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ORIGINAL

Applicability of the inverted classroom methodology in the teaching of occupational health and environment

Aplicabilidad de la metodología de la clase invertida en la enseñanza de la asignatura de salud ocupacional y ambiente

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ABSTRACT

Introduction: the inverse method is currently considered a very effective way of teaching in higher education. However, studies applied to all possible contexts are not available, resulting necessary its application and the reporting of results, which was the main objective of this Case Study.
Method: the inverse method was implemented during 4 consecutive periods in the teaching of occupational safety and health in the industrial maintenance career. For the implementation of the method, the class was extended to a previous period (review of theoretical contents) and a subsequent period (feedback and execution of reinforcement activities) to the classroom meetings, where theory application activities were developed to simulate the actions performed by the safety technician in working life.
Results: data were collected throughout the implementation of the method that allowed analyzing its suitability. Academic performance (71,5 %), pass rate (91,8 %), teacher evaluation (95,7 %) and the results of a satisfaction survey with the applied methodology evidenced the feasibility and efficiency of the method in teaching the subject of occupational health and environment in the context of higher education,
Conclusions: therefore, it is concluded that FL should be implemented in higher education, and similar results are expected under the particular conditions of each university context.

Keywords: Higher Education; Environment and Safety; Active Learning; Inverted Method.

RESUMEN

Introducción: el método inverso es considerado actualmente como una forma de enseñanza muy eficaz en la educación superior. Sin embargo, no se disponen de estudios aplicados a todos los contextos posibles, resultando necesario su aplicación y el reporte de los resultados, lo cual fue el principal objetivo de la presente Caso de Estudio.
Método: se implementó el método inverso a lo largo de 4 periodos consecutivos en la enseñanza de seguridad y salud ocupacional en la carrera de mantenimiento industrial. Para la implementación del método se extendió la clase a un periodo previo (revisión de contenidos teóricos) y un periodo posterior (retroalimentación y ejecución de actividades de refuerzo) a los encuentros en el aula, donde se desarrollaron actividades de aplicación de la teoría que simularon las acciones que ejecuta el técnico de seguridad en la vida laboral.

Resultados: se recolectaron datos a lo largo de la implementación del método que permitieron analizar su idoneidad. El rendimiento académico (71,5 %), el porcentaje de aprobación (91,8 %), la evaluación docente (95,7 %) y los resultados de una encuesta de satisfacción con la metodología aplicada evidenciaron la factibilidad y eficiencia del método en la enseñanza de la asignatura de salud ocupacional y ambiente en el contexto de la educación superior.
Conclusiones: por ende, se concluye en la implementación de la FL en la enseñanza superior, esperándose resultados similares bajo condiciones particulares de cada contexto universitario.

Palabras clave: Educación Superior; Ambiente y Seguridad; Aprendizaje Activo; Método Invertido.

INTRODUCTION

The Higher education represents the final stage in the training of professionals required in order to satisfy the needs of today's knowledge-based society andsolve to solve challenges derived from the great variability of the circumstances faced by humanity.[1,2] Within the wide spectrum of professionals that form the higher education systems, engineering represents one of the most demanded disciplines and with greater employability,[3] and that can provide solutions to the current needs of society, since design in its current conception, both technological and services, do not have the capacity to face these needs,[4] a situation that engineering professionals are able to solve, being the main professionals oriented to the solution of the demands of humanity.[5]

In order to achieve the formation of professionals who contribute significantly to society, it is necessary to apply active teaching strategies within HIEs that focus on the student. It is important to emphasize that the traditional teaching method that has been used since the beginning of universities is less effective than active teaching methods,[6,7] since traditional methods focus on the teacher and not on the students.[8]

One of the higher education methodological alternatives that satisfy these requirements, i.e. that is based on the principles of active learning and is student-centered, is the flipped Learning method (or FL for short).[9]

FL is a very popular alternative to the teaching traditional method of (MT). FL involves a set of techniques that seek to engage students in a deeper learning process.[10] FL involves reversing the roles, roles, and roles of students.

FL consists of inverting roles, activities and spaces of MT,[11] so that formal instruction (imparting theoretical knowledge) takes place in autonomous space and time (outside the classroom), while the activities of application of such knowledge, which involve a higher cognitive level, take place in collaborative space and time (inside the classroom), in conjunction with the teacher.[11,12]

Currently, the diverse and very significant benefits of the application of FL in teaching are widely known, therefore, this methodology is considered as a form of strategic teaching, since it focuses on the student and on active learning techniques, conditions currently estimated as very beneficial for the teaching-learning process,[13,14] within the contexts in which the researches that allowed reaching such conclusions about FL were developed.

