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Article

Flipped learning for teaching biostatistics to peruvian dental students.

Flipped learning para el aprendizaje de bioestadística en estudiantes de odontología peruanos.

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Abstract: Objective: To evaluate the effect of the application of a flipped learning model for teaching biostatistics to dental students in a Peruvian public university. Methodology: A quasi-experimental, crossover, longitudinal and prospective design was used. A non-probability sampling technique was employed. The sample consisted of 63 students that enrolled in the Biostatistics course at the School of Dentistry at Universidad Nacional Mayor de San Marcos. Students were divided into two groups according to their designated training schedule. The contents of two units were assessed. For the first unit (descriptive statistics), the first group was taught using the flipped learning model and the second group with the master class model. For the second unit (inferential statistics), groups were crossed over. At both periods of the study, cognitive, procedural and attitudinal skills were assessed through previously validated questionnaires. Mann-Whitney U test, Cohen is d and multiple linear regression analysis were performed. Results: the mean total score for the second unit was higher (p<0.001) in the flipped learning group (32.58) compared to the master class guided training group (27.94), presenting a Cohen's d=0.97. Procedural (9.23 *versus* 7.80) and attitudinal (15.63 *versus* 12.90) skills were on average higher in the flipped learning group. Regression analysis resulted in R^2=0.245, p=0.003. Conclusion: the flipped learning method achieved a higher content learning in the second unit, compared to the master class model.

Keywords: *Learning; education, distance; education, dental; reversal learning; students, dental; Peru.*

Resumen: Objetivo: Evaluar el efecto de la experiencia de aplicación del modelo flipped learning para el aprendizaje de bioestadística en estudiantes de odontología de una universidad pública peruana. Metodología: Se realizó un diseño cuasi experimental de secuencia cruzada, longitudinal, prospectivo. La muestra se obtuvo de manera no probabilística y estuvo conformada por 63 estudiantes que cursaron la asignatura de Bioestadística en la Facultad de Odontología de la Universidad Nacional Mayor de San Marcos. Se conformaron dos grupos de acuerdo al horario de práctica designado y se evaluaron los contenidos de dos unidades de la asignatura. En la primera unidad (estadística descriptiva) el primer grupo fue sometido al modelo flipped learning y el segundo sometido al modelo presencial clase magistral. En la segunda unidad del curso (estadística inferencial) los grupos se cruzaron. En ambos momentos se evaluaron las capacidades cognitivas, procedimentales y actitudinales a través de cuestionarios previamente validados para el estudio. Se aplicó la prueba U de Mann-Whitney, la d de Cohen y la regresión lineal múltiple. Resultados: En la segunda unidad la puntuación media total fue mayor (p<0,001) en el grupo flipped learning (32,58) en comparación al de clase magistral-práctica dirigida (27,94) con un efecto alto d Cohen= 0,97. Las capacidades procedimentales (9,23 *versus* 7,80) y actitudinales (15,63 *versus* 12,90) fueron en promedios mayores en el grupo flipped learning. Al aplicarse la regresión se halló un R_2=0,245 p=0,003. Conclusión: La aplicación del modelo flipped learning logró un mayor aprendizaje en contenidos de la segunda unidad, en comparación con el modelo presencial clase magistral en los estudiantes.

Palabras Clave: *Aprendizaje; educación a distancia; educación en odontología; aprendizaje inverso; estudiantes de odontología; Perú.*

INTRODUCTION.

A challenge in education is to train people to live in a knowledge society. This implies understanding education as a process of permanent learning, so that people can obtain, update and develop skills, knowledge, abilities, aptitudes and competences for their personal and professional development. Therefore, the purpose of the educational process must focus on promoting an education that encourages learning by oneself. Learning should not be understood as an accumulation of content, but as a process that undertakes a reconstruction of what is within a person, internalizing what one grasps from the outside world.[1]

In order to face this challenge, several learning models and strategies have emerged, based on the great boom in the development and access to information and communication technology (ICT). Thus, facilitating the development of education programs that encourage more active, reflective and collaborative learning, and that maximize and take advantage of the time allotted to learning.

The reverse learning model (flipped learning), also called flipped classroom, draws favorable ideas and arguments from blended learning, developing activities outside the classroom and assisted by ICT. This works in everything that does not require a teacher to develop abilities related to memory and understating (reading material, watching video material).

