

**Analysis of flipped classroom and digital tools in the teaching-learning process about computing through data science techniques**

**Análisis del Aula invertida y herramientas digitales en el proceso de enseñanza-aprendizaje sobre la informática a través de la ciencia de datos**

**Análise da Flipped Classroom e das ferramentas digitais no processo de ensino-aprendizagem em computação por meio da ciência de dados**

**Abstract:**

**Purpose.** The aim of this quantitative research is to analyze the perceptions of the students about the use of flipped classroom and digital tools in the field of computing through data science. **Method.** The participants are 22 students who took the Development of Applications course during the 2017 school year. This study proposes the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application collaboratively during the face-to-face sessions and use of the Kompozer application after the face-to-face sessions. The Dolibarr application allows the use of ERP modules and Kompozer application allows the design and build of the websites. **Results.** The results of the machine learning technique (linear regression) indicate that the activities of flipped classroom positively influence the educational process on computing. Data science identified 3 predictive models about the use of flipped classroom and digital tools during the learning process about the design of web applications through the decision tree technique. The neural network technique establishes the impact of the activities before, after and during the face-to-face sessions. **Conclusion.**

Finally, flipped classroom facilitates the construction of new spaces for learning and teaching through digital tools.

**Keywords:** Flipped classroom; educational technology; higher education; data science.

### **Resumen:**

**Objetivo.** El objetivo de esta investigación cuantitativa es analizar las percepciones de los estudiantes sobre el uso del Aula invertida y las herramientas digitales en el campo de la informática por medio de la ciencia de datos.

**Metodología.** Los participantes son 22 estudiantes que cursaron la asignatura Desarrollo de aplicaciones durante el ciclo escolar 2017. Este estudio propone la consulta de videos YouTube antes de las sesiones presenciales, el uso de la aplicación Dolibarr colaborativamente durante las sesiones presenciales y el uso de la aplicación Kompozer después de las sesiones presenciales. La aplicación Dolibarr permite el uso de los módulos ERP y la aplicación Kompozer permite el diseño y la construcción de los sitios web.

**Resultados.** Los resultados de la técnica aprendizaje automático (regresión lineal) indican que las actividades del Aula invertida influyen positivamente en el proceso educativo sobre la informática. La ciencia de datos identificó 3 modelos predictivos sobre el uso del Aula invertida y las herramientas digitales durante el proceso de enseñanza sobre el diseño de aplicaciones web por medio de la técnica árbol de decisión. La técnica red neuronal establece el impacto de las actividades antes, durante y después de las sesiones presenciales.

**Conclusión.** Por último, el Aula invertida facilita la construcción de nuevos espacios para el aprendizaje y enseñanza por medio de las herramientas digitales.

**Palabras clave:** Aula invertida; tecnología educativa; educación superior; ciencia de datos.

## Resumo:

**Objetivo.** O objetivo desta pesquisa quantitativa é analisar a percepção dos alunos sobre o uso da Flipped Classroom e ferramentas digitais na área de computação por meio da ciência de dados. **Metodologia.** Os participantes são 22 alunos que cursaram a disciplina Desenvolvimento de Aplicativos durante o ano letivo de 2017. Este estudo propõe a consulta de vídeos do YouTube antes das sessões presenciais, o uso do aplicativo Dolibarr de forma colaborativa durante as sessões presenciais e o uso do aplicativo Kompozer após as sessões presenciais. A aplicação Dolibarr permite a utilização dos módulos ERP e a aplicação Kompozer permite o desenho e construção dos websites. **Resultados.** Os resultados da técnica de aprendizagem automática (regressão linear) indicam que as atividades da Flipped Classroom influenciam positivamente o processo educacional em informática. A ciência de dados identificou 3 modelos preditivos sobre o uso da Flipped Classroom e ferramentas digitais durante o processo de ensino sobre o design de aplicações web através da técnica de árvore de decisão. A técnica de rede neural estabelece o impacto das atividades antes, durante e após as sessões presenciais. **Conclusões.** Por fim, Flipped Classroom facilita a construção de novos espaços de aprendizagem e ensino por meio de ferramentas digitais.