Specific research has been developed related to the determination of the advantages of FL versus MT within engineering education, reporting that the implementation of IM improves student participation, autonomous learning, academic performance and pass rate,[15,16] self-regulation, motivation and satisfaction with the method, learning and problem-solving capacity in students, and also provides better conditions for active and collaborative learning and promotes experiential learning compared to MT.[17, 6,18,19]

However, although there is research applied to specific contexts within engineering education, the number of these is limited, i.e., less attention has been given to research related to the implementation of FL in engineering courses and limited research related to this topic is available.[20] The benefits cited respond to specific contexts, disciplines and specific courses of the place where such research was conducted, since the reports indicate that the results studied correspond to specific places, chairs, moments and actors,[21] therefore, the totality of disciplines taught in engineering education have not been covered yet, which is why it is necessary to conduct research that exposes cases of application of IM in the different courses of the broad spectrum of engineering education.

In addition, further research in this field is needed to develop good practices in the implementation of FL in engineering education,[20] since, being a relatively recent teaching methodology strategy, there are still doubts about it,[16] in fact, FL could be considered as a methodology still under development for higher education,[22] which encourages research in this area.

At the time of writing this article, no publications were found in high-impact bibliographic bases dealing with the application of the inverse method in teaching occupational health and environment in higher education, specifically in engineering; therefore, the results reported in this research are unpublished and of great relevance.

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The objective of this research is the application of FL in the teaching of the subject of Health, Occupational Safety and Environment to students of industrial maintenance engineering.

In addition, the following research questions were posed in order to achieve the aforementioned purpose: Is it feasible (in terms of students' and teachers' capabilities and human, technological and economic resources) to apply FL in the teaching of OHS and the environment in the context of undergraduate engineering education? How should FL be applied in the teaching/learning process of the subject of SSO and environment in engineering areas? What is the result, in terms of academic performance and student satisfaction with the teaching method, of the implementation of FL in the teaching of SSO and environment?

METHOD

Research design

This research work was carried out under the "case study" research method, an approach that belongs to quantitative research,[22,23] as well as several researches related to the implementation of FL in the teaching of engineering education.[24,25]

In addition, the case study was selected as a research method since it is related to the analysis of an action in development within a single scenario of interest, adjusting to the objectives of the research work, specifically, to describe the suitability and performance of the application to a real context of FL in the teaching of the subject in engineering education at the Escuela Superior Politécnica de Chimborazo (ESPOCH).

Process

The implementation and assessment of the LF in health, occupational safety and environment was developed over 4 consecutive academic periods (2 years), within the same career, at the same level, the process of which is described below:

Each class (according to the academic schedule) was extended to a phase prior to the classroom meetings, the encounters themselves, and a phase after the encounters (evaluation and feedback).

In the phase prior to the classroom meetings, it was proceeded to the creation of theoretical content based on the topics to be covered according to the syllabus of the course, under the screencast format, video type through PowerPoint or Prezi presentations, since these videos are excellent for teaching and transmission of concepts.[26] Theoretical contents were intended to be of short duration, which favors engagement, content retention and students' focus when watching theoretical videos within the LF.[27]

In addition, the publication of a prudent number of contents was considered avoiding exceeding the students' dedication time to autonomous activities.The theoretical contents were shared on a scheduled and weekly basis, according to the course planning, through the Learning Management System (LMS), since the LMS represent the central tools for the support and organization of information within the teaching.

Moodle and/or Teams were used as the main LMS, being Moodle one of the tools frequently used in the application of the FL The contents were accompanied by a questionnaire that evaluated the students' comprehension capacity regarding the topics exposed through self-qualifying online exams, since this way of evaluating the comprehension of the contents facilitates the evaluation process, which is frequently very extensive.[26]

The scores obtained by the students in the resolution of the questionnaires were included in the evaluation system.

In addition, use was made of the data analysis and student participation module integrated in the LMS to verify student interaction with the theoretical contents, and this interaction was considered in the evaluation system.

In the classroom meetings, time was distributed with the teacher to resolve doubts, carry out activities of application of the theoretical contents, feedback and development of semester projects, as indicated in table 1.

Table 1. Distribution of time spent in classroom meetings

Activity Time	Activity Time allocated, (min)
Resolution of the theoretical contents Doubts regarding review	10
Explanation of the application of the 7activity to be carried out	10
Development and accompaniment of the activities for the application of the theoretical contents	70
Development of the semester project	30

In the classroom, the meetings were mainly devoted to the development of activities related to the application

of theoretical contents previously seen by the students through tasks closely related to the functions performed by SSO professionals. An effort was made to carry out only one activity per meeting.

