Artícle **Journal of Technological Development**
December, 2021 Vol.5 No.16 22-28

Development of a practical module created with 3D printing for the education and training of students in the oil area maintenance career

Elaboración de un módulo práctico creado con impresión 3D para la formación y capacitación de alumnos en la carrera de mantenimiento área petróleo

LICONA-GONZÁLEZ, Marlon†*, QUIROZ-RODRÍGUEZ, Adolfo, GALINDO-MENTLE, Margarita and BLAS-SÁNCHEZ, Luis Ángel

Universidad Tecnológica de Xicotepec de Juárez, Mexico.

ID 1st Author: *Marlon, Licona-González* / **ORC ID:** 0000-0001-7829-4457, **Researcher ID Thomson:** AAR-6259-2021, **arXiv Author ID:** marlon1987, **CVU CONACYT-ID:** 1138370

ID 1st Co-author: *Adolfo, Quiroz-Rodríguez* / **ORC ID:** 0000-0002-9685-9455, **Researcher ID Thomson:** S-9189-2018, **arXiv Author ID:** adolfo-79, **CVU CONACYT ID:** 105471

ID 2nd Co-author: *Margarita, Galindo-Mentle* / **ORC ID:** 0000-0001-5390-5960, **Researcher ID Thomson:** S-9202-2018, **arXiv Author ID:** MargaritaG, **CVU CONACYT-ID:** 160164

ID 3rd Co-author: *Luis Ángel, Blas-Sánchez* / **ORC ID:** 0000-0003-3313-8551, **Researcher ID Thomson:** AAX-2475-2021, **arXiv Author ID:** AnghelBlas, **CVU CONACYT ID:** 554052

DOI: 10.35429/JTD.2021.16.5.22.28 Received July 20, 2021; Accepted December 30, 2021

Abstract

This article is based on an experience carried out in the classroom for the drilling of wells in the Oil Area Maintenance career. The creation of this practical module was carried out thanks to the design and 3D printing and its objective is to motivate in the search for new teaching strategies using technology that is currently available, with this module it is intended that the student visualize the process to follow for the correct assembly of a preventive safety system used in the oil and gas industry in order to make classroom classes more dynamic and practical and make the process easier to understand as opposed to just looking at images on slides which is the most common method of teaching for a career that is new to an institution. The contribution of this method in teaching and learning is reflected through the practices and the exams that the students take and it is demonstrated that it is no longer just about memorizing a process, but about knowing the why of the steps to follow the process.

PLA, 3D Printing, Preventor

Resumen

El presente artículo parte de una experiencia llevada a cabo en aula para la materia de perforación de pozos en la carrera de Mantenimiento Área Petróleo. La creación de este módulo práctico se realizó gracias al diseño e impresión en 3D y tiene como objetivo motivar en la búsqueda de nuevas estrategias de enseñanza utilizando tecnología que se encuentra actualmente al alcance, con este módulo se pretende que el alumno visualice el proceso a seguir para el correcto armado de un sistema de seguridad preventor utilizado en la industria del petróleo y gas con la finalidad de hacer más dinámicas y prácticas las clases en aula y que el proceso sea más fácil de comprender a diferencia de solo mirar imágenes en diapositivas que es el método más común de enseñanza para una carrera que es nueva en una institución. La contribución de este método en la enseñanza y aprendizaje se ve reflejado en las prácticas y en los exámenes que los alumnos realizan y queda demostrado que ya no se trata solo de memorizar un proceso si no de saber el porqué de los pasos para seguir el proceso.

PLA, Impresión 3D, Preventor

Citation: LICONA-GONZÁLEZ, Marlon, QUIROZ-RODRÍGUEZ, Adolfo, GALINDO-MENTLE, Margarita and BLAS-SÁNCHEZ, Luis Ángel. Development of a practical module created with 3D printing for the education and training of students in the oil area maintenance career. Journal of Technological Development. 2021. 5-16:22-28.

