Satisfaction of Postgraduate Students With Hybrid Flipped Learning to Develop Their Mathematical Competencies

Edgar O. Cardoso-Espinosa [1], Jésica A. Cortes-Ruiz [2], Ma. Elena Zepeda-Hurtado [3]

[1]*Instituto Politécnico Nacional (IPN) ESCA-ST, Mexico City, Mexico*
[2]*Instituto Politécnico Nacional (IPN) CIECAS, Mexico City, Mexico*
[3]*Instituto Politécnico Nacional (IPN) CECyT 11, Mexico City, Mexico*

Abstract **– The objective of the research is to assess the effectiveness of flipped learning in the development of mathematical competencies of postgraduate students to determine the level of satisfaction achieved during academic training in hybrid modality. The methodological approach was a quantitative a descriptive scope. The questionnaire was the instrument used with a cross-sectional design. The sample was 32 postgraduate students. The results are that hybrid flipped learning promotes the usefulness of the contents; integrates through discussions, practical cases or problems what has been learned for work performance. The mathematical competencies with the highest level of development are the use of mathematical terminology; use digital tools for the presentation of the strategy. The relevance of the research is to contribute about the effectiveness and use of flipped learning with the support of digital tools to promote quality mathematical training.**

Keywords **– Hybrid flipped learning, mathematical training, quality, student body, student satisfaction.**

DOI: 10.18421/TEM123-64
https://doi.org/10.18421/TEM123-64

Corresponding author: Edgar O. Cardoso-Espinosa,
Instituto Politécnico Nacional – ESCA ST, México
Email: eoce@hotmail.com

Received: 04 March 2023.
Revised: 04 May 2023.
Accepted: 19 July 2023.
Published: 28 August 2023.

1. Introduction

Education makes it possible to transform realities through the training of critical citizens who will shape future societies [1]. Technology and digitization have caused various changes in classroom training practices oriented towards student participation that motivates them not only to acquire knowledge but to discover it, reflect on it and even determine its application in real life [2].

The appearance of the COVID-19 pandemic at the international level generated the confinement of the population, therefore, to continue with the educational service, the organizations implemented the virtual modality through the operation of applications and management systems [3]. The virtual spaces became the center of academic training for the student body through the incorporation of communication tools and platforms where it is possible to exchange information, content, videos, conferences, journal articles and books, which led to the emergence of novel and disruptive practices that it is relevant to analyze to discover their effect on the quality of learning in order to determine their impact and possible inclusion when returning to face-to-face [4].

Based on the above, in the post-COVID-19 era, education continues to be one of the main challenges of any society, which is why it is necessary to implement didactic methodologies, coordinate wills and vocations among educational agents that make it possible to convert educational spaces into places conducive to the development of competencies that generate human capital capable of bringing about transcendental changes in the organizations in which they work [1]. Postgraduate students require integrated academic training in real contexts through practices, case studies, and other activities focused on the application of knowledge, skills, and attitudes that allow them to make what they have learned useful and transcendent [5].

Based on the above, the general objective is: To assess the effectiveness of flipped learning in the development of mathematical competencies of postgraduate students in order to determine the level of satisfaction achieved during academic training in hybrid modality.

2. Literature Review

Flipped learning has as its main foundation the management of knowledge in which there is interaction and participation, in which dynamic and interactive training spaces are created, mediated by digital tools where from the consultation of previous materials (videos, presentations, research articles) are complemented by face-to-face sessions in which active methodologies that encourage collaborative work based on practical cases or problem solving are implemented [6]. The purpose of flipped learning is to encourage higher level students to achieve higher cognitive levels such as evaluating their learning process, increasing their motivation and interest in their training, changing the traditional paradigm of teacher-centered learning, as well as developing the skills desired by employers such as critical thinking, collaboration, communication, leadership, and informed decision-making [7].

