia por demostrar	Realizar pruebas de tensión en probetas de materiales metálicos sólidos para analizar esfuerzos axiales, además del trazo de la gráfica esfuerzo-deformación (E-D).
Objetivo de aprendizaje	Que el educado-aprendiz realice el trazo de una curva E-D por medio de probetas que han sido sometidas a la prueba de ensayo de tensión, y entregue un formato en el cual proporcione la evaluación del comportamiento del material de acuerdo con la instrucción impartida por el instructor.
Objetivo general	Que el educando-aprendiz comprenda el comportamiento de los materiales metálicos sólidos ante las solicitudes del diseño mecánico; esto mediante el análisis de las propiedades mecánicas de los materiales metálicos sólidos a través de la gráfica E-D.
Objetivos específicos	1. Identificar bajo norma las características de las probetas de ensayo de tensión. 2. Identificar la capacidad de resistencia de los materiales metálicos sólidos de acuerdo con la carga aplicada cuando no supera el límite máximo de rotura. 3. Realizar la medición de las dimensiones (transversales y longitudinales) de las probetas por medio de un vernier digital. 4. Utilizar una calculadora básica para determinar dimensiones y variables en estudio (esfuerzo y deformación). 5. Trazar la curva E-D de los materiales metálicos sólidos. 6. Comparar el comportamiento del material metálico sólido en estudio con el referente proporcionado por el fabricante.
Ámbitos de aprendizaje	**Cognitivo** El educando-aprendiz debe conocer la teoría de la mecánica de sólidos y su aplicación en el análisis del comportamiento de los materiales metálicos sólidos cuando son sometidos a ensayos de tensión por requerimientos de diseño mecánico.
	Afectivo El educado-aprendiz debe actuar con honestidad para garantizar la más confiable evaluación del comportamiento del material metálico sólido ante requerimientos de diseño mecánico, sin exponer a riesgos la integridad física de los usuarios finales.
	Psicomotor El educando-aprendiz debe usar los instrumentos de medición, dibujo técnico y cálculo aritmético para determinar los parámetros y el trazo de una curva E-D.
Cualificaciones clave	Conocer, medir, calcular, analizar, realizar, evaluar, comparar, comunicar.

Fuente: Elaboración propia

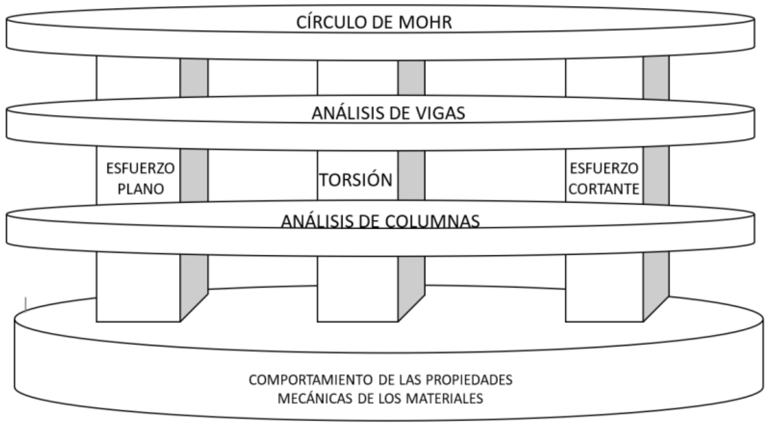
From table 1 it can be affirmed that dual education contributes to creating professional communities of teachers who are capable of working jointly on specific and relevant educational projects according to the context (mechanical design), especially when there is foreign investment from the metalworking industry in a population in the process of development.

However, in order to achieve a high-impact educational project that provides vocational qualification to truncated engineering professionals, it is necessary to describe the specific competences that a student of that specialty must acquire during his / her partial stay at the IES. Therefore, the proposal of a lateral exit in the IES curriculum seeks that the truncated professionals and the labor sector are able to collaborate with each other through a network of connections between different institutions or educational centers, with the commitment for the sustainable change and improvement, under the principle of cohesive diversity (Hargreaves and Fink, 2006, cited by Díaz Barriga, 2010). In this way, we try to promote the design of a flexible curriculum that meets the labor demand with highly pertinent technical qualifications, which could help the student to join the work sector.

Framework

Mechanical design is a professional activity that intrinsically involves the theory, study and development of the mechanics of solids (figure 1), as well as activities to validate experimental methods (through destructive stress tests) and exact results (by drawing the ED curve).