* Correspondence to Author (Email: marlon.licona@utxicotepec.edu.mx)
† Researcher contributing first author

Introduction

Teaching in our country has been stagnant in some practical aspects, especially in universities that are just developing or that are practically new, the resources that reach them are often insufficient to be able to acquire laboratory material. That is why, based on this need presented in the Oil area Maintenance career of the Universidad Tecnológica de Xicotepec de Juárez, the creation of didactic material was proposed, this material can be considered as an industrial layman since from different pieces made with a 3D printer, the sequence of a practice can be shown starting from a real case regarding the assembly of a preventive security system.

Currently there are no practical modules in public institutions that serve as a guide for the assembly of a preventive system or any process in the oil industry, in cases like this the traditional method is used, which is teaching through slides and images, there are also Simulators, but these are out of the reach of most institutions since their cost is very high and only oil companies can afford to acquire them for their personnel training.

Taking into account the above, the practical module was designed and built, which in addition to having an accessible cost for its elaboration, is intuitive for the student since it allows them to visualize the sequence of the assembly of a preventer starting from a real practical case step by step. The module has the characteristic of being made of plastic (PLA) polylactic acid which is a thermoplastic biopolymer whose precursor molecule is lactic acid. Due to its biodegradability, barrier properties and biocompatibility, this biopolymer has found numerous applications since it has an unusual wide range of properties, from the amorphous state to the crystalline state; properties that can be achieved by manipulating mixtures between the D (-) and L (+) isomers, molecular weights, and copolymerization. (Serna & Albán, 2003)

Methods

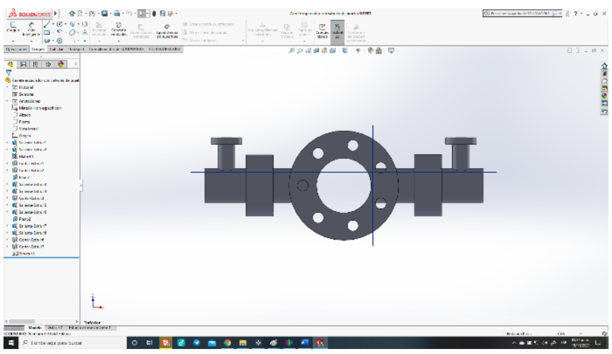
The use of 3D printing or additive manufacturing is not new, however, it has not been taken advantage enough of it to create solutions in the educational field, although it is known that 3D printing has been among us for more than 35 years, many institutions and people are unaware of this technology and how interesting can be to find solutions to everyday problems. The first variables to consider are those related to cost, the acquisition of a 3D printer machine may consider an outlay for the institution, however, the benefits will be greater taking into account the amount of teaching material that can be made with it.

Other variables to take into account are:

- Print volume.
- Material.
- Accuracy.
- Technology.

Regarding the volume of printing, we must consider the size of the pieces to be printed so based on that we can choose a printer with adequate printing volumes to fullfill the needs, once we know the most suitable size according our needs, we must analyze which is the most feasible material for the realization of the pieces, in the market there are different materials used for 3D printing such as ABS, PLA, PETG, TPU, among others, for this case PLA will be used. The precision of the printing will depend on the type of nozzle that is going to be used, normally 3D printers come with a standard nozzle size of 0.4mm, this can be changed for a smaller nozzle if a finish with thinner layers is required. or a larger nozzle when no detail is needed when printing, it is also advisable to take into account that if the piece or pieces to be printed are very large, they may take longer if the nozzle is smaller than 0.4mm although the quality will be higher. If what is needed is speed and not quality, it is advisable to use a 0.6mm nozzle or biggers, in the case of this practical module a 0.4mm nozzle will be used, which is the standard measure and the pieces are not of considerable dimensions.

