Availableonlineathttp://www.journalcra.com

INTERNATIONAL JOURNAL OFCURRENTRESEARCH

ISSN: 0975-833X

International Journal of Current Research
Vol. 11, Issue, 05, pp.3993-3998, May, 2019

DOI: https://doi.org/10.24941/ijcr.35473.05.2019

RESEARCH ARTICLE

ADDIE. INSTRUCTIONAL DESIGN BASED ON FLIPPED CLASSROOM FOR TEACHING AND LEARNING "FROM MINERALS TO METALS: CHEMICAL PROCESSES, USAGE AND RELEVANCE" IN A HIGH SCHOOL CHEMISTRY COURSE

[1]Adriana Jaramillo Alcantar, [2]Adolfo Eduardo Obaya Valdivia, [2,3]Lucila Giamatteo and [2]Yolanda M. Vargas-Rodríguez

[1]Colegio de Ciencias y Humanidades Naucalpan, UNAM
[2]FES-Cuautitlán UNAM. Chemical Science Department. MADEMS (Chemistry) México
[3]Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM) México

ARTICLEINFO

Article History:
Received 25th February, 2019
Received in revised form
20th March, 2019
Accepted 27th April, 2019
Published online 30th May, 2019

Key Words:
Flipped classroom,
Instructional design,
ADDIE, Stoichiometric teaching.

ABSTRACT

Instructional Design ADDIE (Analysis, Design, Development, Implementation and Evaluation) based on Flipped Classroom is presented, raising the subject "From minerals to metals: chemical processes, usage and relevance" in the Chemistry III subject at UNAM´s Colegio de Ciencias y Humanidades High School. This paper was developed in five stages: initial analysis, design, development, implementation and evaluation. During the first phase, previous knowledge and learning style tests were carried out, taking also into account motivation. For the second phase, didactic and educational materials were designed, selected and developed. Subsequently, this was implemented in 2019-I semester in a group of 17 students. When evaluated, didactic efficiency and Hake´s normalized gain were higher than 80%, indicating that the instructional design used influences positively in acquiring concepts, abilities and competencies by stimulating critical thinking, collaborative learning and self-learning.

***Citation: Adriana Jaramillo Alcantar, Adolfo Eduardo Obaya Valdivia, Lucila Giamatteo and Yolanda M. Vargas-Rodríguez,* 2019.** "Addie. instructional design based on flipped classroom for teaching and learning "from minerals to metals: chemical processes, usage and relevance" in a high school chemistry course", *International Journal of Current Research*, 11, (05), 3993-3998.

INTRODUCTION

We are in a sociohistorical time that allows us to access huge amounts of information in just a couple of minutes. Nonetheless, with so much information available, education has the challenge to give importance to certain pieces of information. More importantly, priorization must also take place (Bauman, 2007). In other words, students ´criteria must be shaped in such a way that students can handle the existent information excess. The ADDIE model (Analysis, Design, Development, Implementation and Evaluation) is an interactive instructional design process (Kemp, Morrison and Ross, 1998) in which the results of formative assessment in each phase can lead the instructional designer back to any of the previous phases. The final product of one stage is the starting point for the next one (Morrison, 2010). When a teacher thinks of designing a course, a process is followed with the aim of developing quality formative actions. Having models, such as Instructional Design (ID), optimizes material and didactic strategies design. ID has been defined by several authors, as described in Table1. In literature, there is a conscent over the phases and criteria required that need to be considered in the learning process. This involves the inner characteristics of students, teachers and learning environment.