**Palavras-chave:** Flipped Classroom; Tecnologia educativa; Educação superior; ciência de dados.

## Introduction

Today, Information and Communication Technologies (ICTs) allows the planning and organization of new school activities outside and inside the classroom (Angelini & Garcia, 2019; Guillén-Gámez et al., 2021). Therefore, teachers have the challenge of incorporating digital tools in the educational process to facilitate the assimilation of knowledge and development of skills through the use of

pedagogical models (Angelini & García, 2019; Grunis et al., 2021; Yong et al., 2019).

Flipped classroom allows the realization of activities before, after and during the face-to-face sessions through ICTs (Amira et al., 2019; Shahani et al., 2022). In this pedagogical model, students can consult videos at home and solve the problems and exercises collaboratively in the classroom with the help of teacher (Nouri, 2016; Shu & Gu, 2018; Sun & Xie, 2020).

Universities use pedagogical models to develop the competences of the students and build new educational virtual spaces (Ozbay & Cinar, 2021; Palazón-Herrera & Soria-Vílchez, 2021; Shu & Gu, 2018). In particular, flipped classroom promotes the active role through the use of technological tools at any time (Ozbay & Cinar, 2021; Sen, 2022; Yu & Zhu, 2019).

In fact, flipped classroom is modifying the behavior of teachers and students in the educational field because this pedagogical model allows optimizing the time during the realization of the school activities in the classroom (Angelini & Garcia, 2019; Silva et al., 2018; Zhamanov et al., 2018). For example, class time can be used to solve the exercises, prepare the projects and carry out the discussions (Al-Jarrah et al., 2018; Dong et al., 2021; Sun et al., 2018).

The use of flipped classroom is growing at the higher educational level because teachers can organize creative school activities (Dong et al., 2021; Lundin et al., 2018; Sun & Xie, 2020). Therefore, this quantitative research analyzes the perceptions of the students about flipped classroom and digital tools in the field of computing through the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application collaboratively during the face-to-face sessions and use of the Kompozer application after the face-to-face sessions. The Dolibarr application allows the use of ERP modules and Kompozer application allows the design and build of the websites.

The research questions are:

- What are the perceptions of the students about the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application collaboratively during the face-to-face sessions and use of the Kompozer application after the face-to-face sessions considering the machine learning technique?
- What are the predictive models about the use of flipped classroom and digital tools in the field of information technology considering the decision tree technique?
- How do the activities of flipped classroom influence the teaching-learning process about the design of web applications considering the neural network technique?

## **Flipped classroom**

Educational institutions seek new teaching strategies and pedagogical models to update the activities of the courses ([Brinkley, 2018](#); [Pieterse et al., 2018](#)). For example, flipped classroom promotes the curiosity, creativity, collaborative work and acquisition of knowledge ([Dong et al., 2021](#); [Ouchaouka et al., 2021](#)).

Technological advances have a fundamental role during the construction of educational spaces ([Palazón-Herrera & Soria-Vílchez, 2021](#); [Sen, 2022](#); [Truitt & Ku, 2018](#)). In particular, YouTube videos facilitate the transmission of information at any time ([Palazón-Herrera & Soria-Vílchez, 2021](#); [Sun et al., 2018](#)). In addition, the use of web applications and digital tools in the school activities facilitate the development of skills ([Altakhayneh, 2022](#); [Ozbay & Cinar, 2021](#)).

Flipped classroom proposes the realization of the school activities outside and inside the classroom ([Amira et al., 2019](#); [Dong et al., 2021](#)). At home, students review the videos and digital readings to discuss, reflect and analyze the topics during the face-to-face sessions ([Lundin et al., 2018](#); [Sun & Xie, 2020](#)). In the

classroom, students make presentations, work as a team and use digital tools (Al-Jarrah et al., 2018). In fact, this pedagogical model allows that students control the pace of the learning process and teachers use class time to carry out effective and creative activities (Nouri, 2016; Yu & Zhu, 2019).