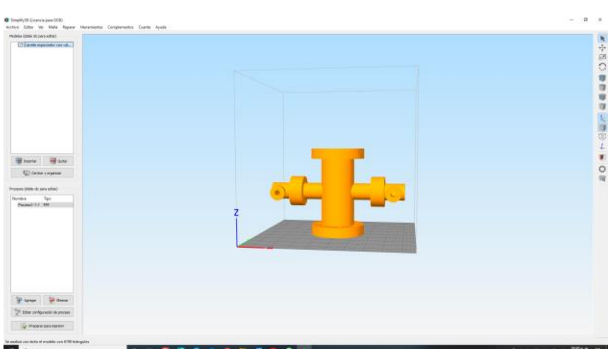
Finally, we must consider the type of technology in the machine, there are machines that support network connections and can be manipulated remotely, in the same way the type of machine must be taken into account, if it is delta or Cartesian in this case, the printer used for the module was an Ender 3 Cartesian printer with a printing volume of 230mmx230mmx250mm, which has an approximate cost of 250 USD. For the realization of the module, the design that will be made in the Solidworks program must be taken into account, in this program, we will design the necessary parts of the module.



Graphic 1 SolidWorks interface, plan view of a spacer spool with test valves.
Source: Author´s contribution (October 2021)

Each of the pieces to be made are different in shape and the dimensions of them must be accurate on detail since they fit one with another.

Once the pieces have been designed, we will proceed to verify if there is any design error through the laminator that will be used to print them, the laminator or printing program is Simplify 3D, this laminator is one of the best laminators on the market because the quality with which parts are printed. This laminator has its own characteristics that not other program has, such as allowing different printing processes that change according to the height.



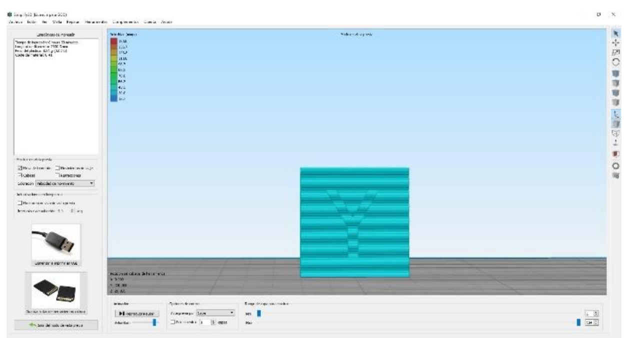
Graphic 2 Preview of a spacer spool with test valves in Simplify 3D
Source: Author´s contribution (October 2021)

Print parameter settings

Once the design has been stablished in the laminator program, the printing parameters must be configured, such as:

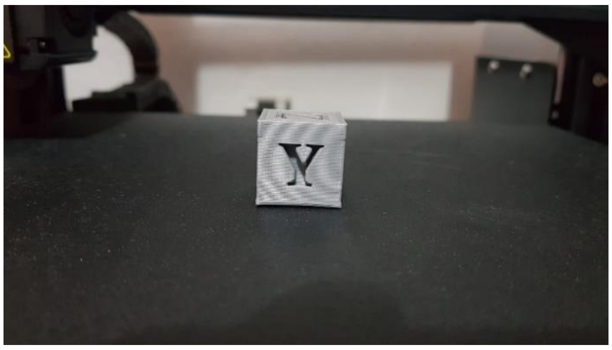
- Layer.
- Infill.
- Support.
- Temperature.
- Cooling.
- Speeds.
- Addition.

Each of the aforementioned parameters has to be tested before starting with the module parts, in the same way the printing platform has to be calibrated and the axes adjusted, for this reason a calibration cube must be printed.



Graphic 3 Preview of the calibrator cube in Simplify 3D
Source: Author´s contribution (October 2021)

In the preview of the laminator, we can observe how the cube is forming layer by layer and thus correct errors in the configuration if there were any, once the simulation was run in the preview, the file must be saved in a format called G code so the printer can recognize it and start the printing process.

