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Use of a techno-pedagogical model in the teaching of Physics

Uso de un modelo tecno-pedagógico en la enseñanza de la Física

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Abstract

The challenges of education in the XXI century are diverse and multifactorial; now if we add that due to the new normality caused by the Covid-19, the importance of the use of technologies as an indispensable tool to continue with the educational process is retaken. However, different investigations have shown that if these are not correctly based, the results may not be the best, hence the importance of the use of techno-pedagogical models, therefore the objective of this study was to implement the TPACK Model in the teaching-learning of the subject of Physics III in the National School College of Sciences and Humanities (ENCCH) in order to promote meaningful and scientific learning, For this purpose, a non- probabilistic sample of 42 students from the Vallejo campus was used, with the purpose of promoting significant and scientific learning, in which approaches such as the flipped classroom, Bloom's taxonomy and the learning cone were integrated, obtaining that a significant number of young people achieved higher order learning levels, therefore it is deduced that this model is a feasible alternative to consolidate knowledge in a non-face-to-face modality.

Learning, Fluids, Bloom's taxonomy

Resumen

Los desafíos de la educación en el siglo XXI son diversos y multifactoriales; ahora si le sumamos que debido a la nueva normalidad ocasionada por el Covid-19, se retoma la importancia del uso de las tecnologías como una herramienta indispensable para proseguir con el proceso educativo. Sin embargo, distintas investigaciones han demostrado que si estas no estan fundamentadas de manera correcta posiblemente los resultados no son los mejores, de ahí la importancia del uso de modelos tecno pedagógicos, por ello el objetivo de este estudio fue implementar el Modelo TPACK en la enseñanza-aprendizaje de la asignatura de Física III en la Escuela Nacional Colegio de Ciencias y Humanidades (ENCCH) con la finalidad de promover aprendizajes significativos y científicos, para ello se empleó una muestra no probabilística de 42 alumnos del plantel Vallejo, con la finalidad de promover aprendizajes significativos y científicos, en el que se integraron enfoques como el aula invertida, la taxonomía de Bloom y el cono de aprendizaje, obteniendo que un número significativo de los jóvenes lograron niveles de aprendizajes de orden superior, por ello se deduce que este modelo es una alternativa factible para consolidar conocimientos en una modalidad no presencial.

Aprendizaje, Fluidos, Taxonomía de Bloom

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Introduction

In Mexico at the beginning of the year 2020 education faced different changes, among them and the most radical was that classes took place entirely in virtual scenarios that challenge our ability to adapt (Ruíz, 2020), which forced teachers to develop activities through different technological platforms, some of them were Google Classroom, Meet, Facebook, Zoom and internal platforms of each institution, among others (Hernández, 2020).

Based on the above, it was necessary to face, in a few weeks, the transformation of education towards the adoption of Information and Communication Technologies (ICT) (Said, Marcano & Garzón, 2021). However, virtual education not only requires the use of technological tools, but also the use of methodologies that improve the interaction between the student and the teacher, thus reducing the distance gap (Medina, 2021, p.1).

From the above perspective, it is necessary that teachers are updated in networked training environments, in tools to communicate, in the design of interactive and collaborative content, which is accessible from any device, and thus take advantage of the multiple advantages that these instruments have in education (Castellanos, Sanchez & Calderero, 2017), due to the fact that they have multiple advantages, among which stand out that of promoting autonomy, increasing motivation, since they depend less on their teachers and at the same time encourages cooperative work (Flores, 2017).

However, despite the multiple technological tools that exist and their benefits, there are still a considerable number of teachers who do not use them or do not do it properly, perhaps one of the reasons is due to the lack of knowledge to incorporate them in the classroom or the little or the little or no pedagogical training to implement these technologies (Monsiváis, McAnally & Lavigne, 2014), therefore, teachers face the need for techno-pedagogical training, with the purpose of developing skills that allow them to adapt to an online modality (Garduño & Salgado, 2020).