The main design criterion for the activities was the competencies to be developed in the students, which came from an analysis of the activities performed by safety technicians in their work, ensuring that the students experience real scenarios and acquire these competencies through experience and the syllabus.

Each activity to be developed in the meetings was closely related to the theoretical contents previously reviewed by the students, as shown in the table 2.

Table 2. Student competencies according to learning contexts

Theoretical content to be developed	Application activities
Presentation of the course	Presentation of the course
Relationship between health and work	Technical language OHS and environment
Theoretical foundations of occupational health and safety and environment 1	Context of industrial maintenance
Theoretical foundations of safety, occupational health 2 and environment	Legal requirements
Introduction to risk management	Understanding the organizational context
Introduction to safety and environmental analytical techniques	Division of the organization into workplaces for risk management
	Partial test
Safety inspection	Delimitation and characterization of workplaces
	Construction of an instrument for the execution of a work inspection
Identification of hazards	Execution of a work inspection
Evaluation of risks	Execution of a risk assessment
Formulation of preventive measures	Formulation of preventive measures specific to industrial maintenance
Emergency response	Construction of an emergency action plan

Each activity was developed under active and collaborative learning techniques. Students worked in the classroom in small groups (maximum 4 members). The groups were formed by their affinity at the beginning of the academic period and they were not modified (except for some particular cases) throughout the period.

The activities corresponded to the actions that the safety technician carries out in the professional field, in accordance with the risk management process: identification of hazards, risk assessment and formulation of preventive measures.

The activities were published prior to the classroom meetings through the LMS, providing the following information: name, learning achievement, description, tasks, deliverables, evaluation criteria and resources needed for the execution of the activity.

Prior to the execution of the activity, the context of the activity was explained, i.e., the scenario and real situation in which the activity is developed in the professional field of the industrial maintenance engineer.

Prior to the execution of the activities related to risk management, students were asked to select a real workplace (inside or outside the institution) to replicate the activities developed in the classroom.

Following the risk management process, in the classroom meetings, within a real context (for example, industrial maintenance laboratories and workshops, private maintenance workshops, etc.), the risk management tasks were executed, trying to replicate each action that the safety technician executes in his work, so that the students enter a real scenario and acquire the competencies that will be required of them as safety technicians.

Once the activity with the teacher was finished, the students, in an autonomous way, went to the real places selected by them and replicated the actions, delivering the products generated in the activity for review.

Upon delivery of the products of the activities, the evaluation and feedback of these activities were considering with the real actions performed by the safety technician, all this through videos in which the mistakes made and the improvements to be made were explained. The activities were considered within the evaluation system.

A project was carried out, which was considered throughout the semester, in the form of partial advances, and a final delivery at the end of the semester. The project was proposed by the teacher at the beginning of the semester for the students to carry out.

All the activities previously carried out included the cumulative semester evaluation divided into three

partial periods (8, 10 and 10 points respectively), considering the following weighting for each partial period: autonomous activities, 35 %; knowledge application activities (in the classroom), 35 % and formative research activities, 30 %. At the end of the semester, students had to submit a main evaluation with a score equal to 12 points.

In the traditional method, the main evaluation is a written and face-to-face exam, which does not respond to the reality of professional practice. Therefore, the students were asked to submit a risk management report as the main evaluation, that is, a compendium of all the activities carried out in real places where the students replicated all the activities performed in class, which recreates the actions of the safety technician almost in their entirety.

The students who did not pass had the opportunity to take a recovery evaluation (20 points), for which they were asked to correct and improve the main activity (risk management report), thus replicating the activities of the safety technician.

