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DISRUPTIVE STRATEGIES IN THE LEARNING OF ISOSTATIC BEAMS BASED ON XVIGAS® SOFTWARE THROUGH CONTENT EVALUATION

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Abstract: *It was proposed to determine the effectiveness of XVigas® software in the learning of isostatic beams in students of electrical mechanical engineering of a Peruvian national university located in Lima. It was used a quasi-experimental design evaluating the experimental and control groups before and after the application of the software. Comparative contrasts were analyzed using T-Student (for paired and independent groups) and analysis of variance (ANVA one way). He concluded that the use of the software proved to be an effective disruptive strategy in content-based learning in these students. It was also demonstrated that there was similarity of performance between cognitive and attitudinal learning. The procedural learning showed significant differences with the cognitive one, recommending deepening the study in this aspect, extending it to the teachers' perspectives.*

Keywords: ICT, educational software; active learning; teaching method.

INTRODUCCTION

In the 21st century, globalization generates competition and stimulates technological change among societies, pushing them to modernize their global companies. This free trade environment has strongly permeated public decisions on higher education, especially regarding the orientation of study plans and programs and their influence on professional training (Lagarda, 2001). The role of the university is not only to optimally train its students, but also to ensure that the knowledge taught will be useful in the labor market (García Ancira & Treviño Cubero, 2020). To achieve this goal, learning must be focused on the needs of the environment and efficiently oriented towards the demanding market.

The use of Information and Communication Technologies (ICT) has made possible the real-time interconnection of many sectors of the world's population as well as, has been the ideal vehicle for globalization that imposes new forms of production, marketing, socialization and education (Lobo et al., 2011). Among university students, the use of ICTs does not yet reveal its real potential, and its use is limited with respect to application programs, even though many authors and academics agree that the use of software, tools and applications related to the professional career they are studying should be encouraged, with the perspective that these uses should be extended during the labor stage (Soto Ortiz & Torres Gastelú, 2016).

The generations of students in the last five years are currently managing to transform the acquisition of knowledge into significant learning from technological implementations that lead to the development of didactic experiences. Therefore, the use of ICT constitutes a tool that allows for better learning methods in "difficult" areas such as mathematics (Espinosa & Idrobo, 2020), especially in professional engineering careers where there is a need to implement effective methodologies that go beyond just understanding formal development procedures and allow for their application to real-life problems (Morales Olivera & Blanco Sánchez, 2019).

One of the advantages of the use of ICT is that it allows the transformation of teachers - students into dynamic actors in the learning - teaching process (Barana et al., 2019), although it should also be said that the use of these technologies implies an obligation to develop teachers' skills (Manco-Chavez et al., 2020).

However, improvements in learning have been demonstrated in different reports such as that of Ugwuanyi & Okeke (2020) who were able to improve the physics performance of university students, even though they only did a process of assistance using computer-assisted instruction (CAI) without using specific software. In contrast, Taipe (2019) used the Matlab® to improve the learning of linear kinematics obtaining good results significantly different from the control group. In another study, similar results were obtained using Hawkes® software for pre-calculus learning (Babaali & Gonzalez, 2015; Serhan, 2019) as well as Raines (2016) and Serhan (2019) who demonstrated the effectiveness of MyMathLab® for algebra learning in an analogous group of students.

In light of the research that used this type of tools, few studies register effectiveness of learning in "isostatic beams" in university students, so, in the perspective of elucidating the effectiveness of the application of the XVigas® software, this work was proposed under the constructivist approach, converged in Biggs' postulates (J. Biggs, 1988, 1993; J. B. Biggs, 2011); who considered necessary the study of academic performance in universities as a complex variable formed by the synergy of students' competences.

Thus, this research defined performance as a set of learning content outcomes in three types: Cognitive ("knowledge" - conceptual), Procedural ("know-how") and Attitudinal ("being") (Merrill et al., 1991; M. David Merrill, 1994; M.D. M David Merrill &

Group, 1996; Coll et al., 1999), allowing clear differentiation of content according to the use students would make of each of them. (De la Fuente et al., 2008).