It is evident then, that technological knowledge acquires a fundamental role for the creation of educational virtual spaces and the development of skills in students (Salas, 2019), hence, models are required to help teachers not only to employ ICT in their practice, but also to know when and how to use these resources to ensure that students achieve meaningful learning.

This research focused on the subject of Physics, considered by a large part of the students difficult to understand possibly, due to its relationship with mathematics and its abstract concepts, which makes it difficult to achieve meaningful learning. In addition, if the words of Calderón, et al. (2016) that alludes to the fact that the subject of Physics shows the lowest percentage of use of ICT and in which, the explanations are made through the blackboard as the only tool and in turn in most cases the use of the internet is limits in the search for information, computers to project some presentations and videos; turning it into a tedious and boring subject for the students, for not finding any relationship with its context.

Based on the above, it is essential that teachers who teach the subject of Physics are updated not only in the use of ICT, but also in aspects that allow them to integrate these instruments in the didactic process, since it must be understood that current educational environments must face the challenges posed by the globalized society. Therefore, it involves betting on a modernized and dynamic teaching process, which provides learning tools and trains young people, in order to live in a highly changing and technified society (Ayón & Víctores, 2020, p.7).

General objective

Implement the TPACK Model in the teaching-learning process of the Physics III subject, at the Escuela Nacional Colegio de Ciencias y Humanidades (ENCCH), in order to promote meaningful and scientific learning in students.

Specific objectives

- Identify the appropriate activities to achieve the learning proposed in the Physics III study program.

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- Choose the technological tools that adjust to the disciplinary and pedagogical approach that contribute to the achievement of meaningful learning.

TPACK Model

From the above perspective, teachers can update school activities and educational practices through techno-pedagogical models, since they integrate technological, pedagogical and disciplinary knowledge that facilitate the creation of innovative and creative spaces for learning and teaching.

Among them, the TPACK (Technological Pedagogical Content Knowledge) model created by Mishra in 2006 stands out, which was developed from the PCK (Pedagogical Content Knowledge) model formulated by Shulman in 1986, since this archetype has somehow modified the way of doing things and of course, the teaching-learning process has not been the exception (Leiva, Ugalde & Llorente, 2018), which is presented in Figure 1.

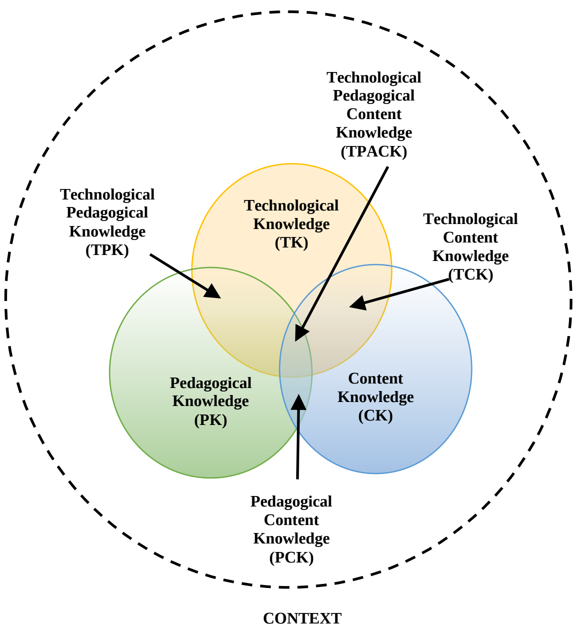

Figure 1 TPACK model
Source: García, Domínguez & Stipcich (2014, p. 84).

Based on García, Domínguez & Stipcich, (2014) and Salas, (2019) allude that the TPACK model studies three types of knowledge and their interrelationships, as stated below:

1. **Disciplinary Knowledge:** It is composed of the models, theories, laws, principles and concepts of the discipline.

2. **Pedagogical Knowledge:** It refers to the knowledge of the processes, methodologies and practices that constitute the teaching- learning process.

3. **Technological Knowledge:** This item focuses on two aspects, the first one to the traditional technology that is constituted by books, blackboards, markers, among other resources and the second ones are the advanced technologies that refer to applications, the internet and technological devices.