Figura 1. Modelo esquemático de la implicación de la mecánica de sólidos en el estudio de las propiedades mecánicas de los materiales metálicos sólidos



Fuente: Elaboración propia

However, it is considered that in the IES the mechanical design actions have focused on the productivity of isolated research groups that have as common elements the integration of activities of computational mechanics (especially the use of simulation software), when The labor demand of the sectors of the metalworking and construction industry requires experts in quality control activities. This means that a curricular flexibility is needed that offers not only the training of professionals dedicated to research.

In this regard, for the National Council of Science and Technology (Conacyt), mechanical design is a very important area of technological development and innovation. Therefore, this institution, together with the National Council for Standardization and Certification of Labor Competencies (Knowing), use as reference the areas of knowledge the North American Industrial Classification System (SCIAN), which groups in three large areas (primary, secondary and tertiary) economic activities in Mexico, the United States of America and Canada, which serves to locate the individual function of mechanical design within one or more sectors (Conocer, 2016).

For that reason, it is considered that the mechanical design in the curricula of the engineering schools brings together a group of subjects capable of configuring an option or terminal line of studies that by itself can be called specialty (competence) within the graduate profiles of HEIs However, only the mechanical properties observable in an E-D curve are treated, and that is the proposal of the mechanics of solids as a unit of competence that integrates the competence of mechanical design (see figure 3).

Method

The methodological justification of this work was exploratory, while the design of the research was non-experimental. The critical apparatus was based on documentary comparison. In the elaboration of this proposal, the recommendations of the Knowing methodology (2016) for the formulation of labor competencies have been addressed, as well as the Tobón, Pimienta and García statements (2010) for the elaboration of didactic sequences through socioformative competences .

The methodology for the design of teaching instruction was based on the philosophy of dual education (Camexa, 2016), which meets the guidelines established in the Camexa Trainer of Trainers course. In this way, the German model of industrial instruction was reproduced in the most faithful way. Currently, the Camexa, together with the federal and state governments, promote the tropicalization of this educational model from the level of EMS (Government of Mexico, 2016), prioritizing the following competencies:

- Methodological competence: The student-trainee must know how to follow an instruction in the outline of an E-D curve and the evaluation of the behavior of the mechanical properties of a solid metallic material according to its inflection points.
- Social Competence: The student-trainee must commit to the process of evaluating an E-D curve, so that it can guarantee the physical integrity of the end users of the mechanical designs.
- Individual Competences: The student-trainee must be able to generate the knowledge, skills and abilities (level 3) that allow him to develop the competence to perform as an analyst of mechanical properties of metallic materials in solid state.

Teaching

In the instruction and proposal the method of the four levels was used (D. Kirkpatrick and J. Kirkpatrick, 2009), which is a simple form (main activity) of the practical instruction in the workplace. With this model the requirements of the educational and learning processes are met, and the basic (cognitive) structures are established for all other more complex forms of instruction derived from constructivism (checklist, etc.). These levels are shown below:

1. **Level 1. Prepare and explain (reaction):** In the designated work place the following actions are carried out:
    a. Prepare the study and analysis materials (tested specimens).
    b. Prepare the measurement, calculation and trace equipment.
    c. Prepare the trace materials (formats)

2. **Level 2. Teach and explain (learning):** The instructor teaches the learner-learner, through demonstration, the following actions:
    a. Identify test tubes.
    b. Measure test tubes
    c. Calculate variables.
    d. Draw the curve E-D.
    e. Evaluate the E-D curve.
    f. Present the results of the instruction in a data table.

- **Level 3. Reproduce and explain to the learner (behavior):** The learner-learner performs and explains each instruction procedure emphasizing those steps that modify or alter the result in the outline of an E-D curve.
- **Level 4: Let practice autonomously (results):** The trainee-trainee draws an E-D curve autonomously, with close supervision of the instructor to verify the reliability of the graph. Then you are asked to evaluate by comparing the E-D curve.

As support for these four levels, the basic classification of learning styles was taken into account (Howard, 2010). In this way, we sought to structure a teaching strategy with high relevance to learning, which was evaluated from a partial control of the results, based on the cognitive channels of perception:

1. *Optical*
   - Identification of the specimens according to their load and displacement.
   - Determination of the precise measurement of the specimens.
   - Use of the formats to document the measurements and make the graph.
   - Comparison between the graph made and the reference graph.

2. *Documentary*
   - Curve stroke format.
   - Data collection format.

