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MODEL BUILDING IN MACHINE ELEMENT EDUCATION

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ABSTRACT
In the teaching methodology many strategies have been suggested to achieve a better process of learning in Engineering's students, specifically in the Mechanical Engineering's Career. This paper adds a little modification to the standard education paradigm, using constructivism. The subject "Design of Machines Elements" is mostly based on the selection of mechanical components. This selection does not have a theoretical analysis but commonly it's based on empirical correlations where the rule is to follow an algorithm. The idea is that the student can to achieve a better knowledge making exercises such as the construction of mechanical transmissions, elevators, etc., fulfilling certain requirements exposed by the professor using drivers, gearboxes, pulleys, chains, general industrial equipment. These exercises increase the student's motivation and interest not only in designing but in learning to assemble mechanisms using standard machines elements, discussing their advantages and disadvantages.

Keywords: Constructivism, design

1 INTRODUCTION

Education's main objective is to achieve an observant being. Students must develop abilities that give them an objective vision of the reality [1]. On the other hand, to learn means to transform; it is a permanent change in the human being behavior as a result of practice and experience [2]. The teaching purpose is to promote the appropriated conditions for learning to take place [3].

The traditional educative model is based on an agreement "if you do the right thing,… I award you" [4], that comes from one kind of the approaches in the teaching - learning process known as behaviourism. Usually, students are concerned about what subject is going to be evaluated in the tests, so they study what they think that the professor will ask them with the only purpose of getting a better qualification, which usually causes them to miss the real meaning of subject.

Also, the cognitive approach is about the processes involved in the student's learning process, how the information is received, organized, processed and located [4] so, it's focused in how people learn.

In the constructivism approach, learning is a process where student builds new ideas based on present and past knowledge. Learning is set up to building our own knowledge from our own experiences. Students can work to clarify and to order their ideas and they can also tell their own conclusions to other students. Students have the opportunity to elaborate what they learned [5].

2 CURRENT STATE OF EDUCATION IN ENGINEERING

Engineers are problem solvers, they take a necessity and solve it, producing systems. When a necessities wide range spectrum exists, a varied number of specialties exist and usually, they complement each other, that's why engineers usually work in teams. The engineer's education must move between science and technology and to achieve it, it's not an easy task because we live in a changing world [4].

Prof. Rodolfo Milani, in a new coming book, makes observations to students next to graduate since he has detected certain deficiencies, such as: lack of understanding of the basic and elementary principles. They cannot determine the physical principles in a problem, consequently they can do no modeling and no solution is given. They cannot understand the physical sense of the equations. And usually, they give more importance to the mathematical calculations than to understand the real problem.

This is due to that student's self preparation to pass the evaluations, they only practice exercises alike the ones solved by the professor. In addition, the lack of understanding of the theoretical concepts is originated because the student has not connected them with his experience and previous knowledge.

3 CHARACTERISTICS OF THE SUBJECT OF DESIGN OF MACHINES ELEMENTS

Subject "Design of machines elements" covers the field from mechanical drawings and resistance of materials and it is where many standard mechanical elements' calculation is distinguished. This subject has been dictated under the standard scheme and it is divided in two parts: the first part is about shaft-hub connections, welding, screwed unions and spring design. The second part is about power transmission mechanisms, such as gears design, belts, pulleys, bearings selection, and transmission mechanisms analysis like gearboxes and planetary gearsets. The evaluation system includes exams to consolidate the theory, and a presentation of a methodology for problem solving. Also, the evaluation system includes projects to link engineering calculations with detail designing and drawings. The lack of knowledge in mechanical parts easily shows because the way they are represented, procedures of assembly and disassembling, etc. Usually, these projects have a perfect of calculation, but a poor detail designing and drawings.

In subject "Design of machines elements II", the concepts, deductions and theoretical analyses have been diminished. The lessons give standard procedures of calculation that follow a recipe for its solution. In order to increase the learning process, the constructivism is used to make emphasis in basic concepts where deficiencies have been observed in students, as well as to enhance the knowledge about assembly - disassembling, installation procedures, mechanical parts, etc.

4 APPLICATION OF THE SHIFTS OF PARADIGM

The idea of this paper is to make a register of the constructivism implementation explained in the previous section, but this application involves a shift of paradigm that links the classroom theory with reality. The strategy is to plan practical exercises and to register them. These exercises push the student's motivation to achieve significant knowledge.

4.1 Educational Models

The proposal of this paper is to design mechanical devices to improve and enhance the learning process, trying to integrate the practice and theory, where students are going to participate and construct their own knowledge.

