ISBN: 978-628-95207-4-3. ISSN: 2414-6390. Digital Object Identifier: https://dx.doi.org/10.18687/LACCEI2023.1.1.147

Modellus software in the learning of kinematics in engineering students

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Abstract*– This research aims to determine the effect of the application of Software Modellus in the learning of kinematics in students of Industrial Engineering of a Peruvian private university. Using a pre- and post-test experimental design, the Kinematics Graph Comprehension Test (TUG-K) was applied to 68 students during a training period and the level of learning achieved was determined using the Hake factor. The results were analyzed using the Shapiro-Wilk and Mann-Whitney U tests. The study showed that the application of Modellus significantly improves the learning of kinematics in the experimental group, obtaining a medium level for the Hake index ($p \leq 0.05$), but regarding gender, better results were evidenced in the women of the experimental group (96%) than in the men. As for the results according to the "registration" variable, 95% of students who attend for the first time took advantage of the use of the software; while second and third-enrollment students took advantage of it 100%. it is concluded that there is a significant increase in the average level in the learning of kinematics by applying the Modellus Software compared to traditional teaching with better results in female students.

I. Introduction

Mechanics studies the movement of bodies and their relationship with the causes that produce said movements. Specifically, Newtonian Mechanics provides the necessary elements for the description and explanation of physical phenomena related to the state of motion of objects within specific frames of reference and predicts important characteristics of motion such as the trajectories of bodies and even planets [1]. Therefore, it is necessary to begin its study by describing the movement of bodies without considering the causes of said movement; The main axis of Mechanics, known as Kinematics, is dedicated to this point.

The analysis of each movement depends on the circumstantial framework where said movement takes place; thus, given that every physical and therefore kinematic phenomenon has a mathematical model, it is possible to predict the movement in future instants as long as the initial conditions of the movement do not change, because if they change, a new analysis must be made [2]. In the study of kinematics, moving bodies are considered as material particles or points, that is, a body whose size and shape are irrelevant in the resolution of mechanical problems. For this, it is necessary to take into account the mobile (the body that performs the movement), the trajectory (the imaginary line that joins the successive positions that the mobile has occupied), the distance (the length or measure of the trajectory followed by a particle) and the displacement (the change in position of the mobile in some interval of time) [3].

Digital Object Identifier: (only for full papers, inserted by LACCEI).
ISSN, ISBN: (to be inserted by LACCEI).
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Laboratory experiences are an important and distinctive part of learning an experimental science such as kinematics and are essential in the training of scientists and engineers at the university level, as they provide students with the opportunity to experiment and discover for themselves the laws of nature. Laboratory practices can help organize the concepts obtained during the theoretical classes in the teaching-learning process, leading the student to improve their cognitive structure [4, 5]. Nevertheless, the learning problems in the field of kinematics presented by university students - which date back to the school stage and whose cause would be found in the use of traditional and unmotivating methods by basic education teachers- have generated that Since the last decade, ICT-mediated pedagogical strategies have been sought and applied. In particular, the use of the Modellus 4.01 software is related to the theoretical content and can be integrated into the experimental practices, promoting the analysis and interpretation of the results of the interaction of the physical variables present in a given experience [6]. Thus, this software -allows to easily simulate any physical phenomenon studied in Physics courses taught at the university level using a mathematical model, to do this, it presents a very friendly environment based on a series of windows, each of which collects or displays a series of extremely specific information. Likewise, it allows the user to explore models elaborated by other people that refers to the exploratory activity or to elaborate their own mathematical models that govern physical phenomena, which we will call expressive activity without having the need of knowledge of the Avanza programming language [7-8].

In particular, it has been shown that Linear Kinematics problems using graphs instead of formulas facilitate meaningful learning and improve the understanding of the behavior of the kinematic variables of rectilinear motion [4]. Meanwhile, other studies showed that the integration of the Modellus software for mechanical problems such as the experimental study of Newton's Third Law in combination with computational simulation improves the understanding of their mathematical language and promotes the evolution of knowledge of the subject, generating curiosity about physical phenomena. Therefore, these studies recommend extending the application of the software to other cases such as kinematics [9].