3. *Verbal*
   - Fluid explanation of the evaluation.
   - Understanding of the classification of the behavior zones of a solid metallic material.
   - Feedback.
   - After the development of the practice, the instructor appreciates the participation of the student-trainee, delivers the evaluation note, comments on the subsequent work and finishes instruction. If the evaluation is favorable, the learner is congratulated for the purpose of increasing and strengthening their self-esteem. If the evaluation is not favorable, you are invited to improve your commitment and to present an upcoming evaluation.

Evaluation

As a high-impact strategy, the development of learning-oriented activities based on social projects was established (Díaz Barriga, 2003), which allows structuring the minimum evidences that the student must develop; In this way the degree of competence that the apprentice can master is not limited.

On the other hand, and for the collection of data, an evaluation format was designed (table 2) to quantify the degree of competences obtained through the generation of evidence. These were assigned a numerical note established by a range scale (table 3), which was integrated into the summative qualification format. For this, the greater amount of elements involved during the teaching process was taken into account (Candia, Galindo, Pichardo y Yonemoto, 2012).

Tabla 2. Cuadro de evaluación

PUNTOS	NOTA	CUALIFICACIÓN
100-92	4	EXPERTO
91-81	3	INTERMEDIO
80-67	2	BÁSICO
66-50	1	APRENDIZ
PUNTOS		

Calidad en el trabajo		RANGO			
Ritmo de trabajo	El aprendiz se ajusta al tiempo indicado a cada punto de la instrucción y no sobrepasa los 8 minutos para realizar el total de la instrucción	4	3	2	1
Capacidad de resistencia	El aprendiz tiene una actitud de confianza y responsabilidad en el uso de equipo de medición	4	3	2	1
Compromiso	El aprendiz realiza un adecuado uso del equipo (evita actos de descuido o daño deliberado) para realizar la instrucción	4	3	2	1
Autonomía	El aprendiz con apoyo de la hoja de instrucción aclara dudas y continua de manera autónoma el desarrollo del producto final	4	3	2	1
Esmero	El aprendiz organiza su actuar de manera que su área de trabajo se encuentra ordenada y limpia	4	3	2	1
(4) Resultado excelente cumple muy bien con todas las características	(3) Resultado bueno: cumple bien con todas las características	(2) Resultado bueno: cumple de forma regular con las características	(1) Resultado poco satisfactorio: cumple con dificultad o no logra cumplir las características	PROMEDIO	

Fuente: Elaboración propia

Tabla 3. Escala de rango utilizada para cuantificar el aprendizaje

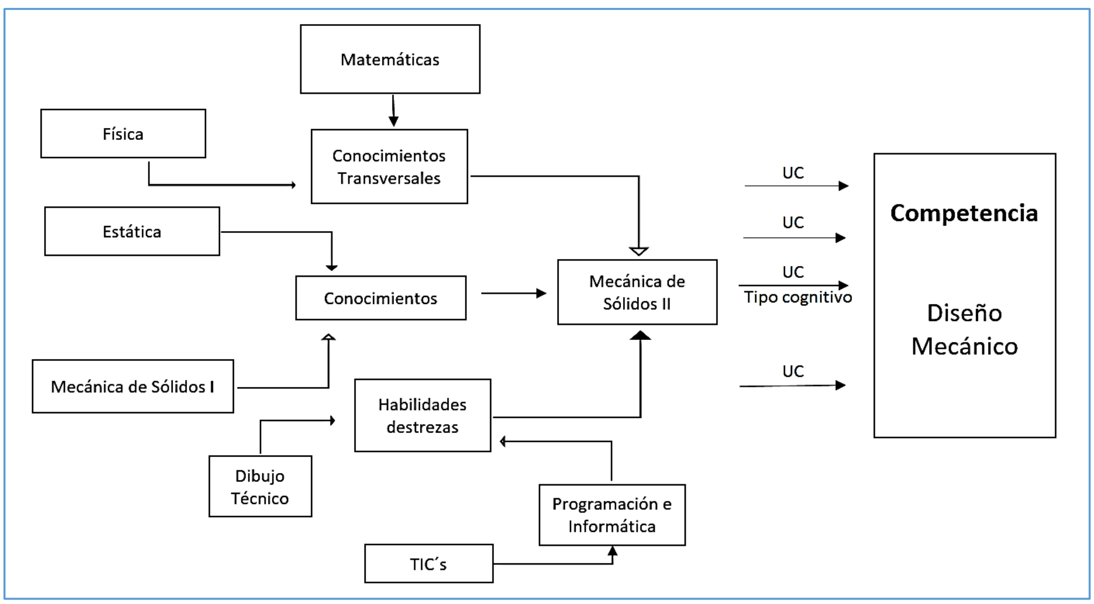
Escala de rango	
Experto	4
Intermedio	3
Básico	2
Aprendiz	1

Fuente: Elaboración propia

Development

The purpose of this section is to show with sufficient argumentation the development of an instruction to consider the Solid Mechanics subject as a unit of competence (see figure 2).