As such, time is allocated in the classroom for activities that require interaction among the students and between the students and the teacher.[2,3] Group work in class becomes a dynamic and interactive learning space where teachers guide their students as they apply concepts and commit themselves to the subject under study.[2]

Previous studies[3-6] have found that this model improves the cognitive and memory capacity of students, as well as the commitment to their own learning, creating an environment of collaboration, interaction and cohesion among participants. As a result, this allows them to regulate their learning by monitoring and assessing their own achievements. The impact of this model on learning when compared to other models varies depending on the author. The results on academic performance are better in comparison to traditional models like master class or presentation-based models,[7-11] showing that the attitudinal component is usually the most appreciated by students and teachers. The reason is because this model allows a much more active participation, and greater commitment to learning.[4,11-13]

Nishigawa *et al.,*[14] Simpson*et al.,*[15] and McLaughlin *et al.,*[16] found that this model has a similar effect to traditional lecture models in the academic performance expressed in grades. However, attitudinal aspects were better valued.

When comparing this model to those traditional face-to-face models, Thai et al., 12 found that students considered it less flexible in terms of managing their time, compared to other authors.[2-4,11]

Biostatistics tends to be a subject of little interest for dental students, since they believe it has little impact on the clinical professional profile they seek.

However, changes in the Peruvian university level reform initiated in 2014 Available from: *https://www.sunedu.gob.pe/nueva-ley-universitaria-30220-2014/.* Advocate for the necessity of training in scientific research due to its interdisciplinary reach. Therefore, biostatistics is considered a necessary and basic tool for conducting research.

Technologies produce educational innovation if they are associated with appropriate educational practices that generate contextualized and motivating learning. Students, who are digital natives, use technology during their daily lives. As such its application in the academic area is considered to be able to increase motivation with subsequent better learning and better use of time inside the university environment.

Blended face-to-face/distance learning models have been poorly appreciated and used in Peru. Therefore, the aim of the present study was to assess the effect of the application of the flipped learning model in the teaching of biostatistics to dentistry students. This study was carried out with the purpose of providing scientific evidence that supports its application in the teaching-learning process.

MATERIALS AND METHODS.

Design of the study

A quasi-experimental crossover design was carried out with the aim of controlling for the individual characteristics of the participants. The study was longitudinal and prospective. The selection of students belonging to the control and experimental group was made according to the training schedule (morning or afternoon) in which students were registered at the beginning of the course. The assignment of the didactic model was done in a simple random manner carried out by the main researcher.

Participants

The study population was composed of students from the School of Dentistry on their fourth term at Universidad Nacional Mayor de San Marcos (UNMSM) in Lima-Peru, enrolled in Biostatistics.

The sample was determined with a non-probability sampling technique at the convenience of the researcher and consisted of 63 students enrolled in Biostatistics in 2016, during regular term, and that accepted to participate in the study by providing and signing informed consent. All students with more than one enrolment in the subject, who did not belong to the admission year 2015, as well as those that took biostatistics during the summer term were excluded from the study.

Procedure

The design of the study was developed over two periods, concerning each of the two teaching units. Initially, content of descriptive statistics for quantitative variables was addressed during the first unit. The first group (n=32) that carried out its training during the morning schedule were taught under the classroom lecture based model, and the afternoon group under the flipped learning model. Contents of inferential statistics (hypothesis test and t-Student) were addressed in the second unit. The groups were thus crossed-over and the group that had been taught under the lecture based training model crossed over to flipped learning, and vice versa. The procedural sequence in each step was as follows: each student in the group taught with the flipped learning model received a 20-minute video and reading material to review at home a week before the face-to-face session.

On that same day, an initial cognitive evaluation was performed to the students during class hours. A week later, the carried out activities were mainly hands-on, problem solving, discussion and group work with classmates. The group that was taught with the face-to-face lecture model attended their master class for 2hrs in the classroom, followed by a guided training (2 hours).

An initial cognitive evaluation was performed prior to the master class. When the sessions were finished, the measurement of the variables correspondent to the learning evaluation in its cognitive, procedural and attitudinal dimensions was carried out in both learning models.

The maximum score as the sum of the three evaluated components was 38 points. Questionnaires were based on the evaluation matrix of the subject and were subdued to validation of content through the Aiken v test, obtaining final coefficients of V=1.0 p=0.025, in each item. A construct analysis was carried out, obtaining significant values for each instrument when the Kaiser-Meyer-Olkin test result was above 0.60. The total value of Cronbach's alpha for each instrument was above 0.70.

Statistical analysis

The processing of information was carried out through the statistical package SPSS, version 24. The U Mann-Whitney test was used when comparing models and when normal distribution of the variables was not present, as well as the Wilcoxon test for the comparison between the two periods of the crossover design. The Cohen's d test and regression analysis allowed for measuring the effect of the flipped learning model on biostatistics learning. A significance level of 0.05 was accepted to refute the null hypothesis.

RESULTS.

From a total of 63 individuals, 31 were taught under the flipped learning model, and 32 under the master class/guided training model for the first part of the crossover design. There were no dropouts in the number of individuals after assignation. Table 1 presents the demographic characteristics of the sample.