Taking this into account, an adequate ID allows more efficient, effective and attractive learning situations and materials. If the learning environments do not use an adequate ID, planning of the formative process will not be adequate. Therefore, ID should not be left aside when producing or implementing educational resources. Opposite to this, ID serves as guarantee of rigor and validity during the whole process. There is a great variety of ID. However, in this case the ADDIE model is used. ADDIE, the acronym for the model, is basic for instructional design since it contains the main phases (Sicán, Etelvina and Fernández, 2014):

- Analysis. The first part involves analyzing students, content and learning environment. From this, the description of formative needs and a specific situation arises.
- Design. A program for the course is designed, emphasizing the pedagogical focus and the way in which content is sequenced and organized.
- Development. Real production of learning content and material occurs, based on the design phase.
- Implementation. This phase involves the execution of the formative action with students´involvement.

- Evaluation. It consists of accomplishing formative assessment of each stage in the ADDIE process, and summative assessment is performed through specific tests that will enable the results´analysis from the formative assessment.

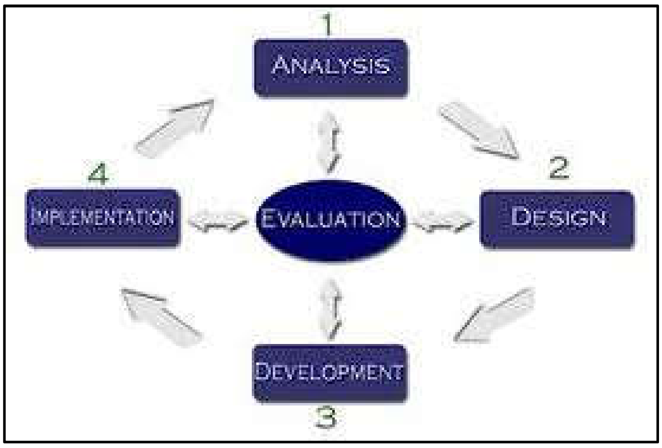

Table 1. ID Definitions

Author	Definition
Bruner (1969)	It is in charge of resources planning, preparation and design, as well as the necessary environments so that learning takes place.
Reigeluth, Merrill, Wilson & Spiller (1980)	It is a discipline interested in prescribing optimal instruction methods by creating desired changes in students 'knowledge and abilities.
Berger & Kam (1996)	Science that creates detailed specifications for development, implementation, evaluation and maintenance of situations that facilitate small and big content units learning in different complexity levels.
Reiser (2001)	Art and science applied to creating instructional environments and clear, effective materials that will help the students develop the ability to perform certain tasks.
Richey, Fields & Foson (2001)	Instructional systematic planning that includes assessing needs, development, evaluation, implementation and maintenance of materials and programs.

ADDIE is proposed as an alternative to organize activities that lead to students´ autonomous learning mediated by learning and communication technologies, as described in the five stages that the model has. Each stage or phase generates a product that represents the analysis or plans of all the interested party and each delivery needs to be confirmed or tested before they become supplies for the following stage in the process (TAC (Morales, Edel and Aguirre, 2014). Considering students participation involves seeing them as a being whose social, emotional, physical and mental development is related to his/her intelligence, cognitive style, motivation, cultural assets, creativity and socioeconomical status. The role of the teacher also denotes complexity by assuming a managing function to identify students´ goals and expectations, analyzing learning needs, organizing contents, selecting resources, guiding the knowledge´s construction process and considering the context conditions that might impact the teaching and learning process (Obaya, Vargas, Montaño and Giammatteo, 2019). As such, self-regulation is promoted as an opportunity for students to reflect upon their learning and achieved goals. Diaz (2016) establishes that goals are necessary to keep focus during the whole process in which activities through the ADDIE model are carried out, avoiding simplified, trivial or artificial tasks.