Figura 2. Representación gráfica de la unidad de competencia



Fuente: Elaboración propia

Objective

Have the student trace the E-D curve of an aluminum test specimen subjected to mechanical design requirements in accordance with ASTM E8 or ISO-6892.

Prerequisites (knowledge)

- Dimensional metrology.
- Technical drawing.
- Availability of the student.
- Industrial safety and hygiene measures.

Product

Graph of the curve E-D of the metallic material in solid state, drawn in Excel sheet format according to figure 3, and verifying that the units are coincident, consistent and approved to the International System of Units (National Center of Metrology [Cenam], 27 de noviembre de 2002).

Figura 3. Plantilla para graficar la curva E-D de los materiales metálicos en estado sólido

Fuente: Elaboración propia

Supplies

The didactic materials were of own elaboration, and represented an indispensable element to carry out the instruction. Consumables were also selected specifically for instructional instruction. Finally, the equipment used was the most general possible (this is usually available in any workshop or university laboratory).

Description of the job

In relation to the cognitive level, the competence has been located in level 3, which corresponds to the taxonomic levels of Bloom (Know, 2016), which are shown below (table 4):

Tabla 4. Niveles taxonómicos de Bloom

Nivel cognitivo	**1**	**2**	**3**	**4**	**5**	**6**
Nivel taxonómico	Conocimiento	Comprensión	Aplicación	Análisis	Síntesis	Evaluación

Fuente: Elaboración propia

Likewise, the recommendations of the Ministry of Labor and Social Welfare (STPyS) regarding the procedure to authorize and register external training agents were considered. (STPyS, 2018).

Tabla 5. Caracterización de la unidad de competencia

Unidad de competencia mecánica de sólidos	
OBJETIVO	Comprender el comportamiento de los materiales sólidos ante las solicitaciones del diseño mecánico, mediante el análisis de las propiedades mecánicas a través del comportamiento del material en una curva E-D.
NIVEL	3
PUESTO	Analista de propiedades mecánicas de los materiales metálicos en estado sólido.
CARACTERÍSTICAS	Realizar pruebas de tensión en probetas y de flexión en vigas. Analizar esfuerzos mediante el círculo de Mohr (axial y cortante). Graficar la curva E-D. Analizar esfuerzos de tensión.
PRODUCTO DE APRENDIZAJE	Trazo de la gráfica E-D del material aluminio 6061-T6.
DESCRIPCIÓN	La unidad de competencia Mecánica de Sólidos es una propuesta como salida lateral que se puede ofrecer a los estudiantes de educación superior que se ven obligados a abandonar sus estudios después del tercer año de estudios. Esta unidad de competencia se valida mediante la presentación de la evaluación de la instrucción declarada en el presente documento, y se oficializa mediante dos diplomas que se emiten de común acuerdo, pero independientes en su emisión entre la institución ofertante y la STyPS (2018).

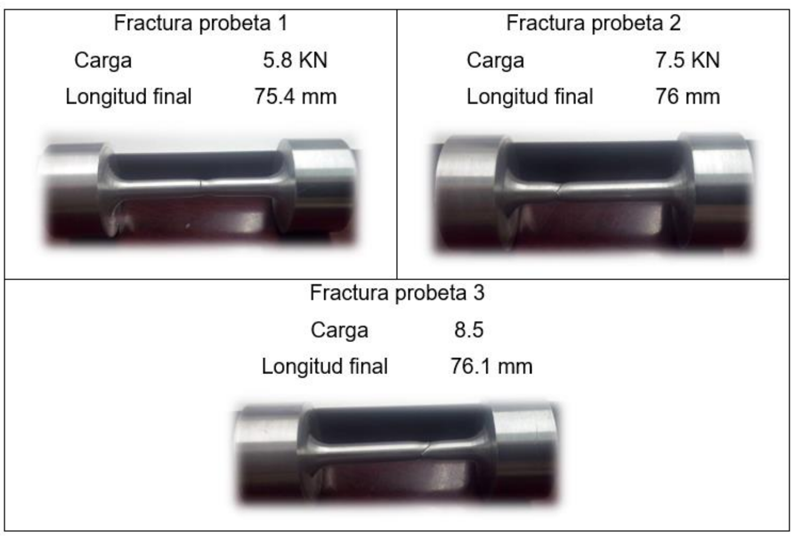
Fuente: Elaboración propia

The endorsement of having acquired this competence enables the student-trainee to work as an analyst of mechanical properties of metallic materials in solid state for metalworking and construction companies.