Kinematics is the basis of the understanding of Mechanics and given its implication in other areas of Physics, it is important that the teacher uses the appropriate educational strategies and resources to fix the key concepts in the student's cognitive structure (such as integrated subsubjector) that will serve to learn in a meaningful way the other concepts of mechanics [10]. This research is relevant because it allows to determine the effect of the use of simulators in Physics laboratory practices. In this sense, it is stated that simulators allow the reproduction of difficult phenomena that lead the student to an understanding of the role of mathematical models in physical phenomena and to knowledge of the physical laws that govern nature; therefore, they serve as complements for the teaching given in the classroom.

In this respect, the objective of this study is to determine the effect of the application of Software Modellus in the learning of Kinematics in university students of Industrial Engineering of a Peruvian private university, taking into account variables such as gender and enrollment status.

II. Materials and Methods

An experimental study was conducted, with pre and post-test, of a descriptive nature.

The study population consisted of 68 students enrolled in the subject of Physics I, who attend pre-university studies in the Faculty of Engineering, specifically in the Professional School of Industrial Engineering, of a private university located in the city of Arequipa (Peru). The study was conducted during the second semester of the 2021 academic year.

In the case of the sample groups, the experimental group consisted of 34 students (22 men and 12 women) and the control group had the same number of students and distribution by gender. Students enrolled in first, second or third enrollment and who present regular attendance to the course (more than 80% attendance) were included. Those students from other Professional Schools and/or who are taking the subject in fourth or higher enrollment were excluded.

Regarding the data collection instruments, a Face-to-face and virtual Laboratory Practice Guide (using Modellus) was used, elaborated for the practices of Uniform Rectilinear Motion (MRU), Varied Uniform Rectilinear Motion (MRUV) and Compound Motion (MC). Likewise, the modified Beichner Test of Understanding of Graphs in Kinematics or TUG-K (Test of Understanding of Graphs in Kinematics) [11] was used, taking into account the evaluation criteria, the material, the equipment, and the facilities of the laboratory.

For the validation of the instruments, a pilot test was applied to three different groups of 30 Industrial Engineering students from another private university located in the same city and who were taking the same course, with similar objectives, skills, and content. From these results, observations were obtained by a research specialist in Physics teaching, in relation to the technical language of the Mechanics subject, such as the units in the international system, the use of the infinitive verb and the use of alternatives in some answers that merited it. The observations were raised. Subsequently, the instrument used for the corrected Pre and Post Test was again reviewed by three university professors specialized in the field of study and validated for its application.

For data collection, the modified Beichner Kinematics Graph Comprehension Test was initially applied to the students of the control group and the experimental group to determine the initial conditions of their cognitive structures around the topic of Kinematics. Next, the experimental practices of uniform rectilinear motion, uniformly accelerated rectilinear motion and Compound Motion were performed with the control group using the Physics I practice guide in a traditional way in one session for each motion as can be seen in the photo. Simultaneously, the Modellus Software was implemented to the experimental practices of uniform rectilinear motion, uniformly accelerated rectilinear motion and Compound Motion of the experimental group to work under the following sequence.

The students of the experimental group used the Modellus simulator in a complementary way after taking real data with the Laboratory Guide. Finally, the Beichner Kinematics Graph Comprehension Test was applied to both groups to verify the effect of the proposal.

The fundamental concepts of kinematics were evaluated thematically, based on 14 proposed items, in their graphic representations, which included the analysis and interpretation of its linear regression. For this, the Kinematics Graph Understanding Test or TUG-K was graded from zero to twenty and the degree of student achievement was expressed by the following qualifiers: From 0 to 7 (Failed), 12 to 16

(Good) and 17 to 20 (Excellent). The grade out of 20 and the qualifiers were assigned in accordance with the standards for evaluating the academic performance of the university under study, to express the degree of achievement of the student.

Once the data was collected, they were statistically qualified and systematized for analysis and interpretation using inferential statistics for comparative relational studies. First, contingency tables were made to express the absolute and relative percentage frequencies. Kolmogorov-Smirnov and Shapiro-Wilk normality tests were applied to verify the normality of the data. And, subsequently, to assess the statistical hypothesis, the Mann-Whitney U test was applied for independent non-parametric samples with free distribution, the proposed hypothesis being:

H1: Valid hypothesis ($p \leq 0.05$)

The application of the Modellus Software improves the learning of Kinematics in Industrial Engineering students of the second semester.