Flipped Classroom: Given the conditions described before, several pedagogical models arise, such as e-learning (through internet), b-learning (by combining online and traditional place-based classroom methods) and flipped learning (which consists of previously checking topics outside the classroom and solving exercises in a traditional setting (Hamdan, McKnight, McKnight and Arfstrom, 2013). The term *flipped learning* is also known as inverted instruction, inverse teaching or flipped classroom. It arises in several contexts and educational levels with great strength to retrieve the protagonist of the learning process, the student. This reality is possible given the learning and communication technologies. Using techniques to introduce topics prior to the class implies profound changes in the pedagogical focus by modifying the courses design, as well as students and teachers roles (Arriaga, Hinojosa 2015). This methodology became popular with two Chemistry teachers, Jonathan Bergmann and Aaron Sams (2012) in Woodland Park High School Colorado, that used multimedia technology such as presentation and videos, among others as support material. In their paper "Flip your classroom: Reach every student in every class every day", Sams and Bergmann (2012) explain the flipped learning creation process. Initially, they focused on creating material for students that were absent. Afterwards, they noticed that other students were also using the material. Additionally, they discovered that students need the teacher when they encounter difficulties in applying concepts, not in the moment they receive content which can be easily accessed by audiovisual means, allowing the teacher to identify specific needs from each student. Given these findings, authors made specific adjustments in considering students learning styles, promoting an individual students advance, developing self-directed learning abilities. Basic pillars for this model are described according to Gil and Chiva (2016) in the following figure:

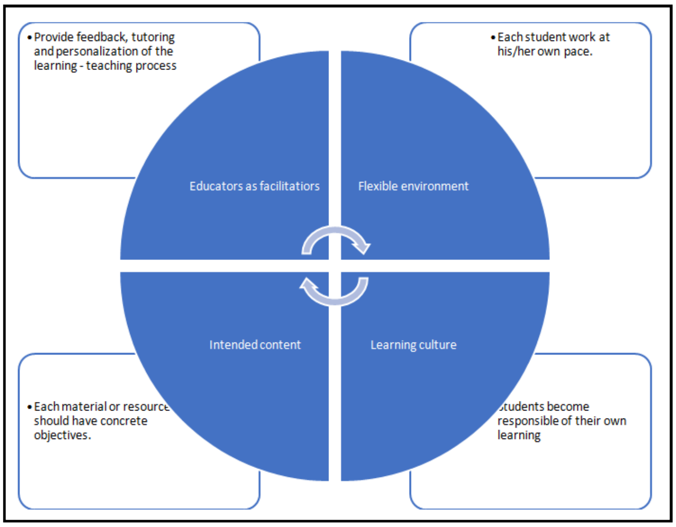

Figure 1. Pillars of flipped learning

MATERIALS AND METHODS

This proposal aimed to create an instructional module by using ADDIE which enables students to make stoichiometric calculations, describe physical and chemical processes, benefits and consequences that are involved in the mining-metallurgic intustry.

Initial Analysis: The following instructional model was used at *Colegio de Ciencias y Humanidades* (CCH), campus Azcapotzalcoin the 2019-I semester, Chemistry III subject, unit 2, named “from minerals to metals: chemical processes, usage and relevance”. Units according to studies plan 2018 is shown in Figure 2, including the topics involved in the design. It is worth to mention that Chemistry III is an optional subject. Hence, students enrolled have a profile linked to science.

Previous knowledge: To determine students´ previous knowledge, a questionnaire “From minerals to metals” (FMM) was used. To validate it, the same questionnaire was applied to first semester chemical engineering students at Facultad de Estudios Superiores Cuautitlán, obtaining favorable results for its implementation. FMM was structured in three sections: the first one was a relating columns exercise for mineral transformation, the second one comprised a multiple choice