Likewise, it should be noted that the theoretical approach chosen for the development of this research is ratified in the precepts of Vermunt (J. D. Vermunt, 1996; Jan D. Vermunt, 1998, 2005) where it was explained that metacognitive activities are the result of the inter-regulation of contextual and personal temporal influences where the attitudinal factors, which generally confer subjective evaluations to the learning tasks-have the power to stimulate or block the orientation of the emotions towards significant learning.

In this perspective, the proposal is justified in the need to continue searching for better options of disruptive strategies that facilitate the learning of human knowledge that requires greater efforts in the teaching process, especially in this era where education has abruptly migrated from a face-to-face modality to a remote one due to the effect of the Covid-19 pandemic and which constitutes a challenge for teachers, especially in the processes of verifying that learning is meaningful (Vértiz et al., 2020) and that guarantees the success of work performance as the backbone of the integral development of our civilization.

ISOSTATIC BEAMS: BRIEF DESCRIPTION

Specifically, the study was oriented to the topic of isostatic beams, which are defined as those structures that do not have rigidity in the union of their elements, having only two points of support, being freely supported on them (Ferreira de Almeida, 2009).

For further illustration, the relationship between distributed load, shear force and moment is presented for an AD beam represented in Figure 1 that is subjected to an arbitrary load w=w(x):

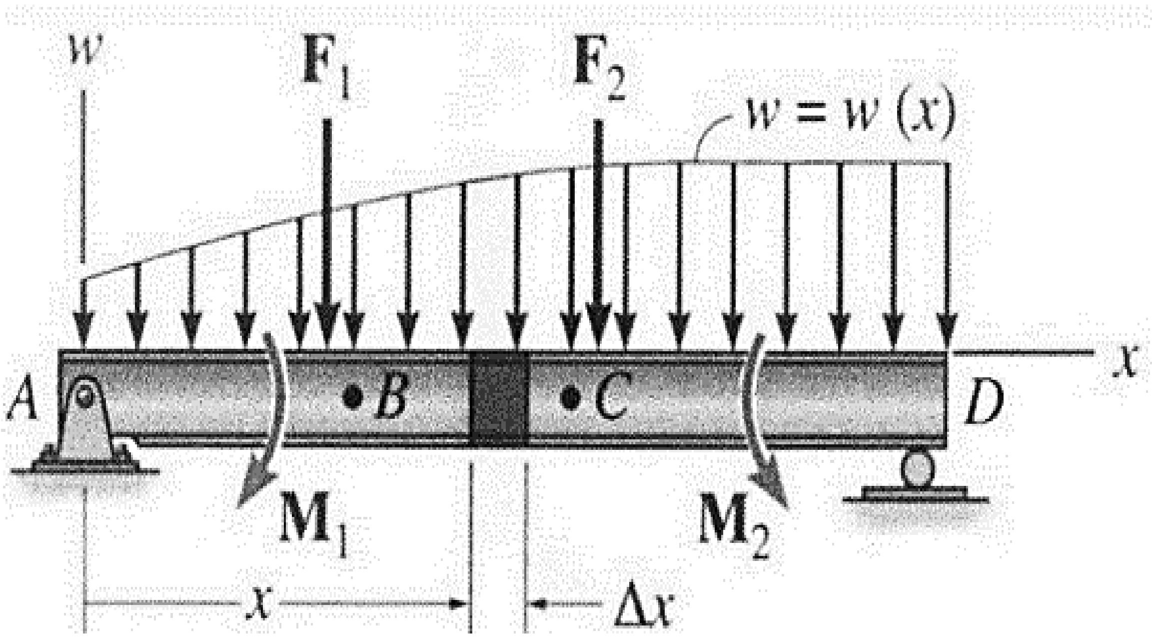

Figure 1. AD beam subjected to distributed load, concentrated force and moment.