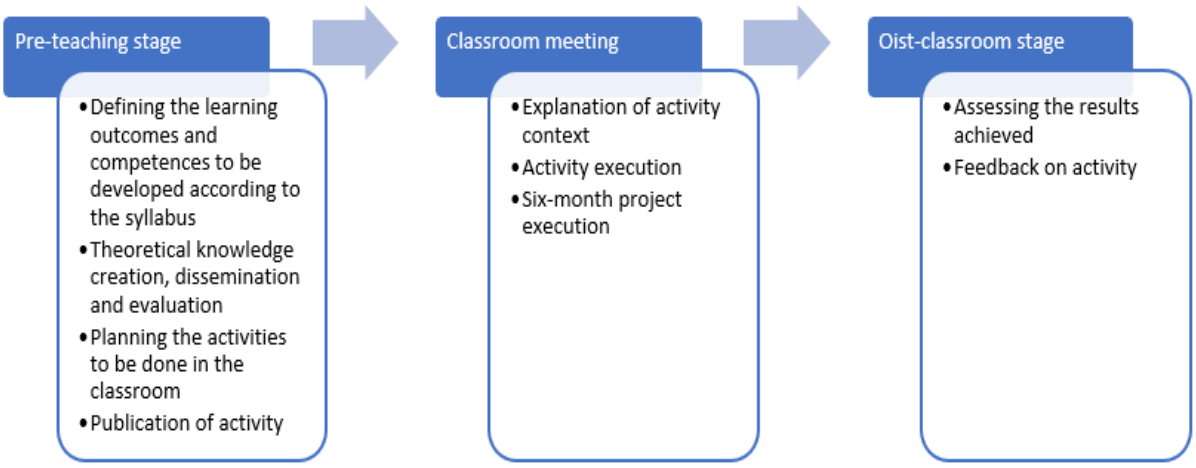

Figure1. The complete process of a class under LF

The applied process was derived and adapted from proposals generated by,[27, 28] for the execution of research under the case study method.

Participants

The criterion for the selection of the case object (or participants) was of the "information-oriented selection-critical case" type, according to the strategies for the selection of samples and objects for this type of research proposed by,[29,30] since this form of selection allows a greater subsequent generalization of the results in similar cases, enhancing the usefulness of the information and allowing a deeper analysis of a particularly useful case, such as studying an educational method not previously applied to the teaching of occupational health and environment, all in congruence with the objectives of the present research.

The students who specifically studied the subject in question were selected as participants as the case to be studied, since there are no publications describing the application of FL in the teaching of the subject of safety and environment in higher education in high-impact bibliographic bases, the analysis applied to the students in question was useful, adjusting the research to the qualities of the case study as an investigative method, a method in which the case to be studied is derived from an interest or a situation that is pertinent to analyze,[29] therefore, the study was framed in the classification of a single case within the division of the various types of case studies.[28]

The occupational health and environment course is taught in the third level (or semester) of the industrial maintenance engineering (IMI) career with a total of 64 hours of learning in contact with the teacher, distributed in 32 sessions of 2 hours over 16 weeks (2 sessions per week).

Students were enrolled automatically through the institutional system, having previously passed mandatory courses. No selection or division into groups was made, since there was only one group (or parallel) per period.

Criteria for inclusion and exclusion of participants

For the analysis of the data, only those students legally enrolled in the IMI course in the academic periods previously described and who completed the course were considered, since, for various reasons, some students suspended their studies during the course, generating partial evaluations that were not useful for the research.

Characteristics of the participants

The participants on whom the case study was focused comprised students of the ESPOCH School of Mechanics who were taking the occupational health and environment course in the third level of the IMI career in the academic periods described in table 1, comprising a total of 117 students during the two years of the implementation of the LF.

Table 3. Detail of students by academic period studied

Period	Number of students	Females	Males
april-august 2022	42	8	34
september 2022-march 2023	28	5	23
april-august 2023	23	3	20
october 2023-march 2024	24	0	24

Data collection and analysis processes

Since the research was developed over two years under the case study modality, the data collection was carried out in conjunction with the implementation of the FC to the selected course throughout the period in question.

Since the research was developed over two years under the case study modality, the data collection was carried out in conjunction with the implementation of the FC to the selected course throughout the period in question.

The data handled responded to the analysis of the suitability of the application of the FL, considering factors evaluated in publications similar to the present one, specifically the academic performance of the students was analyzed in terms of final evaluation and passing grade,[15] the teacher evaluation,[31] and in the last academic period a survey of student satisfaction with the teaching method was applied[,15] translated into Spanish and modified from,[32] ensuring the privacy of the students, which is very important.[25]

RESULTS

Table 4. Final grades by academic period

STADÍSTICAL	VALOR				
	Cumulative evaluation /28	Final evaluation /12	Suspension evaluation /20	Final values /40	Final values /100
		April - august 2022			
Average	21,3	8,9	18,0	30,3	75,8
Median	22,0	9,0	18,0	30,0	75,0
Standard Desviation	1,9	1,0	-	1,8	4,4
Minimum	18,0	7,0	18,0	28,0	70,0
Maximum	25,0	12,0	18,0	37,0	92,5
		September 2022- march 2023			
Media	17,0	9,5	15,3	28,1	70,4
Median	17,5	10,5	15,0	29,0	72,5
Standard Desviation	4,0	2,7	1,6	5,5	13,8
Minimum	4,0	0,0	13,0	4,0	10,0
Maximum	24,0	12,0	18,0	35,0	87,5
		April - august 2023			
Average	19,4	9,3	15,3	29,7	71,6
Median	20,0	9,0	18,0	32,0	77,5
Standard Deviation	4,0	2,6	6,9	6,4	15,1
Minimum	9,0	0,0	0,0	9,0	22,5
Maximum	24,0	12,0	19,0	36,0	90,0
		October 2023 - march 2024			
Average	18,9	8,3	17,0	29,1	68,0
Median	20,0	8,5	17,0	29,5	71,3
standard Deviation	3,9	1,1	0,0	3,4	11,6
Minimum	8,0	7,0	17,0	15,0	37,5
Maximum	24,0	10,0	17,0	33,0	82,5