The results on initial and final cognitive learning between both groups showed no significant statistical differences. As the study was crossed in character, the crossover of groups was analyzed, which showed statistically lower results in the group that went from flipped learning to lecture based master class training (8.65 to 7.63, Wilcoxon Z=2.38 p=0.0085), whereas the opposite group presented no significant differences (8.19 to 7.25, Wilcoxon Z=1.09 p=0.137).(Table 2)

When comparing the scores of both groups on procedural learning, the flipped learning group presented a higher mean score during the second unit compared to the other group (p<0.05). When the groups

Table 1. Base demographic characteristics of the study sample.

Demographic characteristics	Master class lecture-based training		Flipped learning	
Sex	No.	%	No.	%
Male	13	40.6	13	41.9
Female	19	59.4	18	58,1
Age	Mean	SD	Mean	SD
	20.90	2.90	20.67	2.89

Table 2. Cognitive capacity comparison between both teaching models.

Content	Period	Master class lecture-based training			Flipped learning			*p**
		Mean	SD	Median+	Mean	SD	Median+	
First Unit	Start	4.22	1.69	5	4.37	1.98	4	0.415
	End	8.19	1.94	8	8.65	1.6	9	0.125
	Difference	3.97	2.17	4	4.28	2.37	3	0.407
Second Unit	Start	2.83	1.97	3	3.4	1.69	4	0.085
	End	7.63	2.37	8	7.25	2.76	8	0.355
	Difference	4.80	3.17	5	3.85	3.10	5	0.153

***:** Mann-Whitney U Test (Z values: -0.217, -1.15, -0.236, -1.37, -0.373, -1.02).

Table 3. Procedural capacity comparison between both teaching models.

Content	Master class lecture-based training			Flipped learning			*p**
	Mean	SD	Median+	Mean	SD	Median+	
First Unit	7.80	3.15	9	8.56	2.73	10	0.062
Second Unit	7.80	2.50	9	9.23	1.62	10	0.001

***:** Mann-Whitney U Test (Z values: -1,54, -3,11).

Table 4. Attitudinal capacity comparison between both teaching models.

Content	Master class lecture-based training			Flipped learning			*p**
	Mean	SD	Median+	Mean	SD	Median+	
First Unit	14.80	1.72	14	14.97	2.16	15	0.145
Second Unit	12.90	3.03	13	15.63	1.42	16	<0.001

***:** Mann-Whitney U Test (Z values= -1.06, -3.82).

Table 5. Learning result in both teaching models.

Content	Master class lecture-based training			Flipped learning			*p**	Cohen's d
	Mean	SD	Median+	Mean	SD	Median+		
First Unit	30.81	4.68	32.0	32.19	3.95	33.5	0.121	0.32[a]
Second Unit	27.94	5.77	27.5	32.58	3.52	34.0	<0.001	0.97[b]

***:** Mann-Whitney U Test (Z values=-1.17, -3.43). **a:** Moderate Effect size. **b:**High Effect size.

Table 6. Regression analysis for determining the flipped model's effect on the second unit.

Variables	Beta	t	*p*	R^2	F	*p**
Constant	19.35	3.24	0.002	0.245	4.62	0.003
Initial knowledge	0.25	0.71	0.483			
Age	0.19	0.82	0.417			
Sex (M)	2.46	1.87	0.067			
Model (AI)	4.64	3.77	<0.001			

***:**Multiple linear regression.

were crossed over, the group that was first taught under the flipped learning technique presented a significant decrease in their scores, from 8.56 to 7.8 (Wilcoxon Z=1.847 p=0.032), whereas the group that originally was taught under master class training model presented a significant increase in their results, from 7.8 to 9.23 (Wilcoxon Z=1.805 p=0.035).(Table 3)

The score obtained on attitudinal learning in the flipped learning group was higher during the second unit (p<0.001). The students who originally were taught under the flipped learning technique presented a lower attitudinal score after being taught under master class training, from 14.97 to 12.9 (Wilcoxon Z=2.847 p=0.002), whereas the group that changed from lecture-based training to flipped learning presented the opposite effect, increasing their scores from 14.8 to 15.63 (Wilcoxon Z=2.190 p=0.014).(Table 4)

The final evaluation consists of the sum of the groups' cognitive, procedural and attitudinal capabilities. The flipped learning model final results were significantly higher than the master class training model during the second unit (p<0.05). When both groups were crossed over, the group originally taught under the flipped learning model showed a decrease in their final scores (32.19 to 27.94, Wilcoxon Z=3.01 p=0.0015), whereas the other group showed an increase in their score after changing models (30.81 to 32.58, Wilcoxon Z=1.74 p= 0.04). (Table 5)

The regression analysis applied to the contents of the second unit determined that the imposition of this model alone can influence students' learning in a subtle yet significant way. This was determined after verifying and complying with the residue assumptions of linearity, independence, homoscedasticity and normality, as well as the lack of collinearity of predictor variables considered into the model, such as age, sex, initial knowledge and the presence of flipped learning model. (Table 6)

DISCUSSION.