The relationship between distributed load and shear force states that the change in shear force between points B and C is equal to the area under the distributed curve between those points (Hibbeler, 2010).

$$\Delta V_{BC} = -\int w_{(x)} dx \qquad (1)$$

The relationship between distributed load and shear force establishes that the change in moment B and C is equal to the change in shear within the BC region (Hibbeler, 2010).

$$\Delta M_{BC} = -\int V_{(x)} dx \qquad (2j)$$

METHODOLOGY

The research was of a quantitative, applied-type approach. The design was quasi-experimental, being evaluated in two moments (Pre-test and Post-test) (Hernández-Sampieri & Mendoza, 2018) distributing a total of 32 students equally in two study groups (control and experimental).

Only the experimental group was instructed in the use of the XVigas® software in addition to the classes given in both groups. A knowledge test with 20 items was used, considering four alternatives in each of the questions, of which only one was correct.

The final grade was in a twenty scale (0 to 20), taking as a maximum note the total sum of the correct answers and the minimum the absence of correct answers, according to the stipulations of the Peruvian higher education regulations. For the analysis of hypothesis contrast, the T - Student means test (α=0.05) was used for related groups (Pretest & Posttest comparisons) and the same test for independent groups (Control & Experimental Group).

Finally, a comparison was made between the best results of the three types of learning (cognitive, procedural and attitudinal) using an analysis of variance (ANVA - One way) at the same level of significance.

RESULTS

Experimental results

Comparisons of cognitive learning

The approach to the analysis of cognitive learning involved two types of comparisons. The one was made between the pre-test (before) and post-test (after) data of each of the two groups (control and experimental), using a T-test for paired groups.

In that comparison it was observed that there were no significant differences between the averages of the two sets of data of the grades obtained in the students of the control group, however, in the similar comparison of the experimental group there was statistical significance ($p<0.0001$) which determines the effectiveness of the use of XVigas® software in cognitive learning (Figure 2A).

However, to corroborate the effectiveness of this tool, the contrast between the pre- and post-test data between the two groups evaluated independently was also considered. Thus, significant differences were observed ($p=0.0004$) only between the post-test averages of the control group and the experimental group (Figure 2B).

This proves that the only different group was the post-test experimental group, where an average of 15,875 was observed (on a twenty scale (0 20), in accordance with the regulations of the Peruvian Ministry of Education).