Flipped classroom facilitates the interaction between students and teachers through the planning of the activities based on the use of digital and communication tools (Ouchaouka et al., 2021; Ozbay & Cinar, 2021). For example, videos, podcasts, online presentations, interactive contents and web tutorials facilitate the assimilation of knowledge and promote the active role during the learning process (Palazón-Herrera & Soria-Vílchez, 2021; Roux & Nagel, 2018). In the same way, Learning Management Systems (LMS) such as Moodle, Canvas and Blackboard play a fundamental role during the implementation and dissemination of the school activities during flipped classroom (Al-Jarrah et al., 2018).

Several authors (Al-Jarrah et al., 2018; Nouri, 2016; Roux & Nagel, 2018) have used flipped classroom in the field of education to facilitate the learning process. According to Nouri (2016), this pedagogical model increased the motivation and improved the academic performance of the students through videos and Moodle. Also, Roux and Nagel (2018) proposed the use of audiovisual contents and digital materials before the face-to-face sessions and realization of collaborative activities in the classroom in order to develop the skills of the students.

During flipped classroom, Moodle and Blackboard facilitated the consultation of educational resources such as videos and digital readings about computer science (Al-Jarrah et al., 2018). Likewise, social networks allowed the communication and reviewed of the course information at home (Lundin et al., 2018).

Konijn et al. (2018) explain that flipped classroom favored the active role during the learning process, improved the academic performance and facilitated

the application of theoretical content in the practical context. Finally, educational institutions can reorganize the school activities through the use of this pedagogical model and technology (Foster & Stagl, 2018; Lewis et al., 2018; Palazón-Herrera & Soria-Vílchez, 2021).

## **Method**

The particular aims of this quantitative research are to (1) analyze the perceptions of the students about the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application collaboratively during the face-to-face sessions and use of the Kompozer application after the face-to-face sessions through the machine learning technique (2) identify the predictive models about the use of flipped classroom and digital tools in the field of information technology through the decision tree technique and (3) analyze the activities of flipped classroom in the teaching-learning process about the design of web applications through the neural network technique.

## **Participants**

The participants are 22 students of the Computer Science Degree (18 men and 4 women) that took the Development of applications course in a Mexican university during the 2017 school year. The average age of these students is 21.45 years.

## **Procedure**

This study proposed the use of flipped classroom through the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application

collaboratively during the face-to-face sessions and use of the Kompozer application after the face-to-face sessions. In particular, the Dolibarr application allows the interaction with the Products, Suppliers, Stores, Clients and Agenda modules of the ERP system. The free version of this technological tool is available at the following web address: <https://demo.dolibarr.org/public/demo/index.php>. On the other hand, the Kompozer application allows the design and build of the websites. This technological tool is free and available at the following web address: <https://kompozer.uptodown.com/windows>. The procedure began with the planning, organization and creation of the school activities (See Table 1).