4. **Disciplinary Pedagogical Knowledge:** This item refers to how the student constructs his/her knowledge, including planning, organization, sequencing and evaluation, which contemplate learning difficulties and promote the construction of knowledge.

5. **Technological Disciplinary Knowledge:** in this phase, we study which technology is the most appropriate to teach a certain disciplinary knowledge and how to use it effectively to achieve it.

6. **Technological Pedagogical Knowledge:** this stage is constituted by the components of the technology that allow to enhance the teaching and learning process, which are reflected in solid and significant knowledge.

The TPACK model is oriented towards the design and evaluation of the teacher's knowledge, which is focused on effective student learning, in other words, this model is useful for integrating technology into teaching and at the same time studying how it could help in the construction of knowledge (Barajas & Cuevas, 2017).

In addition, the TPACK model is a viable alternative, given that it includes technology as part of the teaching-learning process, to fulfill the educational purpose (Alcívar, 2021, p.6).

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Description of the method

This research was cross-sectional, since it seeks to identify the efficiency of the TPACK model, from a pedagogical approach based on the flipped classroom methodology, since it leaves aside traditional pedagogy, in other words, it no longer only focuses on content exposition, but rather in the analysis and incorporation of collaborative work among colleagues, while the teacher guides them in the development of activities (Cedeño & Vigueros, 2020).

Another reason why the flipped classroom was implemented was because it conforms to Bloom's taxonomy, since it is the classification given to study programs in the ENCCH, in which it refers to the fact that the first two stages that make up this taxonomy are knowing and understanding; that belong to lower cognitive processes. Likewise, according to Zainuddin & Halili (2016, p.315) alludes that the stages of Bloom's taxonomy consist of:

- Remember: in this case, the student must recognize and remember the information, concepts and basic principles of the contents learned.

- Comprehension: at this stage the students interpret the information and summarize what they have learned.

- Application: students practice what they have learned or use their knowledge in a real situation. Analyze: Students use their critical thinking to solve problems, compare their answers with those of their peers, and write summaries.

- Evaluate: in this phase the evaluation of the set of learning concepts is carried out, at the same time a judgment is made on the degree of success of the students' learning achievements.

- Create: students can design, build and produce something new based on what they have learned.

Likewise, the inverted classroom methodology, as its name indicates, inverts the traditional pedagogy, in which the teacher's role is to be a guide, where young people study and learn at home, to finally reinforce their knowledge during the development of the session (Pillajo, 2021), therefore the first two levels of Bloom's taxonomy (Remember and Understand) are worked in asynchronous sessions, since they are lower order cognitive processes, that is, the student can develop them. On the other hand, the last four levels (apply, analyze, evaluate and create) it is necessary that there is an accompaniment by the teacher, in such a way that these must be worked in a synchronous mode as presented in Figure 2.

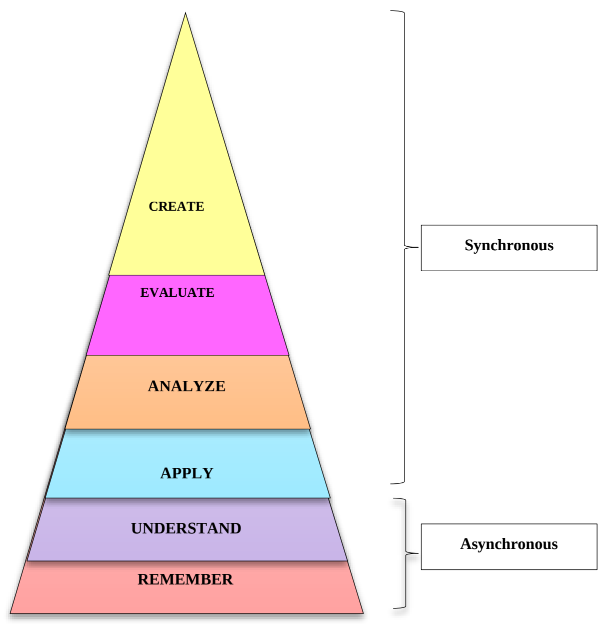

Figure 2 Bloom's Taxonomy in the flipped classroom
Source: Adapted Zainuddin & Halili (2016)

It is necessary to specify that this study was developed for high school in such a way that it only approached the third level that corresponds to "application" according to Bloom's taxonomy, given that the levels of analysis, evaluation and creation by the type of Activities and processes to be carried out are more suitable to build at the university level, since they belong to a higher degree of cognitive difficulty.