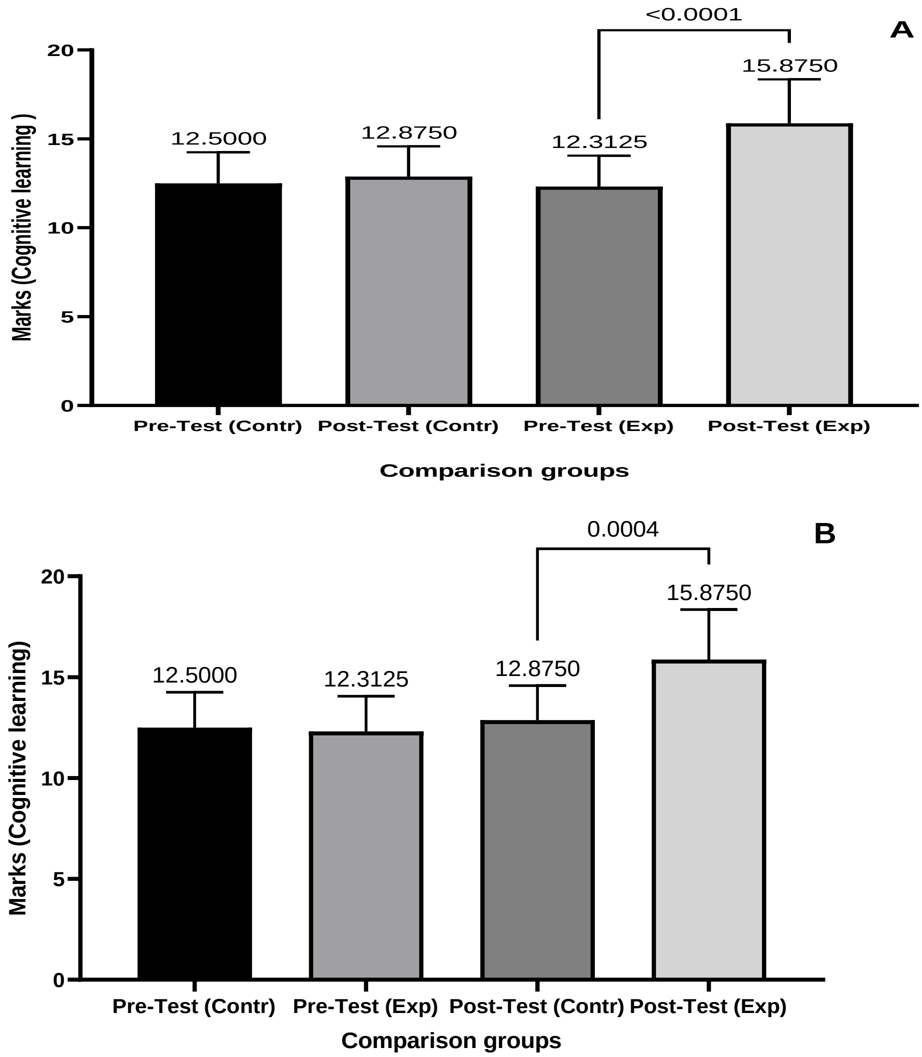

Figure 2. Verification of the differences of the disruptive strategies in the cognitive learning of isostatic beams using the XVigas® software. A. Paired comparisons (pre – post- test) using T test for related groups. B. Independent comparisons (control - experimental) by means of T test for independent groups. (α=0.05).

Procedural learning comparisons

Like the previous analysis, for comparisons of academic performance in procedural learning, only significant differences were observed in the contrast of the experimental group, where the average obtained by the students in the post-test (mean = 12.875) was statistically higher than the pre-test of that same group ($p<0.001$). There were no differences in the pre and post-test data sets of the control group (Figure 3A). When the averages of the two analysis groups were compared, it was seen that both the control group and the experimental group were statistically similar in the pre-test.

However, this did not occur in the post-test, where the average of the experimental group was significantly higher (p=0.04<0.05) (Figure 3B). This indicated that the use of XVigas® software in procedural learning had good results in the engineering students evaluated.