**Table 1:** Activities of flipped classroom

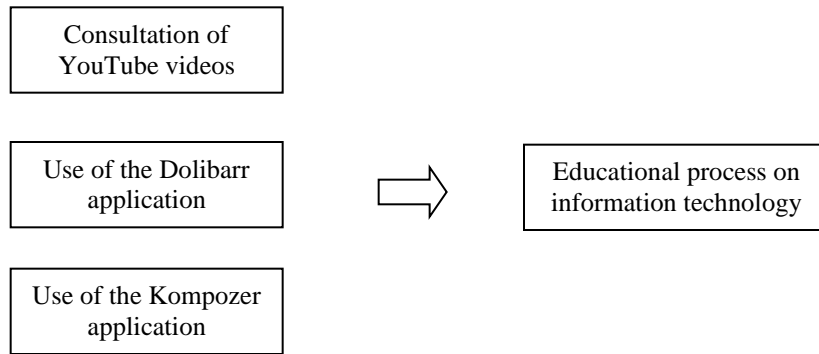
No.	Topic	Before the class	During the class	After the class
1	Products	Check the videos about the use of the Products module in the Dolibarr application	Use the Dolibarr application collaboratively to manage the Products module	Design the web interface about the Products module through the Kompozer application
2	Suppliers	Check the videos about the use of the Suppliers module in the Dolibarr application	Use the Dolibarr application collaboratively to manage the Suppliers module	Design the web interface about the Suppliers module through the Kompozer application
3	Stores	Check the videos about the use of the Stores module in the Dolibarr application	Use the Dolibarr application collaboratively to manage the Stores module	Design the web interface about the Stores module through the Kompozer application
4	Clients	Check the videos about the use of the Clients module in the Dolibarr application	Use the Dolibarr application collaboratively to manage the Clients module	Design the web interface about the Clients module through the Kompozer application
5	Agenda	Check the videos about the use of the Agenda module in the Dolibarr application	Use the Dolibarr application collaboratively to manage the Agenda module	Design the web interface about the Agenda module through the Kompozer application

Note: Own elaboration.



Figure 1 shows the model used to analyze the perceptions of the students about flipped classroom and digital tools.

**Figure 1:** Model about flipped classroom and digital tools



Note: Own elaboration.

The activities of flipped classroom such as the consultation of videos and review of electronic books before the class facilitate the acquisition of knowledge (Lundin et al., 2018; Palazón-Herrera & Soria-Vílchez, 2021). Hypothesis 1 about the use of flipped classroom is:

- Hypothesis 1 (H1): The consultation of YouTube videos before the face-to-face sessions facilitates the educational process on information technology

During the face-to-face sessions, teachers use flipped classroom to organize and carry out the collaborative activities (Ozbay & Cinar, 2021; Palazón-Herrera & Soria-Vílchez, 2021; Sun & Xie, 2020). Hypothesis 2 about the use of flipped classroom is:

- Hypothesis 2 (H2): The use of the Dolibarr application collaboratively during the face-to-face sessions facilitates the educational process on information technology

Various authors (Dong et al., 2021; Ozbay & Cinar, 2021) mention that the activities of flipped classroom facilitate the learning process outside the classroom. Hypothesis 3 about the use of flipped classroom is:

- Hypothesis 3 (H3): The use of the Kompozer application after the face-to-face sessions facilitates the educational process on information technology

On the other hand, the predictive models about the use of flipped classroom in the teaching-learning process are:

- Predictive Model 1 (PM1) about the consultation of YouTube videos and educational process of information technology
- Predictive Model 2 (PM2) about the use of the Dolibarr application collaboratively and educational process of information technology
- Predictive Model 3 (PM3) about the use of the Kompozer application and educational process of information technology

Finally, the neural network establishes how the activities of flipped classroom influence the educational process of information technology considering the use of YouTube videos, Dolibarr and Kompozer.

## Data collection

Table 2 shows the questionnaire used to collect the information about flipped classroom and digital tools during the 2017 school year.

**Table 2:** Questionnaire about flipped classroom and digital tools

No.	Variable	Dimension	Question	Answer	n	%
1	Profile of the	Sex	1. What is your sex?	Man	18	81.82%
				Woman	4	18.18%
		Age	2. What is your age?			

Students	18 years	0	0.00%	
	19 years	1	4.55%	
	20 years	5	22.73%	
	21 years	7	31.82%	
	22 years	5	22.73%	
	23 years	2	9.09%	
	24 years	1	4.55%	
	25 years	0	0.00%	
	26 years	1	4.55%	
2 Flipped classroom	3. The consultation of YouTube videos before the face-to-face sessions facilitates the learning process about the design of web applications	Very much (1)	14	63.64%
		Much (2)	5	22.73%
		Little (3)	3	13.64%
		Very little (4)	0	0.00%
	4. The use of the Dolibarr application collaboratively during the face-to-face sessions facilitates the learning process about the design of web applications	Very much (1)	10	45.45%
		Much (2)	10	45.45%
		Little (3)	2	9.09%
		Very little (4)	0	0.00%
	5. The use of the Kompozer application after the face-to-face sessions facilitates the learning process about the design of web applications	Very much (1)	12	54.55%
		Much (2)	9	40.91%
		Little (3)	1	4.55%
		Very little (4)	0	0.00%
6. Flipped classroom facilitates the educational process on information technology	Very much (1)	9	40.91%	
	Much (2)	10	45.45%	
	Little (3)	3	13.64%	
	Very little (4)	0	0.00%	

Note: Own elaboration.