The present study evaluated learning on its three dimensions: cognitive, procedural and attitudinal. As learning is a procedure that can involve multiple causes, it also may be affected by various possible determinants and contexts that may intervene in its development such as personal issues: cognitive conditions, motivation, intelligence, psychological well-being, among others; social determinants, such as social inequality, family environment, socioeconomic context, demographic variables; and institutional determinants that can be controlled. The present study delved into one of the aspects of the latter: teaching models as methods provided by an institution in order to facilitate learning.[17,18]

Results demonstrate that the flipped learning model had a positive effect on global learning, the development of procedural and attitudinal capacities in the learning of second unit's contents, which presented higher difficulty levels. No statistical difference was found in the learning of contents during the first unit, which presented a lower level of difficulty.

Due to the nature of the study and the fact that it had to be performed on an educational program, some aspects could not be completely controlled. One such characteristic is that some contents from the first unit had been presented on a more general level during a different class during the previous year (Scientific Methods). This meant that some participants has previous knowledge on the matter, which could ease the learning process regardless of the model used. The results show the influence of the flipped learning model in the education of dental students from a Peruvian educational institution with a specific teaching policy. Furthermore, its applicability and generalization capacity indicate that it can be applied in other similar contexts.

Learning is an experience-based and active process, depending on the personal experiences of the subjects and on the previously assimilated contents and the student's perceived self-efficiency.[19] This could explain the results obtained since some of the contents evaluated on the first unit had already been taught, providing some students with a base knowledge on the matter that could ease the learning process regardless of the chosen model.

The flipped learning model philosophy is based on the notion that simpler abilities and competences like memory and understanding could be developed without the direct guidance of a tutor.[2-3] Other abilities such as application, analysis, evaluation and creation are better developed while collaborating with peers and under tutor guidance.

Authors such Findlay *et al.,*[9] Nishigawa *et al.,*[14] Simpson *et al.,*[15] and McLaughlin *et al.,*[16] found no difference in learning when using flipped learning compared to other models. Concluded that students perceived that studying the contents before class improved their learning process, and presented no significant statistical difference between models based on final evaluations.

This outcome is similar to the one obtained in the present study, where the performance obtained with the flipped learning model was higher than the lecture model, with no statistical significance on the first unit content. The contents evaluated during the second unit were virtually unknown for the students, and posed a greater challenge due to their complexity.

Therefore, a model that eases learning would produce better results, such as those obtained in the present study and coinciding with authors like Schwartz,[20] who realized that 75% of the evaluated students presented good performance after learning through the flipped learning model. Likewise, Schwartz concludes that this model would teach statistical contents more efficiently.

The evaluation for the procedural dimension tended to receive a higher mean score for the flipped learning model. These higher results were especially significant when evaluating the contents of the second unit, as they were more complex compared to those of the first unit, and the students had no previous knowledge on the subject. This favors, highlights and evidences the importance of a more active, dynamic and participative and technologically-aided model, and how it may result in better learning results. In their own studies, Bohaty *et al.,*[8] Ramazan,[13] and Strayer[21] evaluated content with a procedural character, and obtained better results when using the flipped learning method. Their results are in agreement with those of the present study.

The attitudinal dimension, as evaluated by many reviewed authors[3,6-8,10-11,22] is the most benefited out of the three dimension when using the flipped learning model. These results coincide with the present study, since it stimulates a higher level of innovation and collaboration among students,[16] as well as favoring commitment to their education and helping them learn in a much more interactive, collaborative and interesting manner.[4,9,11,20]

These aspects have crucial importance in education, where the goal is to teach students to learn making use of all the available tools, to help them adopt a proactive attitude in contrast to a passive one in regards to knowledge, and to develop an interest and motivation for learning. The crossover character of the study allowed the identification of any changes among students when passing from one model to the other.

It is important to emphasize that the moment a student passed from the flipping learning model to the lecture-based training, their learning score decreased. In contrast, when the opposite change happened, the learning scores increased with a significant statistical importance in all learning dimensions, with the exception of the cognitive one.

However, the fact that this increase happened when passing from contents with a lower level of complexity to contents of higher complexity is critical, since it evidences the positive role that the flipped learning model may play when applied to courses of biostatistics in dental education.

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Conflict of interests: The authors declare no conflict of interest.

Ethics approval: Students agreed voluntarily to participate in the study. Students that did not want to participate took their classes under the model usually used: a master class. Evaluations conducted during the study were not considered part of the formal academic evaluation. The study was approved by the Postgraduate Department of the School of Dentistry of Universidad Nacional de San Marcos (006-FO-UPG-2016).

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