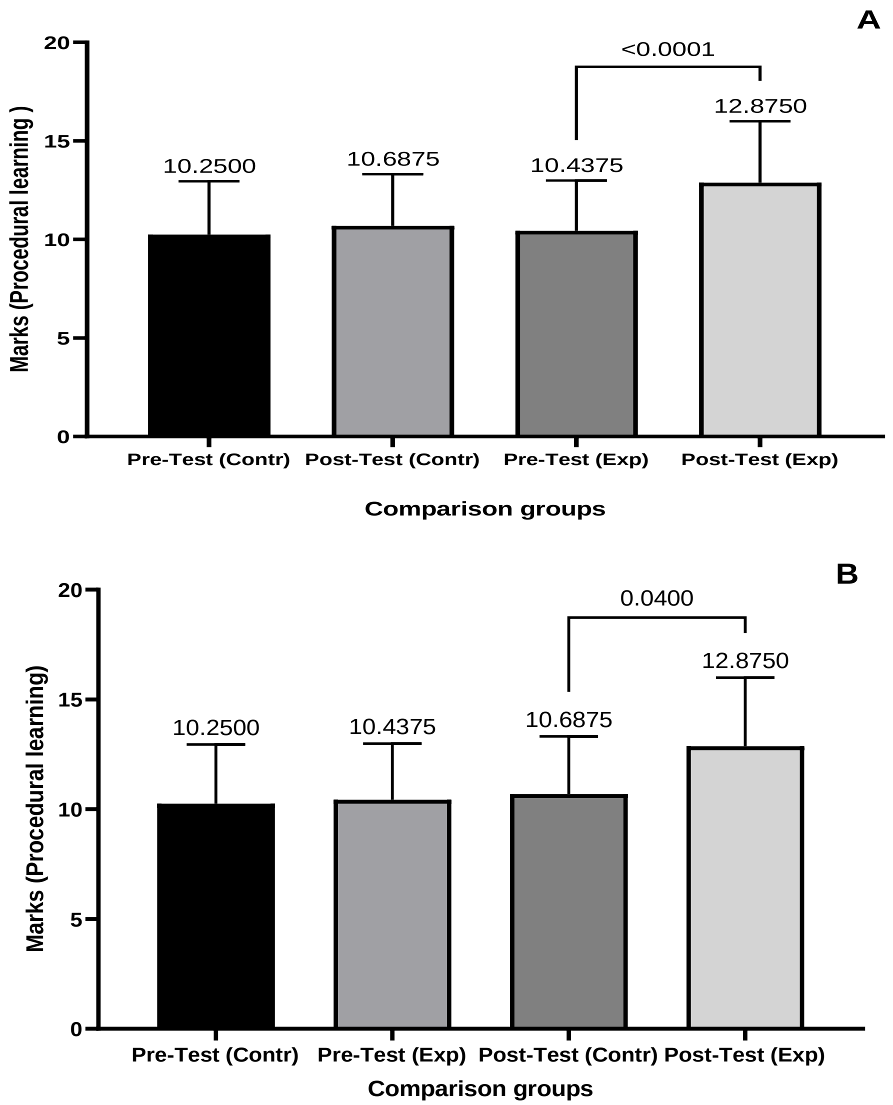

Figure 3. Verification of the differences of the disruptive strategies in the procedural learning of isostatic beams using the XVigas® software. A. Paired comparisons (pre – post-test) using T test for related groups. B. Independent comparisons (control - experimental) by means of T test for independent groups. (α=0.05).

Attitudinal learning comparisons

For the third evaluation component, attitudinal learning, a similar behavior to the previous two was also observed, with significant differences only between the paired data averages of the experimental group, where the average of the post-test evaluation was statistically higher than the pre-test (mean = 14.1875, p<0.0001) (Figure 4A).

On the other hand, in the independent group comparisons it was seen that there were only significant differences between the averages of the control and experimental groups of the post-test evaluation (p<0.0001) (Figure 4B). This result is interesting because it shows a positive variation in the students' attitudinal component, having arguments to give credit to the use of the XVigas® tool.