Thus, flipped learning encourages students to increase both their commitment and involvement in their own training because teachers design activities that are attended outside the classroom, which makes it possible to focus during class sessions on discussion, debate, resolution of practical cases or problems that lead to participation and collaborative work in the student body, which generates an articulation, argumentation and usefulness of the knowledge of the subject and leads to significant and quality learning [8], [9]. The advantages of flipped learning are increasing academic achievement in terms of grades, motivation, collaborative work, self-regulation, as well as student responsibility for their training [10], [11], [12].

Meanwhile, Fornasari [13] points out that the inclusion of ICT in the academic training of students directly affects the incorporation of computer programs that they will use in their work performance, which makes the development of mathematical skills such as the analysis of situations and the interpretation of results possible to a greater extent. The incorporation of ICT as support tools is recommended to motivate students and stimulate learning by linking content development with professional reality.

On the other hand, at the postgraduate level, a mathematical training oriented towards the development of mathematical competencies remains in force as a relevant component that allows students to perform successfully in the labor sector [14].

To achieve this, it is necessary to focus on a mathematical learning based on the know-how with the intention of getting students to identify not only the terminology and concepts but also the field of applications where mathematics is used. In this way, in order to achieve quality mathematical training at the postgraduate level, it is necessary for teachers to design and implement the problematization, construction, analysis and synthesis in the field of application of this subject [15].

Ruiz-Jaramillo and Vargas-Yañez [13] determined that flipped learning increases student motivation and generates an increase in course approval rates as well as quality training. Aguilar-Mediavilla et al [16] found that flipped learning in a blended modality obtained more than half a point of average rating with respect to face-to-face learning, which implies a high responsibility. Morales [17] found that 98% of the students valued in an excellent way the use of flipped learning during the course, highlighting the applications of the contents; 90% in terms of practical activities in an excellent way, 84% that promote collaborative work and 79% that makes it possible to manage time to comply with the subject. Playfoot [18] found in his study that the performance of students in a statistics course increased through flipped learning based on virtual classes and asynchronous activities during the COVID-19 pandemic, as well as increased their commitment, responsibility, and participation in an active way regardless of the classroom context.

However, proposals based on flipped learning have been implemented mostly in face-to-face contexts and rarely in mixed or hybrid modalities [19], so research is required to analyze their effectiveness and impact in the academic training of students [20], [21]. Also, it is extremely important to analyze the link between flipped learning and its didactic implementation through digital didactic tools and resources at the postgraduate level [22], [23], [18]. Sánchez-Rivas et al [24]; Fernández et al [25] affirm that student satisfaction is one of the fundamental factors that determine both the adequacy and viability of a methodology for the quality of learning. Betihavas et al [26]; Presti [27]; Lo and Hew [28]; emphasize the importance of conducting research on the effects of flipped learning at the postgraduate level for the area of mathematics in order to determine its impact on the academic training of the student body.

3. Materials and Methods

The research carried out is integrated by the phases shown in Figure 1.

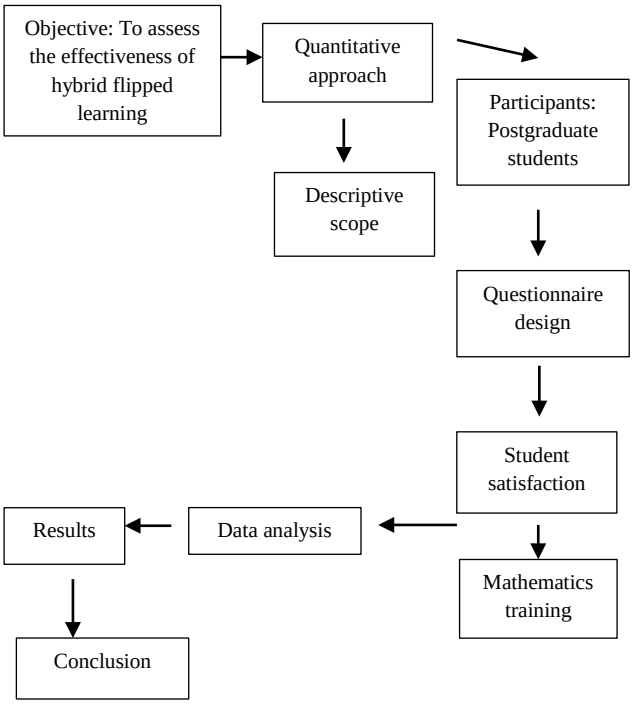

Figure 1. Study methodology

3.1. Research Type

According to Figure 1, the study was based on the quantitative approach with a descriptive scope to achieve the research objective [29].