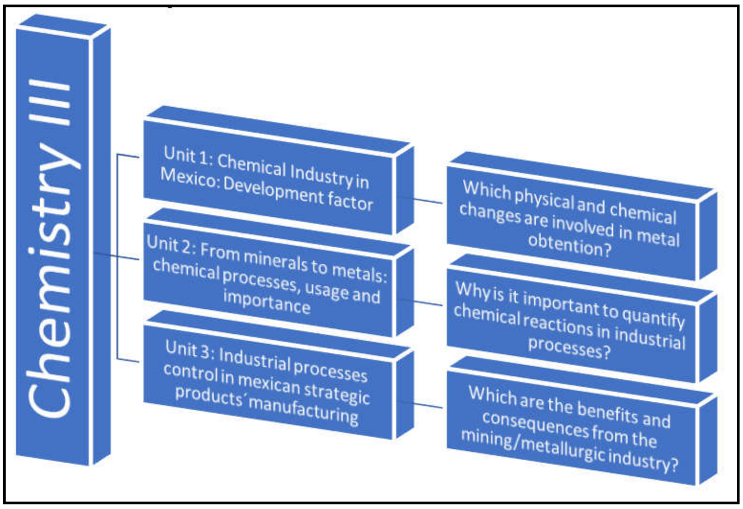

Figure 2. Chemistry III curricular structure from studies plan 2018 at CCH

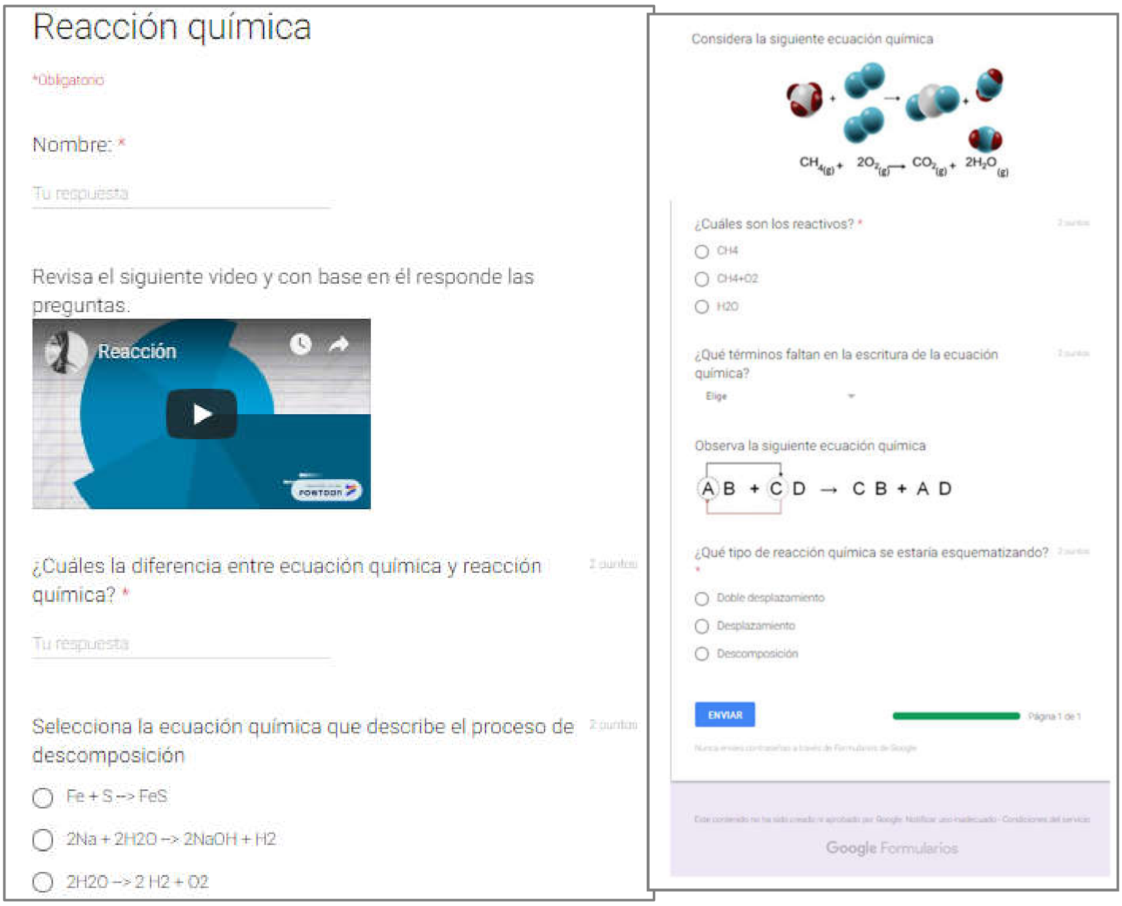

Figure 3. Questionnaire proposed after viewing the chemical reaction video

Sample: The investigation was applied to a group of 17 students from fifth semester whose ages ranged between 16 and 19 years old, made up of 59% women and 41% men, with a medium-low socioeconomical status who had internet access through their smart phones, own computers or in the school´s computer room.