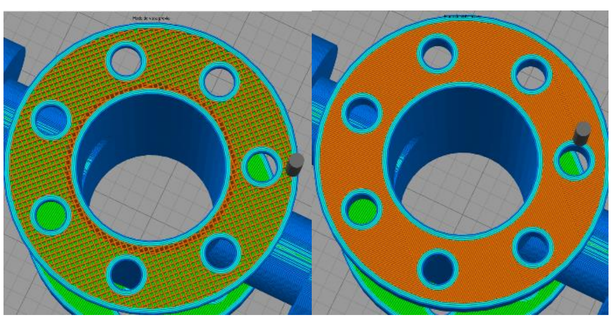


Graphic 4 Printed calibrator cube
Source: Author´s contribution (October 2021)

Thanks to the printed cube it can be observed in which sectors there are errors or if there was any part that detached from the printing platform, we can even observe problems that have to do with temperature or printing speed, this first printed cube will help us to improve some parameters that we consider have an opportunity area.

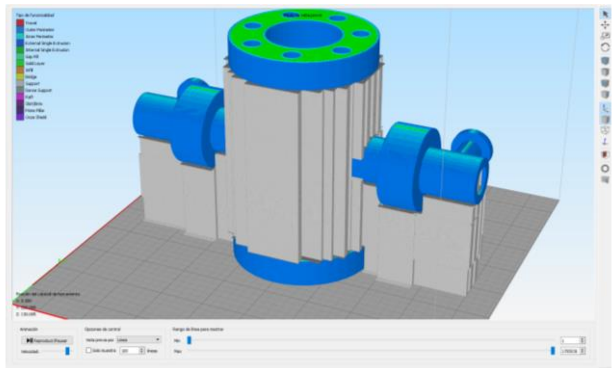
Once the parameters have been improved and the check with a second calibration cube has been made, we will proceed to load the part or parts of the module to the laminator program this will depend on whether we want to print separately or several parts at the same time, in this case each part will be printed separately. To start we must add a process and make specific configurations for the piece to be printed, these configurations will already be minor thanks to the fact that the calibration cube was previously printed.

The first configuration to take into account for the module piece is the layer height and the infill, it will work with a layer height of .2mm and the infill section indicates whether the piece will be hollow, semi-solid or solid through an infill indicator ranging from 1 to 100, for the module pieces an infill of 30% will be used.



Graphic 5 Example: 30% fill (left) 100% fill (right)
Source: Author´s contribution (October 2021)

The second parameter that must be configured is the support, this parameter is important because there are parts of the pieces that protrude, in the same way there is an indicator from 1 to 100 that will allow to choose how dense the support will be, it must also be enable the raft section that will allow the support to be generated on top of it to prevent it from collapsing.



Graphic 6 Support (gray color)
Source: Author´s contribution (October 2021)

The third parameter to configure is the temperature, both the temperature of the nozzle and the temperature of the printing platform must be taken into account to prevent the piece from peeling off, these parameters vary according to the material, in this case as the material is PLA It will start with a 190 ° C nozzle temperature that will gradually increase in the first layers, until it reaches 210 ° C, the platform temperature will remain at 60 ° C.

Layer	Temperature	Platform
First layer	190°C	60°C
Second layer	195°C	
Third layer	200°C	
Fourth layer	205°C	
Fifth layer	210°C	

Table 1 Temperature scales per layer
Source: Author´s contribution (October 2021)

The fourth parameter will be the cooling, that is, the speed with which the fan will cool the layer, normally the first layer does not cool down in order to obtain a better grip on the printing platform, after the first layer the fan will gradually increase its speed.

Layer	Cooling speed
First layer	0%
Second layer	50%
Third layer	100%

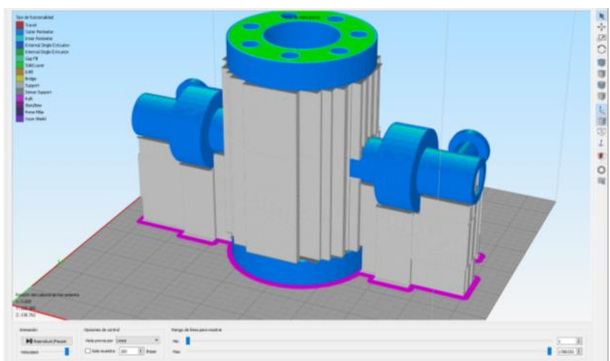
Table 2 Cooling rates per layer
Source: Author´s contribution (October 2021)

The fifth parameter is the printing speed, the quality of the part also depends on this parameter, at a higher speed detail can be lost and imperfections can be generated.