3.2. Sample

The research sample was of a non-probabilistic type because it considered the students who enrolled in the course of Mathematics Applied to Administration that is taught in the first semester of the Master in Business Administration Program at the Instituto Politécnico Nacional with a hybrid model. The total was 32 students with the characteristics shown in Table 1.

Table 1. Participants

Variable		Percentage
Gender	Female	76%
	Masculine	24%
Age (years)	25 to 29	78%
	30 to 34	22%
Work experience (years)	0 to 4	22%
	5 to 9	72%
	More than 9	6%

3.3. Didactic Intervention

The implementation of the hybrid model was conducted during a period of 18 weeks where 9 corresponded to face-to-face sessions while the other 9 were carried out online through an institutional learning management system. The planning and implementation of the hybrid model was based on the three stages of flipped learning: The teachers prepared the digital resources (videos, journal articles and Power Point presentations) to make them available to the students for review prior to each class. For the face-to-face session held once every two weeks, the student body formulated questions or doubts about the materials consulted; then, an activity based on an administrative situation was carried out for its resolution by teams with the guidance of the teaching staff; and finally, it ended in the third stage with an evaluation to determine the level of understanding of each subject content.

3.4. Instrument

In order to obtain the information required for the investigation, a questionnaire was formulated including socio-labor data, satisfaction with respect to flipped learning and the mathematical training developed. The scale established for each item was of a Likert type with five points for the dimension of student satisfaction (totally disagree to totally agree). For the dimension of mathematical competencies, a five-point scale (not developed to fully developed) was used.

The content validation of the instrument was carried out using the expert judgment technique in order to identify the wording and orientation of each item with respect to the hybrid model and mathematical training at the postgraduate level. After this phase, the reliability test based on the Cronbach coefficient ($\alpha = 0.897$) was carried out, which means adequate internal consistency. The exploratory factorial analysis determined that the instrument has empirical validity based on the KMO test whose value was 0.889 and on the Bartlett's sphericity test with a value of $X^2 = 3458.13$; $p < 0.001$.

3.5. Data Collection and Data Analysis

After finishing the course in the hybrid modality, each of the participants was invited to answer the research instrument, mentioning its relevance, and indicating its confidentiality, which allowed obtaining the information. The data obtained were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25 to calculate the mean (M) and standard deviation (SD) of each item, in order to be able to interpret the results.

4. Results

The assessment of the satisfaction provided by flipped learning in the academic training of postgraduate students is shown in Table 2.

Table 2. Descriptive statistics on student assessment

Flipped learning in hybrid modality allowed	M	SD
Consult the digital teaching resources (presentations, articles, and videos) at any time and with easy access	4.86	0.43
Promote active participation during the course through discussions, practical cases, or problems	4.74	0.49
Formulate well-founded questions about the contents after consulting the support materials	4.64	0.53
Promote synchronous and asynchronous communication among students	4.60	0.61
Promote collaborative work	4.65	0.62
Promote time management to attend to various activities (family, academic and work)	4.52	0.77
Synchronous and asynchronous interaction with teachers	4.73	0.68
Recommend flipped learning	4.40	0.81
Reduce frustrating or boring sessions	4.67	0.64
Greater motivation for learning	4.88	0.41
Integrate what has been learned for work performance	4.94	0.35
Recognize the usefulness of the content	4.96	0.31
Improve my attitudes towards mathematics	4.92	0.34
A quality of the training received	4.89	0.42
The teacher to be a guide and facilitator in each session	4.81	0.38
A continuous evaluation	4.63	0.71
A follow-up on my academic training	4.60	0.77

Table 2 shows that the findings of the assessment made by the study participants are favorable regarding the use of flipped learning because the means have values greater than 4 points for each item. The components with the highest averages are: Recognize the usefulness of the contents (4.96 ± 0.31); integrate what has been learned for work performance (4.94 ± 0.35); improve my attitudes towards mathematics (4.92 ± 0.34); a quality of the training received (4.89 ± 0.42); an increase in the motivation to learn (4.88 ± 0.41) and the consultation of digital teaching resources at any time and with easy access (4.86 ± 0.43).