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It should be noted that the decision as to whether the sessions were carried out asynchronously or synchronously was based on the cognitive level to be reached according to Bloom's taxonomy, which is why they were structured in six sessions (three asynchronous and three synchronous) with a duration of 120 Minutes each, conducted through the Microsoft Teams and Zoom platforms, in which the topics that belong to the Physics III study program were reviewed, specifically for unit II entitled Fluid systems (Table 1).

Session no.	Modality	Cognitive level according to Bloom's taxonomy	Thematic
1	Asynchronous	Knowledge and understanding	Static fluids Density Pressure
2	Synchronous	Application	Measuring the pressure of a fluid
3	Asynchronous	Knowledge and understanding	Absolute pressure Gauge pressure Atmospheric pressure
4	Synchronous	Application	Pascal's Principle
5	Asynchronous	Knowledge and understanding	Thrust force Apparent weight
6	Synchronous	Application	Archimedes Principle

Table 1 Distribution of the sessions, by modality, cognitive level and topics developed

It should be noted that the activities developed were decided from the cognitive level and the learning or experience cone that consist “a pyramid in which the methods that are more and less effective for learning to take place” (De la Fuente, 2018, p. 309) as presented in Figure 3.

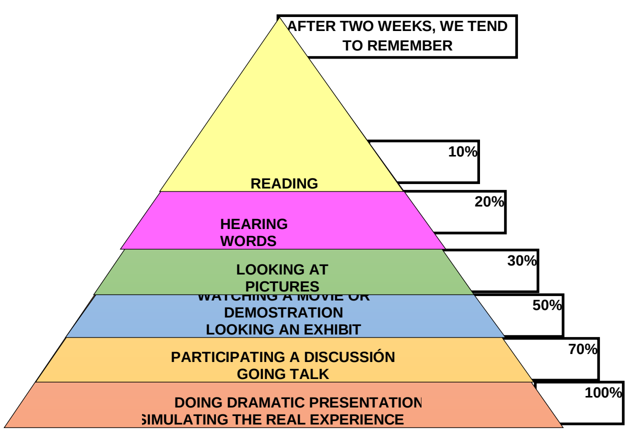

Figure 3 Cone of experience
.Source: Dale, (1932)

Based on the above, Table 2 shows the activities developed according to the cognitive level to be achieved.

Cognitive level	Activities and modality	Nature of the activity
Knowledge	Recognize concepts and definitions and recall information. (Asynchronous)	**VERBAL AND VISUAL ACTIVITY** Readings Pre-recorded conference
Comprehension	Understand information, interpret, compare and contrast facts. (Asynchronous)	**VISUAL ACTIVITY** Videos of some applications
Application	Use information and solve problems. (Synchronous)	**PARTICIPATORY AND RECEPTIVE ACTIVITY** Participate in a conversation and a debate. **PURE ACTIVITY** Use of simulators and virtual laboratories. Solving exercises and carrying out projects.

Table 2 Activities carried out during the sessions depending on the cognitive level

From the previous perspective, educational platforms, videos, web pages, simulators and virtual laboratories were used to carry out the aforementioned activities (Table 3).