The values of Load Factor ( $> 0.700$ ), Cronbach's Alpha ( $> 0.820$ ) and Composite Reliability ( $> 0.880$ ) allow validating the questionnaire about the use of flipped classroom and digital tools (See [Table 3](#)).

**Table 3:** Validation of the questionnaire

Variable	Dimension	Load Factor	Cronbach's Alpha	Average Variance Extracted	Composite Reliability
Flipped classroom	Before the face-to-face sessions	0.853	0.826	0.663	0.886
	During the face-to-face sessions	0.704			
	After the face-to-face sessions	0.855			
	Educational process	0.836			

**Source:** Own elaboration.

## Data analysis

The Rapidminer tool allowed the construction of 3 predictive models about flipped classroom by means of the decision tree technique. The information about the characteristics of the students, flipped classroom and digital tools allows the creation of these predictive models. The target variable is the educational process of information technology.

Also, the Rapidminer tool allows the calculation of the linear regressions (machine learning). The training section used 50%, 60% and 70% of the sample to evaluate the hypotheses about flipped classroom and digital tools through linear regressions. On the other hand, the evaluation section used 50%, 40% and 30% of the sample to identify the accuracy of these linear regressions by means of the squared error. The independent variables are the consultation of YouTube videos, use of the Dolibarr application collaboratively and use of the Kompozer application. Also, the dependent variable is the educational process of information technology.

Finally, the Rapidminer tool allows knowing how the activities of flipped classroom influence the teaching-learning process about the design of web applications through the neural network technique.

## Results

Flipped classroom facilitates very much ( $n = 9$ , 40.91%), much ( $n = 10$ , 45.45%) and little ( $n = 3$ , 13.64%) the educational process on information technology (See [Table 2](#)). The results of machine learning (linear regression) indicate that the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application collaboratively during the face-to-face sessions and use of the Kompozer application after the face-to-face sessions facilitate the educational process on information technology (See [Table 4](#)).

**Table 4:** Results of machine learning

Hypothesis	Training	Linear regression	Conclusion	Value-t	Value-p	Error squared
H1: YouTube videos → educational process	50%	$y = 0.441x + 1.147$	Accepted: 0.441	1.709	0.121	0.261
	60%	$y = 0.543x + 0.891$	Accepted: 0.543	2.334	0.039	0.216
	70%	$y = 0.534x + 0.913$	Accepted: 0.534	2.465	0.028	0.206
H2: Dolibarr application collaboratively → educational process	50%	$y = 0.579x + 0.960$	Accepted: 0.579	2.017	0.074	0.471
	60%	$y = 0.560x + 0.863$	Accepted: 0.560	1.929	0.079	0.352
	70%	$y = 0.546x + 0.895$	Accepted: 0.546	2.064	0.059	0.382
H3: Kompozer application → educational process	50%	$y = 0.642x + 0.857$	Accepted: 0.642	1.566	0.151	0.307
	60%	$y = 0.809x + 0.523$	Accepted: 0.809	2.357	0.037	0.333
	70%	$y = 0.767x + 0.607$	Accepted: 0.767	2.459	0.028	0.342

Note: Own elaboration.

Table 5 shows Pearson's correlations about the use of flipped classroom and digital tools in the field of information technology.

**Table 5:** Pearson's correlations

	Before the face-to-face sessions	During the face-to-face sessions	After the face-to-face sessions	Educational process
Before the face-to-face sessions	1	-	-	-
During the face-to-face sessions	0.391	1	-	-
After the face-to-face sessions	0.700	0.484	1	-
Educational process	0.641	0.496	0.567	1

Note: Own elaboration.