Regarding the mathematical training developed by flipped learning, the results are shown in table 3.

Table 3. Descriptive statistics on mathematical training

Flipped learning in hybrid modality promoted the following mathematical competence	M	SD
Using mathematical symbols	3.91	0.14
Identifying the variables	3.78	0.34
Formulating and designing a strategy	3.75	0.35
Using technological tools to describe and present the strategy	3.84	0.22
Knowing computer programs to use them in the workplace	3.71	0.39
Mathematically justifying the strategy	3.56	0.42
Interpreting the results	3.45	0.53
Determining management decision making	3.42	0.56

Table 3 shows that postgraduate students recognize that mathematical competencies were developed from hybrid inverted learning, standing out with a high level of development: Use mathematical symbols (3.91 ± 0.14); use technological tools to describe and present the strategy (3.84 ± 0.22); identify the variables (3.78 ± 0.34); formulating and designing a strategy (3.75 ± 0.35) and know computer programs to use them in the workplace (3.71 ± 0.39). These results indicate both the effectiveness of flipped learning and a quality mathematical training that will allow each participant a job positioning.

5. Discussion and Conclusion

The emergence of the COVID-19 pandemic as a health crisis generated various effects in different areas of a country where education was no exception. The COVID-19 pandemic must also be analyzed as an opportunity that offers the incursion of new modalities to provide the educational service with the support of digital tools. In this sense, the research carried out provides important information regarding flipped learning as a methodology with high effectiveness and impact for the development of the various capacities in the student body, so the general objective was achieved by the high assessment of the postgraduate students for their professional training.

The previous results allow us to establish the importance and effectiveness of flipped learning in the academic training of postgraduate students by generating training spaces in combination with the use of digital materials, which coincides with studies [6], [14]; coupled with an increase in motivation as indicated by [13], [7].

Also, it agrees with Luo et al [10]; Wu et al [11]; Burgess et al [12]; relation to the fact that flipped learning promotes collaborative work and responsibility in the student body for their training. In addition, it is confirmed with studies [5], [8], [9] in what concerns the teachers being a guide in each face-to-face session and that the activities are oriented towards debates and resolution of practical cases or problems.

These findings confirm what was pointed out by Van Den Heuvel-Panhuizen and Drijvers [15] that to promote quality in mathematics education it is necessary for teachers to design and implement practical activities that through flipped learning encourage the construction, argumentation, and interpretation of situations focused on the workplace. In addition, what was established Ruiz-Jaramillo and Vargas-Yañez [13] regarding the incorporation of computer programs because they trigger mathematical abilities is corroborated. Also, these results provide useful information regarding the impact and feasibility of flipped learning in mathematics education at the postgraduate level as recommended by [26], [27], [28].

Therefore, this research contributes to knowledge about the effectiveness and use of flipped learning with the support of digital tools to promote quality mathematical training at the postgraduate level in a hybrid modality that was established once the confinement period ended. However, the main limitation of the study is that it is focused on a single subject with a small sample size and on a postgraduate program. In this sense, it is suggested to extend to other subjects and educational programs and even to other institutions that allow corroborating or differing from the effectiveness of flipped learning.

Acknowledgements

This paper was supported by the Instituto Politécnico Nacional, Mexico under SIP number 20220749; 20221267.