exercise and the third one a stoichiometry problem. From this, two parameters were evaluated:

a) Concepts interpretation
b) execution

Interpretation criteria pretended to evaluate the student´s conceptual domain before the instructional model, corresponding to the FMM´s first and second section. The execution criterion evaluated procedure knowledge related to the problem included in the FMM´s third section. The reason why these criteria were used is that knowledge should be interpreted as a body of objective and formal information with only one possible interpretation. Nonetheless, it is also interpreted that learning or content assimilation is rather a gradual construction.

Strategy development and design: CCH´s educational model is based on "learning to do, learning to be and learning to learn". Hence, the strategy will be focused on self-learning, collaborative learning and flipped learning.

Flipped classroom: A group was created in Google classroom where previous activities were placed before each session. Basically, a video, reading or presentation was presented with the concept sor topics so that students could then answer a questionnaire (Figure 3). In some occasions, students were asked to create a graphic organizer to diversify activities. Five videos were created covering the following topics: chemical reactions, metals reactivity series, redox concepts (Figure 4), compounds percentual composition and reaction yield, how to balance redox reactions, metal obtention processes and other access-free materials for concepts.

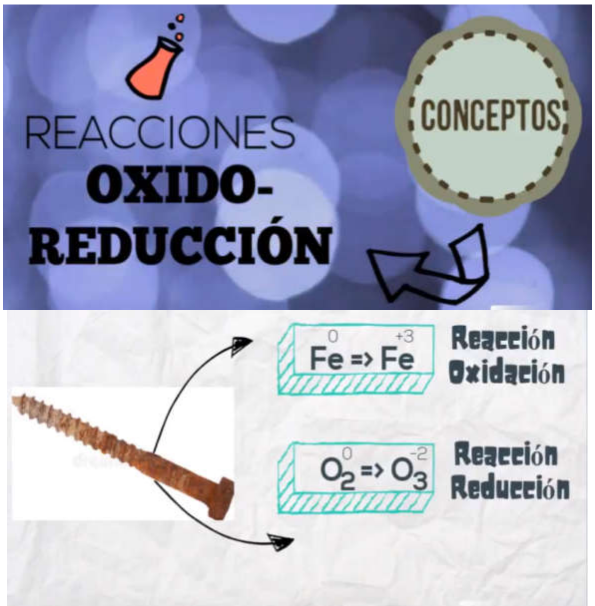

Figure 4. Fragment of the video with redox reactions concepts

Classroom: Once the concepts were previously revised, a couple of minutes in the beginning of each class were devoted to questions related to the class´topics. After that, recovering knowledge activities were carried out to detect defficiencies and to standardize the group´s knowledge. Subsequently, activities were made in a collaborative and participative environment where students had to apply the concepts that were previously seen in class. In certain cases, collaborative evaluations also took place. Finally, closure activities were carried out so that students could converge in what was being checked. Moreover, the formative questionnaire was given to students in which learning, difficulties and opinions were questioned. This allowed reinforcement activities to take place.

Implementation: The application of this instructional model took place during 2019-I semester. Each of the previous activities was calendarized in Google classroom, sending an email to each student as a reminder of what they had to do. After students finished the activity, a grade was automatically assigned for each questionnaire. The designed instructional designed allowed for both quantitative and qualitative data to be collected, as described below.