Results

The summary of the measurements of the test specimens (didactic material) 1, 2 and 3 (figure 4) that have been tested under the suggested didactic sequence (the didactic sequence for its knowledge and application can be requested at the author by mail filinc@hotmail.com).

Figura 4. Probetas previamente ensayadas y utilizadas como material didáctico



Fuente: Elaboración propia

The didactic sequence is considered as the most beneficial alternative because it is an articulated set of learning and assessment activities, which with the mediation of a teacher seek the achievement of certain educational goals. In practice, this implies substantial improvements in the processes of student training, since education becomes less fragmented and focuses on goals (Tobón, Pimienta and García, 2010). Table 6 shows the measurements made in the specimens when the teaching material was developed.

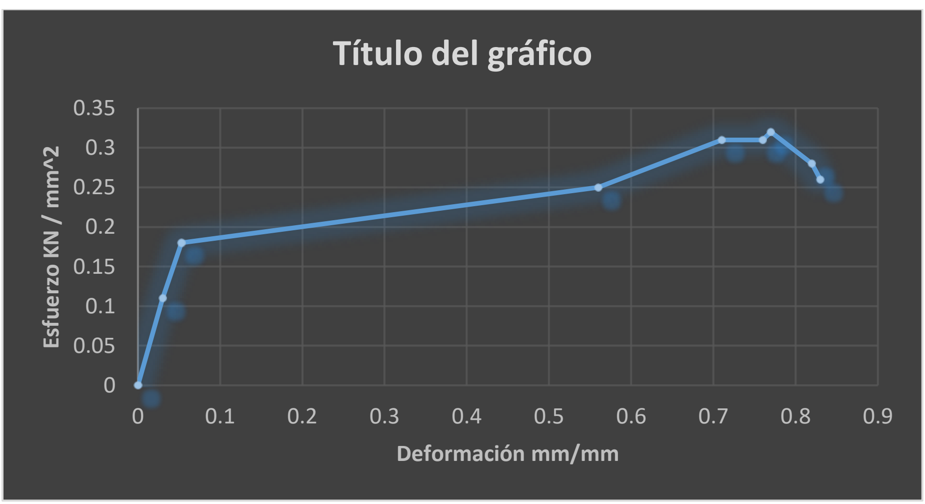
Tabla 6. Datos recolectados por la experimentación de tres probetas para graficar una curva E-D

N.º	Deformación en mm	Esfuerzo en kN / mm^2
1	0.00	0.00
2	0.030	0.11
3	0.053	0.18
4	0.56	0.25
5	0.71	0.31
6	0.76	0.31
7	0.77	0.32
8	0.82	0.28
9	0.83	0.26
10	0.83	0.00

Fuente: Elaboración propia

These measurements allow to show the curve E-D (figure 5), which is contrasted with that obtained during the instruction.

Figura 5. Gráfica de la curva E-D trazada con el promedio de los valores obtenidos de tres probetas ensayadas



Fuente: Elaboración propia

The first difference between the two was the number of measurements. In fact, while in the experimental voltage test ten measurement points were identified, in the instruction only six measurement points were recognized. Even so, it is observed that the main form of the E-D graph is consistent with the main evaluation zones (elastic zone, plastic zone and rupture zone, according to the ASTM E8 standard).

On the other hand, the accuracy in the approximation of results improved significantly when the didactic material and the experimental tests were carried out with a tension testing machine, according to the calibration requirement of the ISO 7500 standard.