References:

[1]. Vargas, J., & Santillán, A. (2022). Diversidad de efectos de factores asociados a los aprendizajes en matemáticas en primarias mexicanas [Diversity of effects of factors associated with learning in mathematics in Mexican elementary schools]. *IE Revista De Investigación Educativa De La REDIECH*, *13*. Doi: 10.33010/ie_rie_rediech.v13i0.1494

[2]. Lundin, M., Bergviken Rensfeldt, A., Hillman, T., Lantz-Andersson, A., & Peterson, L. (2018). Higher education dominance and siloed knowledge: a systematic review of flipped classroom research. *International Journal of Educational Technology in Higher Education, 15***,** 1-30. Doi: 10.1186/s41239-018-0101-6

[3]. López, M., & Contreras, A. (2022). El impacto de la pandemia por COVID-19 en estudiantes mexicanos de educación media superior [The impact of the covid-19 pandemic on Mexican students of upper secondary education]. *RIDE Revista Iberoamericana para la Investigación y el Desarrollo Educativo, 12*(24), 1-27. Doi: 10.23913/ride.v12i24.1141

[4]. Fornasari, M. (2020). La pandemia en contextos educativos: Un enfoque ético sobre los tiempos virtuales y el porvenir. [The Pandemic in an Educational Context: An Ethical Approach on the Virtual Timesand the Coming Times] *Trayectorias, 23*(52), 3-15.

[5]. Sureda, J., & Oliver, M. (2015). *La formació inicial del professorat d'Educació Infantil i Primària a les Illes Balears. Estat de la qüestió i propostes per a la millora*. Universitat de les Illes Balears.

[6]. Fidalgo-Blanco, Á., Sein-Echaluce, M., & García-Peñalvo, F. (2018). Ontological flip teaching: a flip teaching model based on knowledge management. *Universal Access in the Information Society, 17*(3), 475-489. Doi: 10.1007/s10209-017-0556-6

[7]. Overmyer, J. (2015). Research on Flipping College Algebra: Lessons Learned and Practical Advice for Flipping Multiple Sections. *PRIMUS, 25*, 792–802. Doi: 10.1080/10511970.2015.1045572

[8]. Ledo, M. V., Michelena, N. R., Cao, N. N., Suárez, I. D. R. M., & Vidal, M. N. V. (2016). Aula invertida, nueva estrategia didáctica. *Revista Cubana de Educación Médica Superior, 30*(3), 678-688.

[9]. Merla, A., & Yáñez, C. (2016). El aula invertida como estrategia para la mejora del rendimiento académico [The flipped classroom as a strategy to improve academic performance]. *Revista Mexicana de Bachillerato a Distancia*, *8*(16), 68-78.

[10]. Luo, H., Yang, T., Xue, J., & Zuo, M. (2019). Impact of student agency on learning performance and learning experience in a flipped classroom. *British Journal of Educational Technology, 50*(2), 819–831. Doi: 10.1111/bjet.12604

[11]. Wu, W. C. V., Hsieh, J. S. C., & Yang, J. C. (2017). Creating an online learning community in a flipped classroom to enhance EFL learners' oral proficiency. *Journal of Educational Technology & Society*, *20*(2), 142-157.

[12]. Burgess, A., Roberts, C., Van Diggele, C., & Mellis, C. (2017). Peer teacher training (PTT) program for health professional students: Interprofessional and flipped learning. *BMC Medical Education, 17*, 1–13. Doi: 10.1186/s12909-017-1037-6

[13]. Ruiz-Jaramillo, J., & Vargas-Yáñez, A. (2018). La enseñanza de las estructuras en el Grado de Arquitectura. Metodología e innovación docente a través de las TIC.[Teaching structures on Architecture degrees. ICT-based methodology and teaching innovation]. *Revista Española de Pedagogía, 76*(270), 353-372. Doi: 10.22550/REP76-2-2018-08

[14]. Moro, A. I., Moro, J. C. I., López, F. J. M., & Ordaz, M. G. (2016). Las competencias digitales en las grandes empresas del sector empresarial español. *Tec Empresarial, 10*(2), 41-49.