The results obtained are described according to the methodological procedure proposed. First, table. 4 shows the averages obtained regarding the cumulative evaluation, the final evaluation and the supplementary evaluation, which were developed according to the criteria established for the present case study in the occupational health and environment chair after the implementation of the FL during the 4 consecutive academic periods, evidencing that the final values out of 100 points obtained were; 75,8 in the academic period April-August 2022; 70,4 in the period September 2022-March 2023; 71,6 in the period April-August 2023 and 68,0 in the period October 2023-March 2024.

Course approval under the application of the LF method

Figure 2. shows that the percentage of students who passed the course in the four periods of implementation of the FL method exceeded 80 %, while the percentage of students who failed was less than 20 % in three of the four periods, with a low percentage of exoneration only in the first period of application of the method.

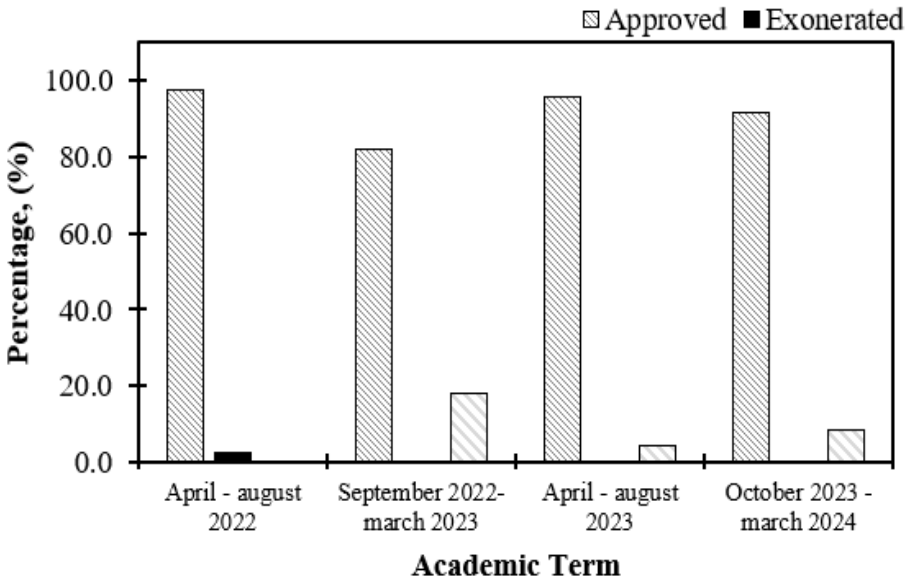

Figure 2. Percentage of approvals

Results of the teaching evaluation under the implementation of the FL

Regarding teacher evaluation, it was evidenced that in the four periods a grade higher than 80 % was obtained, as shown in figure 3, which demonstrated the acceptance by the students of the methodology used by the teacher for the development of the classes, in addition to the established evaluation methods.