This is not the first time that someone uses this methodology to achieve a better understanding in lessons dictated in classrooms. Professor T. Stathopoulus from the Concordia Kansas University, U.S.A., describes in an article the fabrication and use of two didactic models to illustrate the concepts of moments and forces in two and three dimensions [7]. In a Technical Center and Education of Mexico, Prof. Salvador Baltazar Murrieta, [6] helped by students, tries to create different physical demonstrative experiments, to show and share the learning process with other professors and students.

At Simón Bolívar University, in the Mechanical Engineering career, Prof. Renzo Boccardo, [4] along with other professors' support, developed demonstrative models for the subjects of resistance of materials, such as axial load model and Straight flexion model, etc. The results of these models use in classroom are reported in a book written by Prof. Boccardo and the general opinions are favorable and until the present day has not been any not-favorable aspect.

In "Design of Machines Elements" some didactic models for different lessons have been designed and developed, some of them have been built by students as projects evaluated the same subject. It represents a double learning: They learned how it works and how it is built. These models are the result of a personal effort of different professors in the area with the idea to improve and to facilitate the teaching and learning process.

The devices used in the "Design of elements machines" (figures 1):

- Planetary gearsets transmission, no ring
- Spur and helical gears and manual gearbox transmission

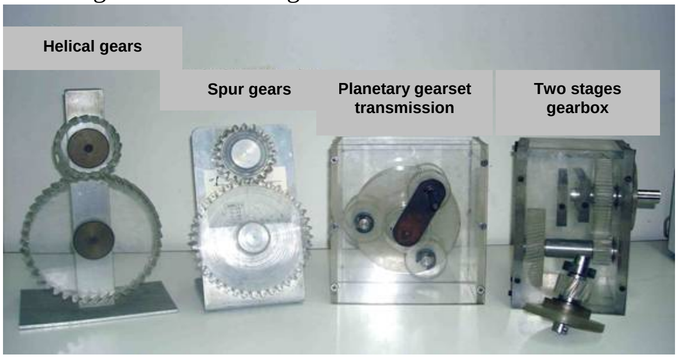

Figure 1 Educational Models developed in Simón Bolívar University

- Two stages gearbox and planetary gearsets transmission
- Automatic gearbox transmission, clutch and differential gearbox

4.2 Laboratory exercises

In the laboratory, an automatic gearbox transmission was recently acquired. The exercise consists disassembling and to assembling the gearbox transmission. This is done by a group of 2-5 students, helped and supervised by another student how works as a laboratory's assistance. In this exercise, students can see all the components that a real automobile gearbox involves. These way students get involved and familiar to procedures of disassembling and assembling of different mechanical parts. The

application of this exercise develops the motivation about the transmission's operation in many of them.
In order to complement this exercise, it has been developed a mechanism model like "MECANO" where the students must design a configuration and assemble the mechanisms. As a first exercise, it was decided to design an elevator mechanism using different electric motor and transmissions such as, chains or vee belts and some mechanical standard elements such as, bearings, housed bearings units, etc. As well we know the commercially existence of this models, the priority in the present paper is to develop our own low budget models and prototypes, adapted specifically to the "Design of Machines Elements" subject. The commercial parts list used in this exercise is the following one:

- One (1) electrical motor: 1,2 HP, 1640 rpm and two (2) 1/4 HP, 1445 rpm
- Two (2) worm gearbox, ratio 1/60 and one (1), ratio 1/30.
- Four (4) pairs of pulleys, ratios: 0.57, 0,66 and 0.86
- Three (3) pairs of sprockets, ratios: 0.5, 0,66 and 0.75
- Ten (10) housed bearings units models P204 and P205.

List of parts developed in the lab for the exercise:

- Twelve (12) square section tubes 38" length and four (4) square section tubes 72" length, drilled each two (2) inches.
- Four (4) corner parts, one (1) axle shaft and one (1) spool
- Eight (8) reinforcement plates for the structure, thickness: ¼".
- Three (3) steel plates thickness: 3/8", use to electric motor support bases.

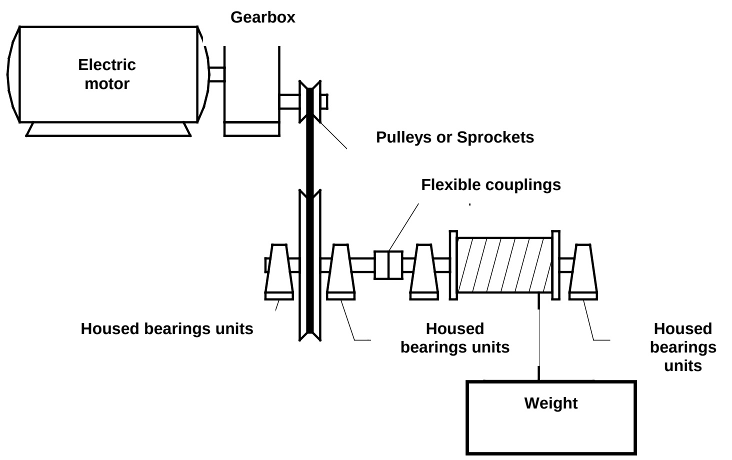

Figure 2 Proposed exercise

The idea of the exercise is that given some parameters such as electric motor's power and r.p.m., students must design the appropriate mechanical configuration that can lift up a weight at constant speed. To achieve it, students must use the existing mechanical parts and they are to consider the electric motor's and gearboxes's efficiencies. Figure 3 shows an example of what students can assemble.