Qualitative data were sustained as follows:

- Formative assessments where progress and learning for each class were described the formative evaluation; where setting the progress and learnings in each class
- Formative questionnaires, KPSI, allowing students to know their mastery of certain knowledge through self-reflection, self-regulation and co-regulation.
- Teacher´s observations at different moments (online platform based on previous questionnaire results or activities carried out after students checked the given materials, through class participation and students initial questions, while carrying out activities)

Quantitative data was obtained through pre and post FMM questionnaires, calculating statistical parameters as mean ($\bar{X}$), standard deviation (s), Hake gain and didactic efficiency.

RESULTS

Results obtained from the FMM questionnaire and Castañeda´s learning styles and motivational test (2004), as well as statistical parameters are shown in the following figures. To determine certaincharacteristics, Castañeda´s test (2004) "Estilos de Aprendizaje y Orientación Motivacional al Estudio (EDAOM)" wasapplied. This instrument has already been validated for these type of variables. Figure 5 shows the percentages obtained by the group for each one of the 13 subscales.

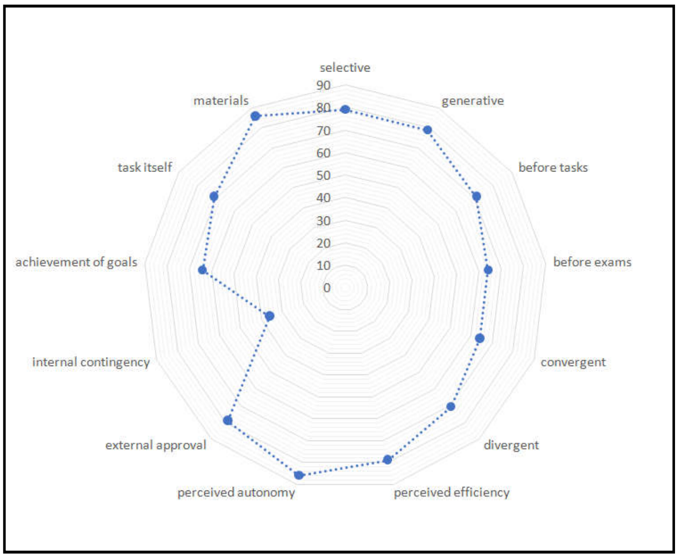

Figure 5. EDAOM results

In Figure 6 the obtained results in the pre and post tests for FMM are shown, where topics revised for each session included in the instructional model were assessed.

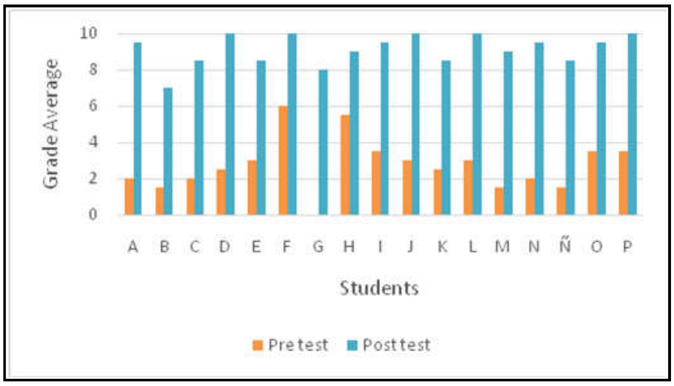

Figure 6. FMM grades for pre and post tests

The following charts show the Hake gain score, first per student in the pre and post test and last, the normalized value considering each question.