Contour speed	75%
infill speed	90%
Support speed	85%
X / Y axis speed	150mm/s
Z axis speed	16.7mm/s

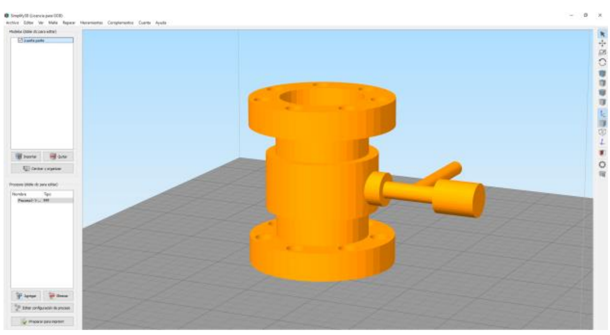
Table 3 Print speeds.
Source: Author´s contribution (October 2021)

The sixth parameter is the addition, this allows us to create a raft which will serve to adhere the piece and the supports to the printing platform and prevent the piece from falling or any support from collapsing during the printing process.

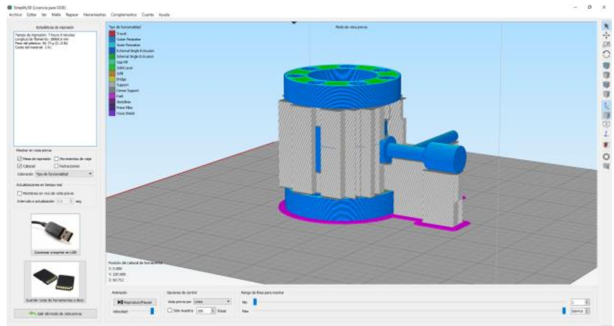


Graphic 7 Raft (pink color)
Source: Author´s contribution (October 2021)

Once all the configurations have been made, each of the pieces will be printed, repeating or improving the parameters as the case may be, since each piece can demand specific requirements that must be established to avoid errors during printing.



Graphic 8 Spool with test valves without support configuration and addition
Source: Author´s contribution (October 2021)



Graphic 9 Spool with test valves configured
Source: Author´s contribution (October 2021)

Results

All the designed pieces were printed, the parameters were the same for all the pieces, the printing times were as follows.

Part	Time
Double ram	10 hrs
Simple ram	7 hrs
Campaign	3 hrs
Spacer spool	4 hrs
Valve spool	6 hrs
Annular preventer	18 hrs
Casing pipes	3 hrs
Drill Pipes	2:30 hrs
Drill Collars	2 hrs
Test valves	3:30 hrs

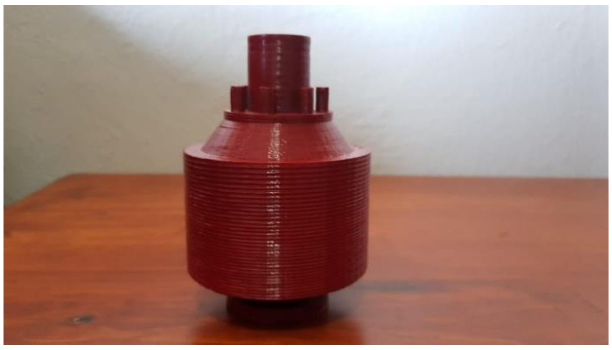
Table 4 Printing times by pieces.
Source: Author´s contribution (October 2021)

Once all the pieces of the module are printed, we proceed to sand the parts where they fit each with other so that the assembly is easier to carry out and the student does not use excessive force and can break them.