4.3 Student's Opinion

After laboratory's exercises (figure 4), it was taken an opinion's register of the students through an exit poll. The polls collect each student's opinion about the exercise.
The commentaries registered in the opinion polls were:

a. - About educational models:

"Educational models like the planetary gearset helps to understand the mechanism itself, sometimes the drawings on the blackboard or in the textbooks are not really clear"

"The devices are completely illustrative, I would like that the evaluations were made using these mechanical models. It's easier to understand the mechanism when you can manipulate it and take it in with your hands than instead of looking at an image"

"The mechanical models illustrate the concepts given in the classroom, but not necessarily how they are connected to other equipment such as, electric motors, etc"

"In the classroom, I usually try to imagine how it works. With the model it's really easy to understand what happens"

b. - Automatic gearbox transmission and clutch exercise:

"This exercise illustrates the automatic gearbox operation and it shows how difficult and complex a real mechanism can be, it is definitely superior to the educational models shown in the classroom"

"The exercise complements the visualization of many components shown in the classroom. It is possible to get the real mechanism and take it to a model so, it is possible to understand the modeling simplifications"

Figure 3 Students doing the exercise

"Any practical activity in a subject is welcome. A student, who does not have enough interest, can spend the entire career without manipulating a screwdriver"

"In my case, first I made the automatic gearbox exercise and later I saw the theoretical model in class. I really understood what was shown in the classroom and of course the problem that we were solving"

c. - Educational model type "MECANO". The following observations were registered:

"The exercise prints a didactic-practical character on the theoretical formation shown in classroom. Definitively, the best way to learn is doing it"

"The exercise enhances my mechanical knowledge, because it allows an approaching to the machines world. In addition, improve my abilities on assembling and developing real and functional devices"

"With this exercise, the student is capable of understanding and analyzing a transmission system in real life"

"It is a situation that we could face in the work field. On the other hand, it's very important the team work and it is something that we have to learn"

5 CONCLUSIONS AND RECOMMENDATIONS

The use of many teaching-learning methods in education, allows the improvement of the possibility for students to get skills that lead them to achieve significant learning's.

These exercises link the theoretical and practical knowledge. So, students' motivation increases and learning interest wakes up, also the physical phenomenon understanding is enhanced. This link is very well welcomed by students.

Students' opinions polls were highly positive and encouraging, recommending the continuous use of these techniques to improve the learning process in classrooms.

This paper shows some ways to wake up the students' motivation connecting the theoretical and practical aspects; the constructivism methodology represents a different way that could be incorporated in other areas of knowledge in engineering, for example: heat transfer, thermodynamics, hydraulic, etc.

It is possible to offer internships for students interested in designing and making educational models of different topics; therefore a double learning would be fulfilled. Students, who design and make the mechanical devices, will understand and be able to explain the phenomenon, and the user students will be able to observe, analyze and to understand it.

REFERENCES

[1] M. E. Espino, *La participación del estudiante en el aula: factor de desarrollo intelectual y moral, y de formación de compromiso social en el aula.* Available: http://www.mxl.cetys.mx/info/dired/dcsa1.htm [Accessed on 2000], (1995)

[2] Ertmer, Peggy A.; Newby, Timothy J. *Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from a Design Perspective. Performance Improvement Quarterly*, 1993, 6(4), pp.50-72,.

[3] P. Vela Mesa. *La reconstrucción de la cultura en el aula: Estrategia para favorecer el aprendizaje significativo en el CETYS*. Available: http://www.mxl.cetys.mx/info/dired/dcsa3.htm [Accessed on 2000], (1995)

[4] R. Boccardo, *Nuevos Modelos del Proceso de Enseñanza – Aprendizaje Aplicados a la Docencia en Ingeniería Mecánica* , (vol. 1, pp. 17, 1999)

[5] Ormrod, J. E., *Educational Psychology: Developing Learners,* (Fourth Edition, pp. 227-232, 2003)

[6] S. Baltazar Murrieta, *Elaboración – Exhibición de un experimento y su influencia en el aprendizaje de la física*. Available: http:/orca.ens.cetys.mx/coco195/Eda95-2.htm [Accessed on 2002], (1998)

[7] T. Stathopoulos, *Simple Demostration Device for the Statics Course, Engineering Education*, 1989, pp 439-440.

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