### Before the face-to-face sessions

The consultation of YouTube videos before the face-to-face sessions facilitates very much ( $n = 14$ , 63.64%), much ( $n = 5$ , 22.73%) and little ( $n = 3$ , 13.64%) the learning process about the design of web applications (See Table 2).

The results of machine learning with 50% (0.441, value-t = 1.709, value-p = 0.121), 60% (0.543, value-t = 2.334, value-p = 0.039) and 70% (0.534, value-t = 2.465, value-p = 0.028) of training indicate that H1 is accepted (See [Table 4](#)). Therefore, the consultation of YouTube videos before the face-to-face sessions facilitates the educational process on information technology.

[Table 6](#) shows 7 conditions of the PM1 with the accuracy of 72.73%. For example, if the student considers that the consultation of YouTube videos before the face-to-face sessions facilitates much the learning process about the design of web applications and has an age > 21.5 years then Flipped classroom facilitates much the educational process on information technology. On the other hand, if the student considers that the consultation of YouTube videos before the face-to-face sessions facilitates very much the learning process about the design of web applications then Flipped classroom facilitates very much the educational process on information technology.

**Table 6:** Conditions of the PM1, PM2 and PM3

Predictive Model	No.	Technological tool → learning process	Sex	Age	Flipped classroom → educational process
PM1	1	Very much	-	-	Very much
	2	Much	-	> 21.5 years	Much
	3	Much	Man	≤ 21.5 & > 19.5 years	Very much
	4	Much	Woman	≤ 21.5 & > 19.5 years	Much
	5	Much	-	≤ 19.5 years	Little
	6	Little	-	> 20.5 years	Little
	7	Little	-	≤ 20.5 years	Much
PM2	1	Very much	-	> 20.5 years	Very much
	2	Very much	-	≤ 20.5 years	Much
	3	Much	-	> 23 years	Very much
	4	Much	Man	≤ 23 & > 20.5 years	Much
	5	Much	Woman	≤ 23 & > 20.5 years	Little

	6	Much	Man	≤ 20.5 years	Very much
	7	Much	Woman	≤ 20.5 years	Much
	8	Little	-	-	Little
	1	Very much	-	-	Very much
	2	Much	-	> 24 years	Very much
	3	Much	Man	≤ 24 years	Much
PM3	4	Much	Woman	≤ 24 & > 20.5 years	Little
	5	Much	Woman	≤ 20.5 years	Much
	6	Much	-	≤ 19.5 years	Little
	7	Little	-	-	Little

Note: Own elaboration.

### During the face-to-face sessions

The use of the Dolibarr application collaboratively during the face-to-face sessions facilitates very much (n = 10, 45.45%), much (n = 10, 45.45%) and little (n = 2, 9.09%) the learning process about the design of web applications (See Table 2). The results of machine learning with 50% (0.579, value-t = 2.017, value-p = 0.074), 60% (0.560, value-t = 1.929, value-p = 0.079) and 70% (0.546, value-t = 2.064, value-p = 0.059) of training indicate that H2 is accepted (See Table 4). Therefore, the use of the Dolibarr application collaboratively during the face-to-face sessions facilitates the educational process on information technology.

Table 6 shows 8 conditions of the PM2 with the accuracy of 81.82%. For example, if the student considers that the use of the Dolibarr application collaboratively during the face-to-face sessions facilitates very much the learning process about the design of web applications and has an age > 20.5 years then flipped classroom facilitates very much the educational process on information technology. On the other hand, if the student considers that the use of the Dolibarr application collaboratively during the face-to-face sessions facilitates very much the learning process about the design of web applications and has an age ≤ 20.5 years then flipped classroom facilitates much the educational process on

information technology.