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Tool	Type of activity	Activities
FísicaNET It is a site that you can consult notes and exercises of different disciplines for the high school.	Verbal	The notes corresponding to hydrostatics were shared, since they addressed all the issues to be reviewed. https://n9.cl/8d5ro
YouTube It is a social network in which a large number of videos are hosted.	Visual	Videos of fluid statics and troubleshooting examples were shared; its application with experiential environments for the themes of Pascal and Archimedes principle.
Tu prep@ en vídeos de la SEP It is a platform that gives students access to educational videos of different disciplines for the high school	Visual	On this page we worked on block I: entitled, it explains the behavior of fluids. http://www.tuprepaenvideos.sep.gob.mx/en/tuprepaenvideos/principio_de_pascal_fisii_bqi
Khan Academy It is a web platform where you can access educational resources from different areas of knowledge.	Visual	Videos corresponding to pressure and Pascal's principle were reviewed, among which included the pressure at a certain depth in a fluid, finding the height of the fluid with a barometer, the buoyant force, and Archimedes' principle.
Microsoft Teams It is a platform in which collaborative work is promoted.	Verbal y visual	In this platform the notepad section was opened in order to share the materials and the links, the instructions to perform the tasks requested in the asynchronous sessions. Likewise, the evaluations corresponding to the tasks and the questionnaires carried out in Microsoft forms were carried out.
Zoom It is a tool that promotes collaborative work through the virtual sessions section and at the same time promotes two-way communication between the teacher and the students.	Participative and responsive	Synchronous sessions were held on this platform in which debates, guided discussions or feedback on the activities carried out asynchronously took place.
Walter Fendt Site with different Physics content simulators.	Pure	Hydrostatic pressure and thrust force simulators in liquids were reviewed.
Vascak It is a site to find simulators for the subject of Physics.	Pure	Simulators on the theme of pressure were shared.
Virtual Laboratory: Physics On this page you will find several experiments of the different branches of the Physics subject.	Pure	In this laboratory, the sections of fluid statics that included Archimedes' Principle, hydrostatic pressure and pressure variation with height were worked on. https://labovirtual.blogspot.com/p/fisica.html

Table 3 Technological tools used according to experience cone

Participants

The sample was non-probabilistic and by convenience, made up of 42 students, of which 45.23% (19) were female and 54.77% (23) male, between the ages of 16 and 18 years old, enrolled in the ENCCH Plantel Vallejo, who were taking Physics III, which is studied in the fifth semester.

Evaluation instruments

Three corresponding evaluation instruments were designed for the topics of fluid pressure measurement, Pascal's principle and Archimedes' principle.

It should be noted that the evaluations were carried out through written tests with a total of 24 items, which were classified according to the cognitive levels of Bloom's taxonomy (Knowledge, Comprehension and Application); they were designed using the Microsoft Forms tool, which were applied at the end of the synchronous sessions (Table 4).

Cognitive level	Number of items	Evaluation activity
Knowledge	12	Multiple choice and true-false questions.
Comprehension	6	Reflection and comprehension essay type questions.
Application	6	Questions of application of procedures and problem solving.

Table 4 Structure of the evaluation instruments applied at the end of the asynchronous sessions

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It should be noted that the results were classified into three levels, based on the number of correct answers obtained by the students (Table 5).

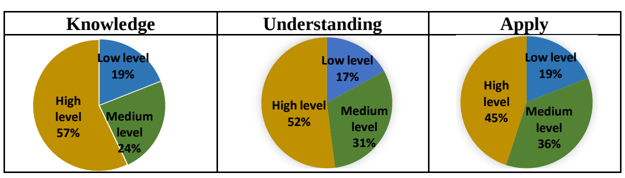
Cognitive level	Ranking criteria according to number of correct answers
Knowledge	1 to 4 hits Low level
	5 to 9 successes Intermediate level
	10 to 12 hits High level
Comprehension	1 to 2 hits Low level
	3 to 4 successes Intermediate level
	5 to 6 successes High level
Application	1 to 2 hits Low level
	3 to 4 successes Intermediate level
	5 to 6 successes High level

Table 5 Classification of the results obtained by the students according to the number of correct answers obtained

Results

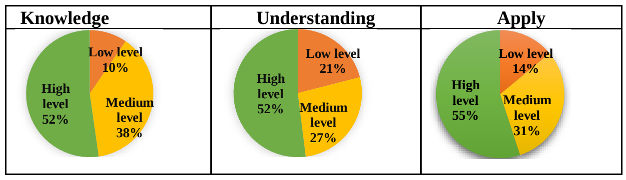
In relation to the evidence collected, it was obtained that for the topic of measuring the pressure of a fluid, more than 50% of the students reached the levels of knowledge and understanding; however, for the application stage, only 45% of the trainees achieved a high level, the reason for this may be due to the fact that young people have to use a procedure that includes a greater number of steps in order to solve a new problem.