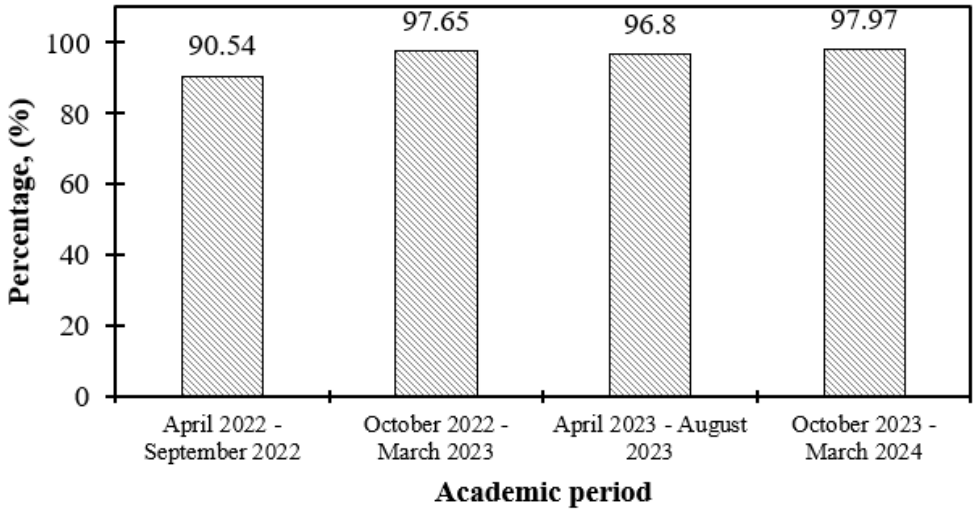

Figure 3. Teacher evaluations

Results of the satisfaction survey with the teaching methodology

Table 5 presents the results of the satisfaction survey carried out on students instructed with the FL method, evidencing a high acceptance of the evaluated criteria, since more than 25 % of the students surveyed responded favorably with what was evaluated, and more than 63 % of the students were in high agreement. Three of the twelve questions had an acceptance rate of more than 70 %, and they mention the following; the teaching content was systematically organized, the key parts of the classes were reinforced and the difficult and simple points

Table 5. Aplication of the satisfaction survey

CRITERIUM	STUDENTS ANSWERS				
	Altamente de acuerdo, %.	De acuerdo, %.	No estoy seguro de cuál es mi respuesta, %.	En desacuerdo, %.	Totalmente en desacuerdo, %.
The theoretical content was rich	63,64	36,36	0,00	0,00	0,00
The practical content of the classes was sufficient	54,55	45,45	0,00	0,00	0,00
The depth and relevance of the content taught was appropriate.	63,64	36,36	0,00	0,00	0,00
The teaching content was systematically arranged	72,73	27,27	0,00	0,00	0,00
The teaching content was systematically arranged	63,64	36,36	0,00	0,00	0,00
Key parts of the classes were reinforced, and difficult and simple points complemented each other.	72,73	27,27	0,00	0,00	0,00
La enseñanza fue una combinación adecuada de teoría y práctica	63,64	36,36	0,00	0,00	0,00
The attention paid to the students was appropriate, training and empowering them.	63,64	27,27	9,09	0,00	0,00
The basic teaching equipment was adequate	63,64	36,36	0,00	0,00	0,00
The teacher's qualities were optimal for teaching	63,64	36,36	0,00	0,00	0,00
The online teaching platform was appropriate	63,64	36,36	0,00	0,00	0,00
The online teaching platform was appropriate	63,64	36,36	0,00	0,00	0,00
The evaluation method was appropriate	72,73	27,27	0,00	0,00	0,00

DISCUSSION

The most important result related to the implementation of FL is related to academic performance, that is, the final grades obtained by the students in the four different periods showing a decrease in the final averages obtained from the first period whose average was 75,80/100 until the fourth period with an average of 68,00/100, these results are close to those obtained in a similar study carried out by,[33] in which the final values of the periods analyzed were between 73,84 and 68,21/100 which verifies that, although the application of the method still requires improvement, the performance of the students has been acceptable under the use of FL. Furthermore, studies such as the one carried out by,[34] mention post-covid academic problems such as poor academic performance in university students, so the decrease in the final average could be due to the fact that only the first period was developed under virtual modality due to the covid-19 pandemic, while the following periods occurred in person, in the analysis of results carried out it was also evident that there is a percentage greater than 80 % of approved students, with a percentage less than 20 % of failed students.

When carrying out the teaching evaluation indicated in the institutional regulations of the university in which the study was developed, the results reflected a percentage greater than 80 % in the grades given by the

students during the four academic periods, which reflects approval by the students towards the methodology used. Regarding the satisfaction survey, all the students surveyed stated that they agreed or strongly agreed with the evaluated criteria as indicated,[35] the survey allowed to measure the way in which the FL allowed the students to learn, the results show that the students approve the use of FL as an innovative methodology for the study of the subject of occupational health and environment. Due to the nature of the research, the results obtained can be generalized to the external context of the case object (local or national universities in which the occupational health and environment course is taught), since the results of a case study type research can be extrapolated to other similar cases.[30]

CONCLUSIONS

It was possible to quantify the academic performance of the students during the implementation time, which was equal to 71,5 %, in average of the periods studied, verifying that it was satisfactory in contrast to similar research (case studies of the implementation of the FL in higher education). In addition, the degree of approval of the course was high (91,8 % on average of the periods evaluated), while the teacher evaluation was acceptable (95,7 % on average in the periods analyzed) and the results of the execution of a satisfaction survey with the method were satisfactory, which leads to the conclusion that the implementation of FL is feasible within the teaching of OHS and environment in the context of higher education.

Although the present study was applied to a specific context (industrial maintenance students of an Ecuadorian university), due to the nature of the results, the responses can be extended to other contexts related to higher education.

Therefore, the implementation of the FL in the teaching of OHS and environment in the context of higher education is recommended, however, the particularities of each situation should be considered and the methodology should be modified to adapt it to the particular conditions of each context.