Table 2. Hake gain score and statistical values per student

Student	Grade		Hakegain score
	Pre test	Post test	
A	2	7	0.62
B	1.5	7	0.64
C	2	8.5	0.81
D	2.5	10	1
E	3	8.5	0.78
F	6	10	1
G	0	8	0.8
H	5.5	9	0.77
I	3.5	9.5	0.92
J	3	10	1
K	2.5	8.5	0.8
L	3	10	1
M	1.5	9	0.88
N	2	9.5	0.93
Ñ	1.5	8.5	0.82
O	3.5	9.5	0.92
P	3.5	10	1
$\bar{X}$	2.73	8.97	0.85
s	1.46	0.99	

Table 3. Hake normalized gain score per correct answer in the FMM and didactic efficacy

g_{prom} (%)	53.92
g_{max} (%)	64.21
g_{norm}	0.84
Didacticefficacy	85.11

Evaluation and resultsanalysis: EDAOM was applied with the aim of determining specific characteristics that belonged to the group being studied, which are graphically shown in figure 5. This shows that students have an intermediate – high degree in most of the evaluated parameters. This was essential to confirm important characteristics needed in the strategy designed for flipped learning, such as autonomy, goals and tasks achievement, among others. The percentage of students using strategies to selectively acquire information is high (79%). In the subscale of generative acquisition this group values the use of this strategies to a similar extent, making it possible for them to acquiring knowledge by using both strategies. When referring to the personal domain, in the self-regulation scale students percieve themselves as high level apprentices (79%). Their self – evaluation in terms of external approval shows that they do not usually depend on others for approval (79%). This data is confirmed by observing the autonomy scale where 86% of them consider themselves as autonomous learners. Their internal contingency scales also show high values (86%). By analyzing data corresponding to processing information, a diversity is observed within the group, whereas in the memory retrieval the value is higher in tasks compared to exams. The self-regulation for homeworks is considered to be average. Since the FMM initially showed an average grade of 2.73, this indicates that students had prior knowledge in organic chemistry. The standard deviation (s)was 1.46, indicating that there is variation between the group´s general average and each student´s grade. Regarding the FMM final delivery, average was 8.97. This indicates that the instructional module was acquired as previously described was 0.99. When contrasting this value with that of the pre value, it is evident that flipped learning help standardize knowledge.

Considering results shown in Table 2, Hake gain score (g) was 0.85, a high value according to Hake´s ranges (1998). Normalized gain (g_{norm}) for the number of correct answers in FMM initial and final was 0.84. Both values indicate a significant conceptual achievement. The didactic efficacy shown in chart 3 was 85.11, corroborating a favorable influence in learning and teaching by using the flipped learning strategy with the described instructional design. By exposing students to an inverted model for the first time, they seem renuent at first, assimilating the structure with the course progress and after perceiving a more fluid rythm for the course, allowing more information to be covered in a shorter period of time. Previous activities allowed students to analyze things through their own perspective after they interacted with the instructional materials, concluding over what they show the most interest on and what is hardest to understand. This information enabled teachers to come up with new activities that helped students overcome learning difficulties and more homogeinity in the group of students. Students were generally motivated and participative in all sessions. In the formative questionnaire, students expressed they were satisfied with what they had learned. A well-structured flipped classroom provides students with more independence, facilitating *learning to learn* and critical thinking abilities. Finally, students coincide in that learning objectives were met and that contents were covered in the anticipated time. Moreover, instructional design stimulated collaborative and independent learning. The didactic materials used were pleasant for studying and easy to develop. The evaluation favored obtaining feedback from content. Flipped learning was therefore useful to understand each topic´s main concepts and the activities that were carried out helped students consolidate what was previously checked. As a result, students accepted the instructional design based on flipped learning.