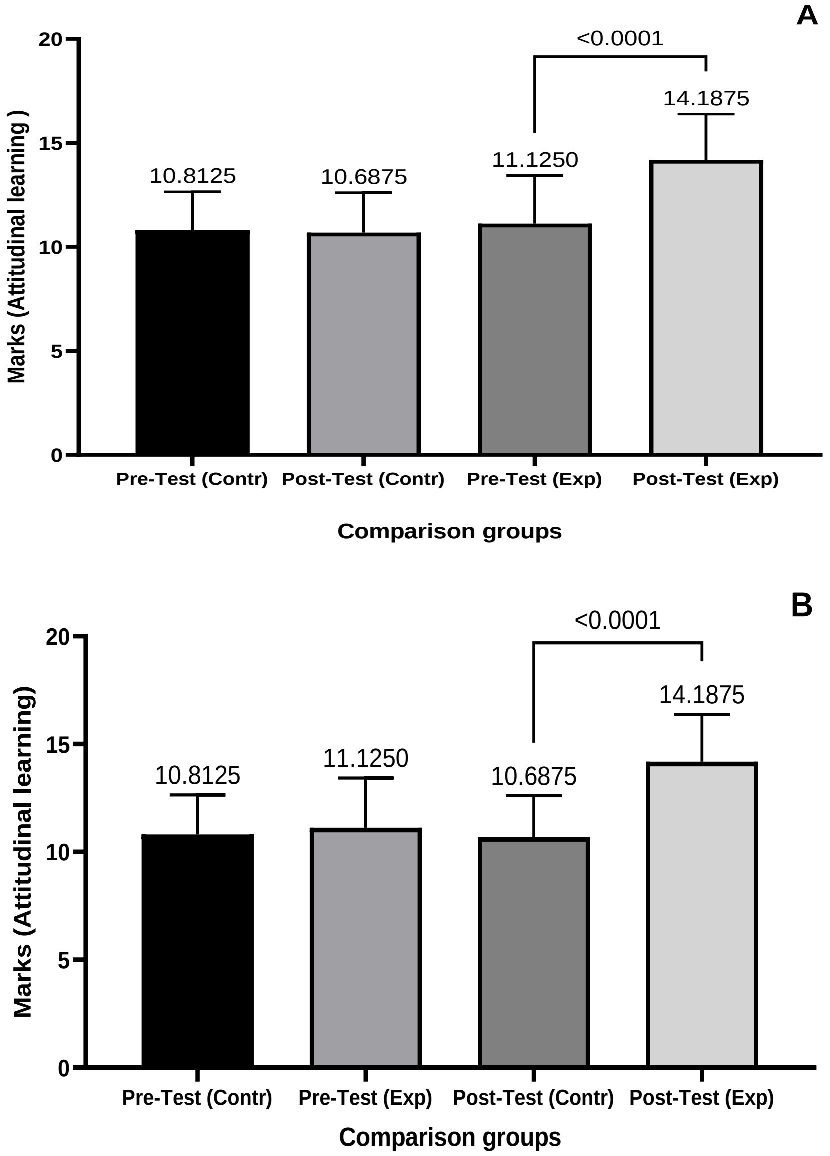

Figure 4. Checking the differences of disruptive strategies in attitudinal learning using XVigas® software A. Paired comparisons (pre – post-test) are using T test for related groups. B. Independent comparisons (control - experimental) by means of T test for independent groups. (α=0.05).

General results of the post-test learning

The results of the three evaluation components showed significant differences in all the contrasts, however, it was necessary to compare them among them. The analysis of variance revealed significant differences between the averages obtained in cognitive and procedural learning (p=0.0064<0.05), while with attitudinal learning there were none. Likewise, it was observed that between procedural and attitudinal learning there were no significant differences either (Figure 5).

Finally, taking into account the average obtained in each of the learning components, the descending order would be as follows: Cognitive learning, attitudinal learning and procedural learning. Resultados generales de los aprendizajes post- test.

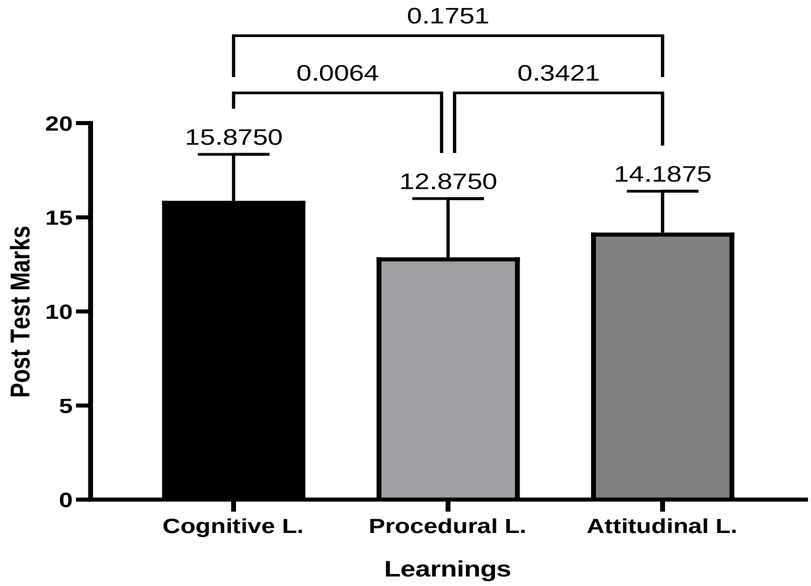

Figure 5. Verification of the differences of the evaluated learning of the experimental group after the use of XVigas® software in engineering students.