### **After the face-to-face sessions**

The use of the Kompozer application after the face-to-face sessions facilitates very much ( $n = 12$ , 54.55%), much ( $n = 9$ , 40.91%) and little ( $n = 1$ , 4.55%) the learning process about the design of web applications (See [Table 2](#)). The results of machine learning with 50% (0.642, value-t = 1.566, value-p = 0.151), 60% (0.809, value-t = 2.357, value-p = 0.037) and 70% (0.767, value-t = 2.459, value-p = 0.028) of training indicate that H3 is accepted (See [Table 4](#)). Therefore, the use of the Kompozer application after the face-to-face sessions facilitates the educational process on information technology.

[Table 6](#) shows 7 conditions of the PM3 with the accuracy of 72.73%. For example, if the student considers that the use of the Kompozer application after the face-to-face sessions facilitates much the learning process about the design of web applications and has an age  $> 24$  years then Flipped classroom facilitates very much the educational process on information technology. On the other hand, if the student considers that the use of the Kompozer application after the face-to-face sessions facilitates much the learning process about the design of web applications and has an age  $\leq 24$  years then Flipped classroom facilitates much the educational process on information technology.

Finally, the neural network with 50% (YouTube videos: 0.938, Dolibarr application: 1.000 and Kompozer application: 0.665), 60% (YouTube videos: 0.661, Dolibarr application: 1.000 and Kompozer application: 1.000), 70% (YouTube videos: 0.623, Dolibarr application: 0.863 and Kompozer application: 0.564) and 80% (YouTube videos: 0.623, Dolibarr application: 0.863 and Kompozer application: 0.564) of training indicates that the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application collaboratively during the face-to-face sessions and use of the Kompozer application after the



face-to-face sessions positively influence the educational process on information technology. In fact, the most significant value is the use of the Dolibarr application collaboratively during the face-to-face sessions.

## **Discussion**

Today, technological advances and pedagogical models are changing the organization and realization of the school activities (Dong et al., 2021; Lundin et al., 2018; Yu & Zhu, 2019). In particular, flipped classroom promotes the active role of the students before, after and during the face-to-face sessions (Amira et al., 2019; Palazón-Herrera & Soria-Vílchez, 2021; Sommer & Ritzhaupt, 2018). For example, 45.45% of the students (n = 10) consider that flipped classroom facilitates much the educational process on information technology. In the Development of applications course, the use of YouTube videos, Dolibarr and Kompozer improved the teaching-learning conditions and encouraged the active role. Also, flipped classroom facilitates very much (n = 9, 40.91%) the educational process on information technology. Therefore, most of the students (86.36%) have a favorable opinion about this pedagogical model.

### **Before the face-to-face sessions**

In flipped classroom, students review the contents of the courses at home to discuss, analyze and reflect the topics during the face-to-face sessions (Amira et al., 2019; Ozbay & Cinar, 2021; Sommer & Ritzhaupt, 2018). In particular, 63.64% of the students (n = 14) think that the consultation of YouTube videos before the face-to-face sessions facilitates very much the learning process about the design of web applications. Multimedia resources allow acquiring the knowledge from anywhere and facilitate the personalized learning at home. Also, the consultation of YouTube videos before the face-to-face sessions facilitates much (n = 5, 22.73%)

the learning process about the design of web applications. Therefore, most of the students (86.37%) have a favorable opinion.

This study shares the ideas of various authors ([Dong et al., 2021](#); [Ozbay & Cinar, 2021](#)) about the use of multimedia resources at home to acquire the knowledge during flipped classroom. The results of machine learning about H1 are higher than 0.440, therefore, the consultation of YouTube videos before the face-to-face sessions facilitates the educational process on information technology.

Data science identified 7 conditions of the PM1 with the accuracy of 72.73%. In this predictive model, the Sex and Age of the students determine how the consultation of YouTube videos before the face-to-face sessions influences the educational process on information technology.