Likewise, it is required to highlight that the percentage of learners who were located in the low level, almost is the same percentage for the three cognitive levels reviewed, which allows inferring the importance of developing lower order skills, to achieve the deepening of knowledge (Caeiro, 2019), all this seems to affirm that if young people do not recognize and understand the necessary concepts hardly, they will be able to implement it in problem solving (Graphic 1).



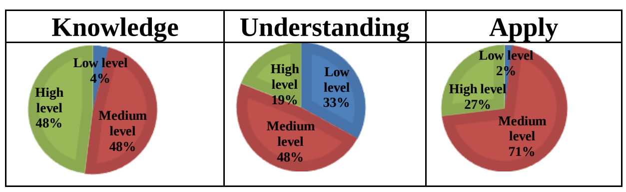
Graphic 1 Results by cognitive level for the topic of fluid pressure measurement

It is worth considering that for the topic of Pascal's Principle, the three cognitive levels evaluated obtained a percentage higher than 50% and even for the last stage evaluated the maximum value was achieved with 55%, note that in addition, for the comprehension level, specifically for the low item, 21% of the students were located, perhaps this is a consequence of using essay-type reagents for this section, where in most cases they had notions, however, their answers were scattered among the concepts of density, pressure, force and area, showing that the trainees had difficulty interpreting and explaining Pascal's Principle (Graphic 2).



Graphic 2 Results by cognitive level for the topic of Pascal's principle

Graphic 3 shows the results obtained for the topic of Archimedes' Principle, in this case the values were very varied and this is not difficult to understand, given that it is a complicated topic for the students to understand, although it is necessary to highlight that for level three of Bloom's Taxonomy only 2% of the students were located in the low category, this is significant, since it is necessary that the young people integrate different definitions and at the same time use mathematical skills to solve the exercises.



Graphic 3 Results by cognitive level for the topic of Archimedes' principle

About the previous perspectives, it can be alluded that the cause of the achievements in the subject of Archimedes' Principle, is that when considering this learning difficult to acquire by students, the use of pure activities such as simulators was emphasized, which are very useful tools to promote the learning of natural sciences, especially for the subject of Physics considered by many students, complicated to understand due to its level of abstraction (Ayón & Víctores, 2020).

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Conclusion

Throughout this study, a strategy was presented through the application of a techno-pedagogical model such as TPACK, where the importance of aligning pedagogical, disciplinary, and technological aspects has been established. In the case of this research, it was evidenced that a large percentage of students achieved skills to solve exercises or problems, which based on our teaching experience, is sometimes difficult to achieve for young people because of the different previous skills needed to perform this task.

It is interesting to note that, although the results were intermediate, they are considered to be significant, given that the topics reviewed include different abstract concepts, which make it difficult to achieve the learning proposed in the Program of Studies; although this task was difficult to obtain in a face-to-face context, in an online modality it was not easy either, hence the TPACK model is considered a viable option to plan the actions to be implemented in the teaching-learning process.

It should be noted that it is necessary to understand that the use of technology is the means and not the objective; therefore, it is suggested to use free, intuitive technological tools, according to the educational level; based on a methodology or model, therefore, teachers have the responsibility to be constantly trained in these issues.

Finally, it can be deduced that the TPACK model can support a greater number of students to achieve higher order learning levels; however, it is proposed as future work to conduct a longitudinal research to evaluate the long-term effects and at the same time to determine the variables that mainly intervene in the process of knowledge assimilation.

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