This module works through practical cases that are made known to the student, depending on each case the student will carry out the corresponding assembly of the pieces and the teacher in charge of the subject will proceed to review the assembly, giving feedback if necessary, in the same way, this module can be used for personnel training in the oil and gas industry, with this we not only limit ourselves to looking at images through slides, but we can interact in real time with something that is tangible and easier to understand.

ISSN 2531-2960

Graphic 10 Spacer spool
Source: Author´s contribution (October 2021)



Graphic 11 Annular preventer
Source: Author´s contribution (October 2021)

Graphic 12 Simple ram
Source: Author´s contribution (October 2021)

Graphic 13 Double ram
Source: Author´s contribution (October 2021)

Basic assembly of the module

Depending on the practical case, the assembly may be different. The basic assembly of the module is shown below.

Graphic 14 Double and single ram socket
Source: Author´s contribution (October 2021)

Graphic 15 Double and single ram socket with spool
Source: Author´s contribution (October 2021)

Graphic 16 Double and single ram socket with annular preventer spool
Source: Author´s contribution (October 2021)

Graphic 17 Double and single ram socket with spool and waterline.
Source: Author´s contribution (October 2021)

Conclusions

The teaching process is a very complex path, new ways of teaching have to be explored so that the student can understand situations from practical cases and these can serve in the future to have a broad overview in the productive sector.

With the proposal of this teaching strategy, discussions that favor the comprehension of the topics in students are generated, it fosters also the exchange of ideas and points of view that broadens the knowledge providing a new source of information and generating a more meaninful learning process.

The teaching environment that is intended to be built with this module not only refers to the means or resources, but also the forms of interaction and exchanges in a group.

This module is only a part of what is desired to create in the future, more pieces will be added and in the same way it is intended to be replicated in other subjects that do not have the necessary equipment to carry out practices, there are areas for improvement in terms of materials and the time consumption, the use of recycled material is considered, it is considered also to take this module to companies that carry out work in the oil sector in order to adequately train their personnel.

Acknowledgment

This work was carried out under the sponsorship of the Universidad Tecnológica de Xicotepec de Júarez for the Industrial Maintenance and Petroleum career. The support provided is appreciated.

Also, we thank Rocio Santos Martínez for her support in the translation of this work.

References

Beltrán Gómez, C. Y., & Villamarín Origua, Y. D. (2021). Diseño de Guías para el aprendizaje en Fábrica Didáctica a partir de caso de estudio para la Asignatura Gestión Logística 4.0.

Davini, M. C. (2008). Métodos de enseñanza. Didáctica general para maestros y profesores. Buenos Aires: Santillana.

Gutierrez Franco, C. K., & Vasquez Ramos, M. (2021). Centro de Formación e Investigación Agrícola para el Desarrollo de la Agricultura Familiar en el distrito de Santiago-Ica.

Litwin, E. (2002). Las nuevas tecnologías y las prácticas de la enseñanza en la universidad.

Prados, F., Boada, I., Poch, J., Soler, J., & Soler, J. (2004). El e-learning como complemento a las clases presenciales un caso práctico: el proyecto ACME. In trabajo presentado en el Congreso Virtual Educa.

Ruiz Jiménez, E. A. (2021). Diseño de un modelo de gestión de proyectos con la integración de Industria 4.0 para mejorar la productividad de la industria manufacturera en la Región Occidental de la Sabana de Bogotá.

Solórzano, A. D. L. (2021). Tesis de Doctorado en Diseño UP recomendada para su publicación: Trama, aunque sea urdimbre*. Las transformaciones de las representaciones visuales. Cuadernos del Centro de Estudios de Diseño y Comunicación, (126).

Serna, L., & Albán, F. (2003). Polylactic acid (PLA): Properties and applications. Engineering and competitiveness, 5(1), 16-26.

Ventura, A. C. (2011). Estilos de aprendizaje y prácticas de enseñanza en la universidad: Un binomio que sustenta la calidad educativa. Perfiles educativos, 33(SPE), 142-154.