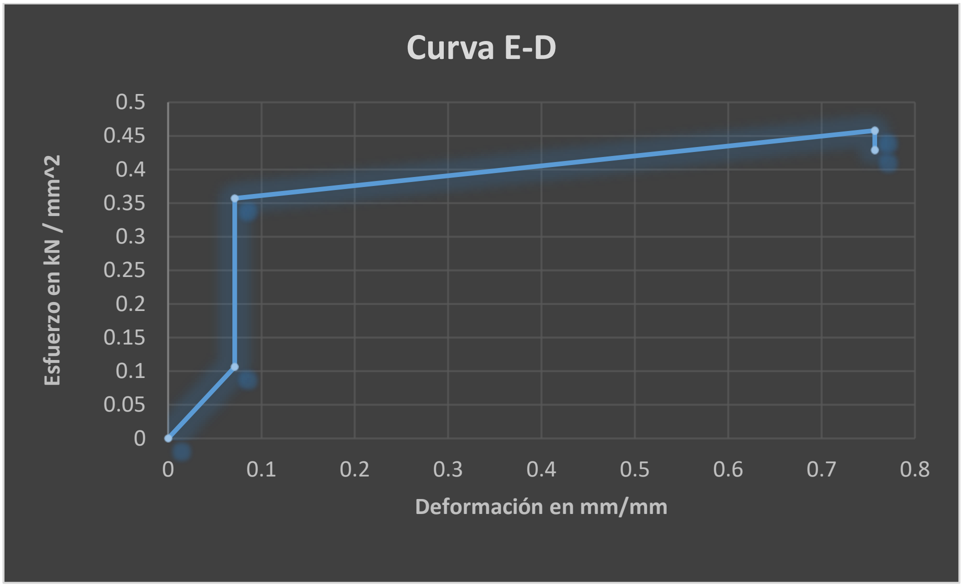
The units of the International System of Units were used for the plot of the E-D graphs, with a quite approximation consisting of the maximum and minimum values of effort, as well as displacement. Table 7 shows the average of the measurements made during the instruction, which allows, using a graph, to show the curve E-D (figure 6). This shows the main behavior of the mechanical properties (elastic zone, plastic zone and rupture zone).

Tabla 7. Datos recolectados por la instrucción para graficar una curva E-D

N.º medición	Diámetro (d) (mm)	Área (mm2) $A = (\pi * d^2)/4$	Longitud inicial (Lo) (mm)	Longitud final (Lf) (mm)	Carga (F) (KN)	Deformación $\varepsilon = \frac{L_f - L_i}{L_i}$	Esfuerzo (N / mm2) $\sigma = F/A$	Comportamiento de las propiedades mecánicas
1	6	28.275	70	70	0	0.000	0.000	ZONA ELÁSTICA
2	6	28.275	70	75	3	0.0714	0.106	
3	5	19.635	70	75	7	0.0714	0.357	ZONA PLÁSTICA
4	5	19.635	70	75.3	9	0.757	0.458	
5	4.56	16.331	70	75.3	7	0.757	0.429	ROTURA
6	4.56	16.331	70	75.3	0	0.757	0.000	

Fuente: Elaboración propia

Figura 6. Gráfica de la curva E-D trazada con el promedio de los valores obtenidos de la instrucción



Fuente: Elaboración propia

Table 8 concentrates the experimental measurements made with a total of ten test specimens, and allows to show by means of a graph that the values (sixteen measurement points) of the lines of the E-D curves remain consistent. In fact, the greater the number of data, the average allows a graph that is closer to that presented by the manufacturer, which has verified compliance with ISO 7500 (calibration of test machines).

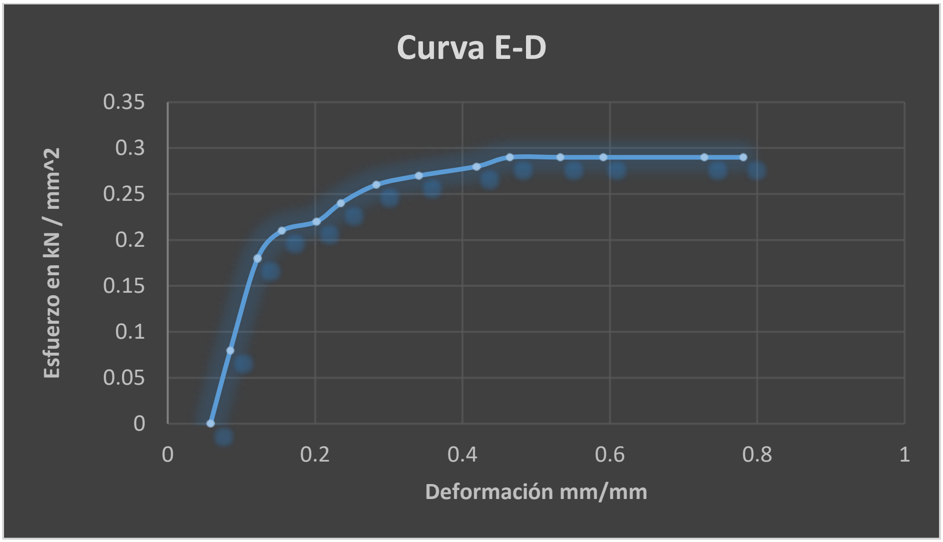
Tabla 8. Datos recolectados por la experimentación de diez probetas para graficar una curva E-D