[15]. Van Den Heuvel-Panhuizen, M., & Drijvers, P. (2014). Realistic mathematics education. In S. Lerman (Ed.), *Encyclopedia of mathematics education*, 521-525. Springer. Doi: 10.1007/978-94-007-4978-8_170

[16]. Aguilar-Mediavilla, E., Buil-Legaz, L., Sanchez-Azanza, V., & Valera-Pozo, M. (2022). Flipped classroom pos-COVID-19 para alumnado universitario. In S. Olmos-Migueláñez, M. J. Rodríguez-Conde, A. Bartolomé, J. Salinas, F. J. Frutos-Esteban, & F. J. García-Peñalvo (Eds.), *La influencia de la tecnología en la investigación educativa pospandemia* [The influence of technology on post-pandemic educational research], 59-71. Octaedro.

[17]. Morales, R. (2022). La gamificación como estrategia de evaluación bajo el enfoque flipped learning. [Gamification as an evaluation strategy under the flipped learning approach]. *Revista Iberoamericana para la Investigación y el Desarrollo Educativo*, *13*(25), 1-25. Doi: 10.23913/ride.v13i25.1296

[18]. Playfoot, D. (2021). Flipped classrooms in undergraduate statistics: Online works just fine. *Teaching of Psychology*. Doi: 10.1177/00986283211046319

[19]. Fidalgo-Blanco, Á., Sein-Echaluce, M., & García-Peñalvo, F. (2020). Hybrid flipped classroom: adaptation to the COVID situation. *Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality*, 405-409. Doi: 10.1145/3434780.3436691

[20]. Gil, J. M. C., Lominchar, J. A., & Pucha, Á. B. F. (2021). Percepción estudiantil sobre la educación online en tiempos de COVID-19: Universidad de Almería [Student perception of online education in times of COVID-19: University of Almería]. *Revista Scientific*, *6*(19), 185-207. Doi: 10.29394/Scientific.issn.2542-2987.2021.6.19.9.185-207

[21]. González, M., & Abad, E. (2020). El aula invertida: un desafío para la enseñanza universitaria. VEC: Virtualidad [The flipped classroom: a challenge for university teaching]. *Educación y Ciencia*, *11*(20), 75-91.

[22]. Khodaei, S., Hasanvand, S., Gholami, M., Mokhayeri, Y., & Amini, M. (2022). The effect of the online flipped classroom on self-directed learning readiness and metacognitive awareness in nursing students during the COVID-19 pandemic. *BMC Nursing*, *21*(1). Doi: 10.1186/s12912-022-00804-6

[23]. Jia, C., Hew, K., Bai, S., & Huang, W. (2021). Adaptation of a conventional flipped course to an online flipped format during the COVID-19 pandemic: Student learning performance and engagement. *Journal of Research on Technology in Education*, *54*(2), 1–21. Doi: 10.1080/15391523.2020.1847220

[24]. Sánchez-Rivas, E., Sánchez-Rodríguez, J., & Ruiz-Palmero, J. (2019). Percepción del alumnado universitario respecto al modelo pedagógico de clase invertida [Perception of university students regarding the flipped class pedagogical model]. *Magis, Revista Internacional de Investigación en Educación, 11*(23), 151-168. Doi: 10.11144/Javeriana.m11-23.paur

[25]. Fernández, I., Riveros, V., & Montiel, G. (2017). Software educativo y las funciones matemáticas. Una estrategia de apropiación. *Omnia*, *23*(1), 9-19.

[26]. Betihavas, V., Bridgman, H., Kornhaber, R., & Cross, M. (2016). The evidence for 'flipping out': A systematic review of the flipped classroom in nursing education. *Nurse Education Today, 38*, 15-21. Doi: 10.1016/j.nedt.2015.12.010

[27]. Presti, C. (2016). The flipped learning approach in nursing education: A literature review. *Journal of Nursing Education, 55*(5), 252-257. Doi: 10.3928/01484834-20160414-03

[28]. Lo, C., & Hew, K. (2017). A critical review of flipped classroom challenges in K-12 education: Possible solutions and recommendations for future research. *Research and Practice in Technology Enhanced Learning*, *12*(4), 8-15. Doi: 10.1186/s41039-016-0044-2

[29]. Hernández, R., & Mendoza, C. (2018). *Metodología de la investigación: Las rutas cuantitativa, cualitativa y mixta.*[*Research methodology: quantitative, qualitative and mixed routes*]. México: Mc Graw Hill.