REFERENCES

1. Carvalho A, Teixeira SJ, Olim L, Campanella S de, Costa T. Pedagogical innovation in higher education and active learning methodologies – a case study. Educ Train. 27 de noviembre de 2020;63(2):195-213.

2. Dieguez et at. Visión de la Potenciación de la Innovación Social a través de metodologías activas en la Educación Superior [Internet]. 2022 [citado 16 de diciembre de 2024]. Disponible en: https://papers.academic-conferences.org/index.php/ecmlg/article/view/777/843

3. Informe_empleabilidad_2022.pdf [Internet]. [citado 16 de diciembre de 2024]. Disponible en: https://www.fundacioncyd.org/wp-content/uploads/2022/05/Informe_empleabilidad_2022.pdf

4. AB, Samuel TM, Ajewole PI, Anyanwu OM. Competence-driven engineering education: A case for T-shaped engineers and teachers. Int J Eval Res Educ IJERE. 1 de marzo de 2020;9(1):32-8.

5. Aslaksen EW. The relationship between engineers and society: is it currently fulfilling its potential? J Proc R Soc New South Wales. junio de 2015;148(1):28-43.

6. Gamez-Montero. Aprendizaje invertido y conceptos de umbral en la sección de Turbomáquinas del curso de Ingeniería de fluidos - Gamez-Montero - 2021 - Aplicaciones informáticas en la educación en ingeniería - Biblioteca en línea de Wiley [Internet]. 2021 [citado 17 de diciembre de 2024]. Disponible en: https://onlinelibrary.wiley.com/doi/10.1002/cae.22280

7. Carrazco DC, Tobar-Ruiz MG, Salazar-Torres SM, Godoy MMP, Sánchez-Salazar M, Veloz-Cherres D, et al. Systematic review of socio-environmental responsibility in sustainable higher education institutes. Salud Cienc Tecnol. 1 de enero de 2025;5:954-954.

8. Palomino M del CP. Metodologia docent en el màster de Formació de professorat d'educació secundària: valoració de l'alumnat. RUSC Univ Knowl Soc J. 15 de mayo de 2015;12(3):61-71.

9. Mingorance Estrada ÁC, Granda Vera J, Rojas Ruiz G, Alemany Arrebola I. Flipped Classroom to Improve University Student Centered Learning and Academic Performance. Soc Sci. noviembre de 2019;8(11):315.

10. Cold SJ. Partially flipped: experiences using POGIL. En: Proceedings of the 14th annual ACM SIGITE conference on Information technology education [Internet]. New York, NY, USA: Association for Computing Machinery; 2013 [citado 16 de diciembre de 2024]. p. 133-4. (SIGITE '13). Disponible en: https://doi.

org/10.1145/2512276.2512314

11. Jessop JLP, Flaming AL. Just the Flippin' FAQs. En 2018 [citado 17 de diciembre de 2024]. Disponible en: https://peer.asee.org/just-the-flippin-faqs

12. Hoult R, Peel M, Duffield C. Lessons from Flipping Subjects in Engineering: Effectiveness of Student Learning in a Flipped Environment at the University Level. J Civ Eng Educ. 1 de enero de 2021;147(1):04020012.

13. Quinde-Herrera K, Pinos-Vélez V, Esteve-González V, Valls-Bautista C. Aprendizaje invertido en Educación Superior: Una revisión de alcance de la implementación. Edutec Rev Electrónica Tecnol Educ. 30 de junio de 2023;(84):18-34.

14. Moreno MS, Martínez AM. Analysis of the Flipped Classroom Model as a Proposal for Teaching Innovation. J High Educ Theory Pract [Internet]. 31 de agosto de 2022 [citado 17 de diciembre de 2024];22(10). Disponible en: https://articlegateway.com/index.php/JHETP/article/view/5385

15. García-Ramírez Y. Pavements Course: Is the Flipped Classroom Model Effective in All Cases? A Case Study in a Developing Country. En 2024 [citado 17 de diciembre de 2024]. p. 509-16. Disponible en: https://www.scitepress.org/Link.aspx?doi=10.5220/0008397705090516

16. Galindo-Melero J, Sanz-Angulo P, De-Diego-Poncela S, Martín Ó. Analysis of academic results from implementation of a flipped learning methodology in a subject in higher engineering education. Eur J Educ. 2024;59(2):e12611.

17. Kuntinee Maneeratana et al. Estudio preliminar sobre la utilización y la eficacia de una clase invertida en Tailandia | Publicación de la conferencia IEEE | IEEE Xplore [Internet]. 2017 [citado 17 de diciembre de 2024]. Disponible en: https://ieeexplore.ieee.org/document/7851819

18. Cho HJ, Zhao K, Lee CR, Runshe D, Krousgrill C. Active learning through flipped classroom in mechanical engineering: improving students' perception of learning and performance. Int J STEM Educ. 22 de julio de 2021;8(1):46.