Conclusions

Implementing flipped learning in the classroom is not trivial. Since it depends on the teacher´s stregths and abilities, it was decided for this to be included in the instructional design, allowing its design, evaluation and immediate modification in each phase of the process. Initially, the student´s characteristics were assesed through FMM and EDAOM, allowing activities and materials to be designed, develiped and planned for both the flipped classroom and the traditional one. Adjustments took place during the implementation, such as question initial time and activities to review previous concepts to standardize the latter ones within the group were incorporated. The proposed method allows teachers to easily obtain and analyze information derivated from students´ interactions with the material to rethink class activities, learning and formative assessment. By evaluating Hake´s gain score and didactic efficiency, it can be demonstrated that the flipped classroom strategy through ADDIE instructional design for learning and teaching unit 2 "From minerals to metals: chemical processes, usage and relevance" in Chemistry III at CCH Azcapotzalco had a positive impact on students. It is important to mention that in such cases where concepts are needed, such as stoichiometry, this flipped classroom model allows time to be shifted from revising concepts to focusing on solving exercises or problems. This enabled students to clear out doubts and practised specific abilities. After the application, it is evident that for experimental phases it makes sense to use flipped learning for revising concepts in advance with audiovisual materials and previous questionnaires, leading students to the topic that will be then experimentally developed and converging in the desired learning outcomes. Flipped learning is suggested for groups of students that are independent, combining it with the responses obtained from students previous questionnaires and adapting class activities and optimizing students´ learning.

REFERENCES

Bauman, Zygmunt 2007. Los retos de la educación en la modernidad líquida. Barcelona: Gedisa.

Bergmann, J., &Sams, A. 2012. Flip your classroom: Reach every student in every class every day. Washington, DC: ISTE; and Alexandria, VA: ASCD.

Bruner, J., S., 1969. Hacia una teoría de la instrucción. México: Uthea.

Castañeda, S. y Ortega, I. 2004. Evaluación de estrategias de aprendizaje y orientación motivacional al estudio. En S. Castañeda (Ed). Educación, aprendizaje y cognición: teoría en la práctica. México, Manual Moderno, pp. 277-299.

Gil, J. y Chiva, Ó. 2016. Flipped-classroom (clase invertida). En Ó. Chiva y M. Martí (Coords). Métodos pedagógicos activos y globalizadores. Barcelona: Graó.

Hake, R. 1998. Interactive-engagement vs traditional methods: a sixthousand-student survey of mechanics test data for introductory phýsics courses. AmericaJournal of Physics, 66(1), 64-74.

Hamdan, N.; McKnight, P. E.; McKnight, K.; &Arfstrom, K. M. 2013. A Review of Flipped Learning. Arlington, VA: Flipped Learning Network.

Hinojosa, A. C., Arriaga, A. A., 2015. Los alumnos opinan sobre la metodología FlippedClassroom: una experiencia con estudiantes universitarios de Grado en Psicología. XII Jornadas Internacionales de Innovación Universitaria

Kemp,J., Morrison, G. and Ross,S. 1998. Designing Effective Instruction. 2 Ed. Prentice Hall. N.J.

Morales, G. B., Edel, N. R., y Aguirre, A. G. 2014. Modelo ADDIE (análisis, diseño, desarrollo, implementación y evaluación): Su aplicación en ambientes educativos. Los Modelos Tecno-Educativos, revolucionando el aprendizaje del siglo XXI, 33-46.

Morrison, G.R. 2010. *Designing Effective Instruction*, 6th Edition. New York: John Wiley & Sons

Obaya, A. Vargas, Y-M., Montaño, C. and Giammatteo, L. 2019. "The role of educational research in teaching chemistry". *International Journal of Development Research* 09 (01) 25253-25257

Reigeluth, C. M., Merrill, M., D., Wilson, B. G. & Spiller, R.,T., 1980. The elaboration theory of instruction: A model for sequencing and synthesizing instruction. InstructionalScience , 9 (3), 195-219

Reiser, R. A. 2001. A history of instructional design and technology. Trends and Issues in Instructional Design and Technology (págs. 57-67). New Jersey, EUA: Prentice Hall College Division.

Richey, R. C., Fields, D. C. &Foxon, M. 2001. Instructional design competencies: The standards (3.ª ed.) New York, EUA: ERIC Clearinghouse

Sicán C. S., Etelvina S. L. & Fernández M. K. 2014. Implementación del modelo ADDIE en el diseño instruccional del Curso de Inglés Básico de la Universidad Gerardo Barrios de El Salvador.

****