N.º	Deformación en mm	Esfuerzo en kN / mm^2
1	0.058	0.00
2	0.085	0.08
3	0.122	0.18
4	0.155	0.21
5	0.202	0.22
6	0.235	0.24
7	0.283	0.26
8	0.341	0.27
9	0.419	0.28
10	0.464	0.29
11	0.533	0.29
12	0.591	0.29
13	0.728	0.29
14	0.781	0.29
15	0.589	0.27

Fuente: Elaboración propia

Also, in the development of the graph of figure 7, a preload value was assigned that caused an initial displacement in the measuring instrument, which simultaneously allowed the start of the load in zero Newton. For the graph of this group of data a preload value of 0.058 mm and 0.01 kN / mm2 was used, load value that was subsequently adjusted to 0.00 kN/mm^2.

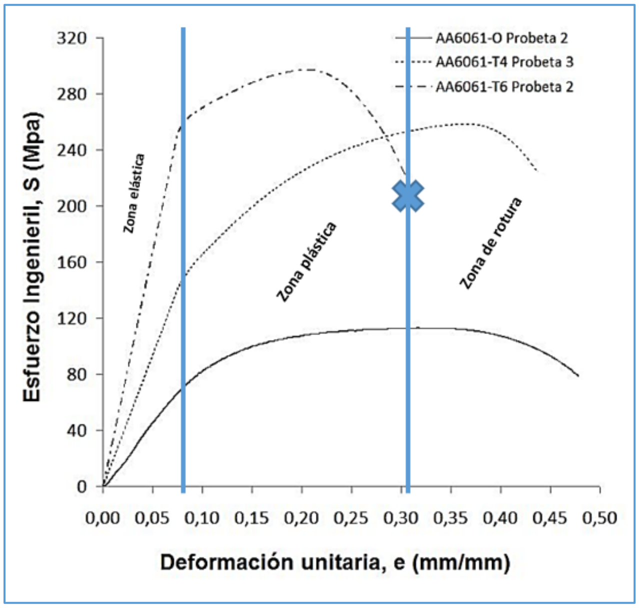
Figura 7. Gráfica de la curva E-D trazada con el promedio de los valores obtenidos de diez probetas ensayadas



Fuente: Elaboración propia

Considering the comparison between stress-strain values and the curve provided by the manufacturer (figure 8), we have that from the maximum value measured, which was 0.29 kN / mm², when converting it to units of megapascals, we obtain a value of 290 MPa, which is equivalent to a fairly close approximation in terms of the precision of the effort. A data for further analysis is the value of the deformation, because although in the experiment it was extended to 0.589, 0.076 and 0.086 from the manufacturer's value of 0.40, the data remained constant, which allowed us to deduce that the approximation error It is attributable to the dial meter used.

Figura 8. Curva E-D del material aluminio 6061 de acuerdo con especificaciones del fabricante



Fuente: Elaboración propia

From these results it can be affirmed that this proposal is viable to be used in the classroom, because it allows to relate the teaching process with authentic learning situations, which allows the students to show their performance in the real world. (Díaz Barriga, 2006).

Discussion

In this work the definition of curriculum coined by Unesco in 1958 (Vila, 2011) has been adopted, which refers to all the experiences, activities, materials, teaching methods and other means used by the teacher to achieve the aims of The education. This, consequently, is a sociocultural theory, because within the formation of the school curriculum priority is given to the transversal themes that are articulated with the problems of the individual, the environment, health and society. Herrera and Didriksson (1999) put it this way:

> An innovative and flexible curriculum will be oriented to the mastery of competencies that will be evaluated based on the ability to cope with the unexpected, control, anticipate and prevent them (p. 37).

Likewise, it has sought to generate an association between curriculum and research in order to motivate, mediate and guide self-learning and self-discipline to acquire new knowledge. For that reason, Casarini Ratto (1997) thinks:

> [This is] a vision of the curriculum that does not exclude metacognitive processes -at the theoretical-practical level-, because it provides concepts and orientations regarding the learning processes of the students, that is, with respect to how to learn (p. 40).

This means that the type of source must be epistemological and professional, since the origin of the curriculum is institutional because they do not change the graduation profile, the policies of the institution or its vision and mission. As an additional source, the professional experience of the teachers is considered, which implies the identification of indispensable contents for the student's learning and their work qualification.