### **During the face-to-face sessions**

Flipped classroom improves the teaching-learning conditions and develops the skills of the students through the collaborative work and use of web applications during the face-to-face sessions ([Pasaribu & Wulandari, 2021](#); [Sen, 2022](#)). In particular, 45.45% of the students (n = 10) think that the use of the Dolibarr application collaboratively during the face-to-face sessions facilitates very much the learning process about the design of web applications. According to the students of the Computer Science Degree, the incorporation of the Dolibarr application facilitated the understanding of the topics and allowed the interaction with the Products, Suppliers, Stores, Clients and Agenda modules of the ERP system. Also, the use of the Dolibarr application collaboratively during the face-to-face sessions facilitates much (n = 10, 45.45%) the learning process about the design of web applications. Therefore, most of the students (90.90%) have a favorable opinion.

According to [Palazón-Herrera and Soria-Vílchez \(2021\)](#), flipped classroom

allows the organization and realization of the school activities in the classroom. The results of machine learning about H2 are higher than 0.540, therefore, the use of the Dolibarr application collaboratively during the face-to-face sessions facilitates the educational process on information technology.

Data science identified 8 conditions of the PM2 with the accuracy of 81.82%. In this predictive model, the Sex and Age of the students determine how the use of the Dolibarr application collaboratively during the face-to-face sessions influences the educational process on information technology.

### **After the face-to-face sessions**

This research shares the ideas of various authors ([Pasaribu & Wulandari, 2021](#); [Shahani et al., 2022](#)) about the importance of technological tools to carry out the school activities outside the classroom. In particular, 54.55% of the students (n = 12) think that the use of the Kompozer application after the face-to-face sessions facilitates very much the learning process about the design of web applications. In the Development of applications course, this application allowed the design and build of the websites. Also, the use of the Kompozer application after the face-to-face sessions facilitates much (n = 9, 40.91%) the learning process about the design of web applications. Therefore, most of the students (95.46%) have a favorable opinion.

Similar to [Palazón-Herrera and Soria-Vílchez \(2021\)](#), technological tools allow the realization of the activities outside the classroom during flipped classroom. The results of machine learning about H3 are higher than 0.640, therefore, the use of the Kompozer application after the face-to-face sessions facilitates the educational process on information technology.

Data science identified 7 conditions of the PM3 with the accuracy of 72.73%. In this predictive model, the Sex and Age of the students determine how the use of

the Kompozer application after the face-to-face sessions influences the educational process on information technology.

Also, the neural network with 50%, 60%, 70% and 80% of training indicates that the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application collaboratively during the face-to-face sessions and use of the Kompozer application after the face-to-face sessions positively influence the educational process on information technology. Finally, flipped classroom is a pedagogical model that is modifying the organization and realization of the school activities through the use of digital tools ([Altakhayneh, 2022](#); [Ouchaouka et al., 2021](#); [Ozbay & Cinar, 2021](#)).

## **Conclusion**

Flipped classroom is a pedagogical model that facilitates the creation of new school activities through the use of digital tools. In particular, this quantitative research proposes the consultation of YouTube videos before the face-to-face sessions, use of the Dolibarr application collaboratively during the face-to-face sessions and use of the Kompozer application after the face-to-face sessions.

The results indicate that the activities of flipped classroom positively influence the educational process on information technology. According to the results of the neural network, the activity that most favors the teaching-learning process is the use of the Dolibarr application collaboratively during the face-to-face sessions.

This research recommends the use of the Dolibarr application in the educational field because the students interact with the Products, Suppliers, Stores, Clients and Agenda modules of the ERP system. Similarly, the Kompozer application allows the design construction of websites and the consultation of YouTube videos facilitates the acquisition of knowledge at home.

The limitations of this study are related to the sample and the use of the YouTube videos, Dolibarr application and Kompozer application during flipped classroom. Therefore, future research can use online questionnaires, digital games, web simulators and social networks to update the school activities and promote the active role of students before, after and during the face-to-face sessions.

The implications of this study encourage that teachers search, select and use technological and communication tools in the field of education in order to develop the skills of the students and facilitate the assimilation of knowledge. Finally, educational institutions have the opportunity to modify the teaching-learning process through the use of flipped classroom and digital tools.

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