DISCUSSION AND CONCLUSIONS

It was evident that in all the contrasts the use of the XVigas® tool showed an improvement in the academic performance of the students evaluated, which is part of a disruptive strategy in the learning of isostatic beams, which allows to ratify what is suggested by the literature (Lobo et al., 2011; Soto Ortiz & Torres Gastelú, 2016; Morales Olivera & Blanco Sánchez, 2019; Espinosa & Idrobo, 2020), and it can be combined as part of a package of tools with potential use in other engineering topics.

An interesting aspect was to determine that the procedural learning was statistically different from the cognitive learning, which would put in discussion the effectiveness of the "know-how" process in these young people, alerting both teachers and university managers to the importance of emphasizing this type of learning, which could begin with teacher training, since it is likely to be a generational consequence of traditional university education (De la Fuente et al., 2008).

On the other hand, in a theoretical explanation there are reports that point to a greater association between cognitive and attitudinal learning (Boyle et al., 2003), which is consistent with the theories of M. David Merrill (1994) and Jan D. Vermunt (2005), leaving the procedural component in a position of double bonding since this aspect is explained in the sense that the apprentice gives to what he or she has learned (Zabala et al., 1994) and the possibilities of application in the exercise of his or her professional career.

Therefore, procedural learning is the cornerstone of meaningful learning, but it is probably the most difficult to achieve because "know-how" is inherent to every human being. Consequently, establishing precisely what should be empowered in students to improve performance in this learning would imply disaggregating the components that would make it understandable based on the functionality that it would have according to the expectations of each student.

On the other hand, from the teacher's perspective, the act of transmitting the potential applications of each one of the topics taught in the classrooms involves a high capacity to visualize and explain so that the student can discern the utilities and, according to his preference (in which the attitudinal component is placed) extend his conceptual learning to what he considers he must learn to "know how to do".

This circumstance leads to reflect that, one of the inevitable activities of teachers is "know how to do" understand students the 'why' could serve them what they learned and show them in a comprehensive manner the range of possibilities that would open in a labor market that changes rapidly and requires more and more skills in their workers.

In the light of these results, we could ask ourselves whether university teachers have not sufficiently developed their procedural didactic competencies, or whether it is perhaps a question of an educational system that has been derived from an educational model with a mixture of constructivism and behaviorism that conditions the weakness of this type of learning, or whether the latter is the cause of the former. These questions allow us to put on the table an aspect that has been little treated in academia: the inefficiency of the teaching processes.

Thus, Chireshe (2011) alluded to this situation explaining that the ineffectiveness of teaching -visualized in the performance- would be produced by an asynchronism of the priorities that teachers have with respect to that of students and could trigger even greater problems between these two educational actors (Zayac et al., 2020).

However, Scheerens (2016) deepened the theme indicating the need to theorize it by involving the planning processes, contingency theories, market dynamics and the role of cybernetics. This proposal is interesting because of the complexity of the variables to be analyzed and the need to establish the characteristics of the effectiveness of significant learning (Moges, 2014).

In any case, it is also important to explore more and better these aspects in university environments, taking into account the constant evolution of the environment of this knowledge society and depersonalization of education (Oliveira et al., 2019). Finally, it is concluded that: the use of the XVigas® tool proved to be an effective disruptive strategy in learning by isostatic beam content in engineering students.

It was also demonstrated that there was similarity of performance between cognitive and attitudinal learning. The procedural learning showed significant differences with the cognitive one, recommending deepening the study in this aspect, extending it towards the teachers' perspectives.

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