The sources of the curriculum

In this work we examined the different alternatives or scenarios to try to answer the following questions: why and what to teach-learn ?, what to teach-learn ?, how to teach-learn ?, what, when and how to evaluate ? In this sense -and since the original intention was to incorporate instructional teaching within the IES curriculum to offer work opportunities to students who had a truncated curriculum in engineering-, it is held that the contents must be relevant (proper management of the tools of workshop), consequent (use of specialized technological equipment) and adaptable (change of classroom teaching by situated teaching). Likewise, these must be organized to ensure that a theoretical-conceptual knowledge associated with the work activity is learned. Consequently, the configuration (type and form) of the instructional contents must be of this type:

- Documentary, through selected readings of scientific publications in electronic journals specialized in instructional curricular design.
- Audiovisual (videos) with the opinion of experts on the relevance of situated and technological education.
- Textual (blogs) on the results of the use, handling and optimization of the technique of the analysis of metallic materials in the solid state, as well as of peers from other institutions that carry out the same type of instruction.

In addition, the contents must also be oriented according to their nature, that is, conceptual, procedural and attitudinal, as they point Tobón, Pimienta y García (2010).

Theories of learning

In the research the theory of learning by association was used because it allows to motivate the student through the stimulus-response phenomenon (both in classical and instrumental conditioning) and to encourage self-learning through visual stimuli. However, it is important to note that in conjunction with conditioning strategies, the strategies of cognitive pedagogical theory are associated, which understand learning as the result of a series of successive modifications in the student's mental structures, which are activated through of the stimuli. In this regard, Casarini Ratto (1997) opines the following:

> From these cognitive processes the student becomes a mediator, as he "sifts" messages, values, ideas, purposes, etc., according to his cognitive and emotional profile, his personal history, his previous learning, etc. It is obvious that in any case this psychological mediation is highly influenced by other factors, such as social and cultural, among others, that define individual mediations (intellect, family, social class, generational factor, specific socio-political period, etc.). (p. 51).

Conclusions

During the development of this document has been monitored to encourage and predominate problem-based learning, as in this type of learning students not only actively participate in the development of the requested activities. They also feel motivated by the educational experiences carried out by themselves through instructional didactic sequences. Through the design of a pragmatic environment students identify a significant improvement in their self-regulatory skills and make their thinking more flexible, since they can collaboratively conceive different points of view, as well as problem-solving strategies. To carry out the development of the sequence and didactic instruction, stimulated the development in the student of diverse types of knowledge associated to activities, abilities and cognitive and motor relations.

Based on the basic knowledge, it was useful to clearly identify the mechanical properties of the solids and their behavior in front of the boundary conditions (forces and supports) in response to design requirements. Cross-knowledge was promoted, which allows to integrate the knowledge of the mechanics of solids with the mechanical design. A creative knowledge arose, since the study of the determination of stresses and deformations was the one that allowed to evaluate the failure criteria and the safety conditions of the structural elements. The critical knowledge was developed when the competence was reached at the end of the instruction which allowed to evaluate the mechanical properties of metallic materials in solid state.

From this organization of contents, the integration of three areas of knowledge is achieved, that is, the mechanics of solids, the quality control and the criterion of inspection passes-does not pass. The degree of mastery of this knowledge focuses on the ability of the academic curriculum to configure the relevant training of an Engineering student who aspires to perform as an analyst of mechanical properties of solid-state metallic materials.

On the other hand, it has been observed (especially in the analysis of the E-D graphs) that complementing the student's education with improvised laboratory practices, without calibration and with the absence of equipment certification limits the teaching of solid mechanics. Therefore, in this proposal the main objective has been for the student to understand the behavior of solid metallic materials in real industrial design situations, through the analysis of their mechanical properties and through an instruction based on the principles of dual education. Therefore, it is recommended that during the implementation of a study plan in Engineering systematically combine processes of conscious learning (exercise) and unconscious (motor development) taken into consideration prior knowledge.

Therefore, it is concluded that it is possible to integrate a lateral output in the curriculum of the IES study programs in Engineering, in order to allow the job empowerment of students who leave their university career. In this way, the dynamic and revolutionary educational change represented by being immersed in knowledge societies is supported.

Finally, regarding the technical section, it can be concluded that the results of the instructional development coindise with the behavior assumed by the ASTME E8 standard. This shows that the unit of competence provides the necessary skill to perform as an analyst of the mechanical properties of metallic materials in the solid state.

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