19. Wang J, Wang M. Influences of Use of Flipped Classroom Models on the Learning Outcomes of Students Majoring in Road and Bridge Engineering Technology. Int J Emerg Technol Learn IJET. 7 de marzo de 2023;18(05):114-27.

20. Bárbara Kerr. El aula invertida en la enseñanza de la ingeniería: un estudio de la investigación | Publicación de la conferencia IEEE | IEEE Xplore [Internet]. 2015 [citado 17 de diciembre de 2024]. Disponible en: https://ieeexplore.ieee.org/document/7318133

21. Aliye Karabulut-Ilgu et al. Una revisión sistemática de la investigación sobre el método de aprendizaje invertido en la educación en ingeniería - Karabulut-Ilgu - 2018 - British Journal of Educational Technology - Wiley Online Library [Internet]. 2018 [citado 17 de diciembre de 2024]. Disponible en: https://bera-journals.onlinelibrary.wiley.com/doi/10.1111/bjet.12548

22. Prevalla y Uzunboylu - 2019 - Flipped Learning in Engineering Education.pdf [Internet]. [citado 17 de diciembre de 2024]. Disponible en: https://www.temjournal.com/content/82/TEMJournalMay2019_656_661.pdf

23. «Incluir rigor y maestría en un estudio de caso como una estrategia cualitativa» por Prema Gaikwad [Internet]. [citado 17 de diciembre de 2024]. Disponible en: https://nsuworks.nova.edu/tqr/vol22/iss13/4/

24. Priya A. Case Study Methodology of Qualitative Research: Key Attributes and Navigating the Conundrums in Its Application. Sociol Bull. 1 de enero de 2021;70(1):94-110.

25. Basitere M, Rzyankina E, Le Roux P. Reflection on Experiences of First-Year Engineering Students with Blended Flipped Classroom Online Learning during the COVID-19 Pandemic: A Case Study of the Mathematics Course in the Extended Curriculum Program. Sustainability. enero de 2023;15(6):5491.

26. Baig MI, Yadegaridehkordi E. Flipped classroom in higher education: a systematic literature review and research challenges. Int J Educ Technol High Educ. 30 de noviembre de 2023;20(1):61.

27. Slemmons K, Anyanwu K, Hames J, Grabski D, Mlsna J, Simkins E, et al. The Impact of Video Length on Learning in a Middle-Level Flipped Science Setting: Implications for Diversity Inclusion. J Sci Educ Technol. 1 de octubre de 2018;27(5):469-79.

28. Álvarez Álvarez C, San Fabián Maroto JL. La elección del estudio de caso en investigación educativa. Gaz Antropol. 2012;(28):14.

29. Ceballos-Vacas E, Trujillo-González E, Esteban MIF, Delgado MYG. El Estudio de Caso en la Investigación del Cambio en la Cultura Escolar. REICE Rev Iberoam Sobre Calid Efic Cambio En Educ. 29 de junio de 2023;21(3):193-209.

30. Flyvbjerg, B. Five Misunderstandings About Case-Study Research - Bent Flyvbjerg, 2006 [Internet]. 2026 [citado 17 de diciembre de 2024]. Disponible en: https://journals.sagepub.com/doi/10.1177/1077800405284363

31. Hassan MHA, Othman NA. Flipped Classroom Approach in Rigid Body Dynamics: A Case Study of Five-Semester Observation. Int J Eng Pedagogy IJEP. 19 de enero de 2021;11(1):87-94.

32. Gao S, Zhuang J, Chang Y. Influencing Factors of Student Satisfaction With the Teaching Quality of Fundamentals of Entrepreneurship Course Under the Background of Innovation and Entrepreneurship. Front Educ [Internet]. 12 de octubre de 2021 [citado 17 de diciembre de 2024];6. Disponible en: https://www.frontiersin.org/journals/education/articles/10.3389/feduc.2021.730616/full

33. Soto LS, García-Martín J. El impacto psicoeducativo de la metodología Flipped Classroom en la Educación Superior: una revisión teórica sistemática. Rev Complut Educ. 9 de enero de 2023;34(1):217-29.

34. Marcillo et al. Síndrome diarreico infeccioso causado por Salmonella spp | RECIMUNDO [Internet]. [citado 17 de diciembre de 2024]. Disponible en: https://recimundo.com/index.php/es/article/view/533

35. Suwapaet N. Introducing a flipped classroom to engineering students: A case study in mechanics of materials course. AIP Conf Proc. 28 de marzo de 2018;1941(1):020041.

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