Ho: Null Hypothesis ($p > 0.05$)

The Software Modellus application does not produce any learning of Kinematics in Industrial Engineering students of the second semester.

The contrast of the diagnostic hypothesis of the investigation was worked with the Hake factor or index.

II. RESULTS

Table 1 shows that the experimental group and the control group are made up of 65% male students and 35% are female. Comparing both groups, they have the same percentages of men and women; based on this, it will be possible to observe if the gender of the student is a factor in the learning gain.

TABLE I
STUDY POPULATION, ACCORDING TO SAMPLE GROUP BY GENDER AND ENROLLMENT

Category	Subcategory	Group	
		Experimental	Control
Gender	Men	22 (64.70%)	22 (64.70%)
	Woman	12 (35.29%)	12 (35.29%)
Enrollment condition	First	28 (82.35%)	30 (88.23%)
	Second	2 (8.88%)	2 (8.88%)
	Third	4 (11.76%)	2 (8.88%)

According to the enrollment number in the subject, it is evident that the highest percentage in the experimental group (82%) and in the control group (88%) corresponds to those students who take the subject for the first time, and a small percentage (6%) in second enrollment in both groups, while in the experimental group there are 12% students in third enrollment, double that in the control group, this criterion is important since it is desired to improve learning to prevent students from reaching repeat the subject.

TABLE II
QUALIFYING ACCORDING TO THE GRADE OBTAINED BY THE STUDENTS IN THE PRE AND POST TEST

Proof	qualifiers	Group	
		Experimental	Control
pre-test	Failed	34 (100%)	34 (100%)
	Good	0 (0.00%)	0 (0.00%)
	Excellent	0 (0.00%)	0 (0.00%)
post-test	Failed	7 (20.58%)	22 (64.70%)
	Good	27 (79.41%)	12 (35.29%)
	Excellent	0 (0.00%)	0 (0.00%)

In Table 2, the percentage (100%) of failed students in the experimental group and in the control group is represented, according to the grade they obtained in the Pre Test, it is observed that no student obtained a passing grade, In this aspect, both groups show that the pre-existing subsubjectors in the cognitive structure are at the same level. Meanwhile, in the Post Test it is observed that in the experimental group 79% of the students passed while in the control group only 35% obtained the same qualification. This reflects that the traditional method is not adequate. At the same time, the fact that the percentage of students who passed the experimental group is greater than twice the percentage of students who passed the control group reflects that simulation as a complementary method provides better results for meaningful learning, since the new concepts were anchored to the subsubjectors in a way that satisfactory compared to a conventional chair.

TABLE III
LEARNING GAIN GIVEN BY THE HAKE FACTOR AFTER APPLYING THE PROPOSAL

hack factor	Group	
	Experimental	Control
Bass	1 (2.94%)	13 (38.23%)
Medium	33 (97.05%)	21 (61.76%)
Tall	0 (0.00%)	0 (0.00%)

In Table 3, the Hake Factor indicates that in the experimental group, 97% of students obtained a medium significant learning and a single student (3%) obtained a low factor. While in the control group only 38% of the students obtained a medium learning and, unlike the experimental group, 13 students (38%) obtained a low Hake factor. Meanwhile, 62% of students in the control group reached a medium level. The exposed data reflect the improvement in the learning of kinematics by the implementation of the proposal that allowed the organization, sequencing and modeling of objects fulfilling Ausubel's second condition.

TABLE IV
LEVEL OF GAIN IN LEARNING ACCORDING TO GENDER OF PARTICIPATING STUDENTS

Group	measurement factor	levels	Gender	
			Men	Women
Exp.	Hack factor	Bass	1 (4.55%)	0 (0.00%)
		Medium	21 (95.45%)	12 (100%)
	Total		22 (100%)	12 (100%)
Control	Hack factor	Bass	12 (54.55%)	1 (8.33%)
		Medium	10 (45.55%)	11 (91.67%)
	Total		22 (100%)	12 (100%)
Total	Hack factor	Bass	13 (29.55%)	1 (4.17%)
		Medium	31 (70.45%)	23 (95,835)
	Total		44 (100%)	24 (100%)

In Table No. 4 we note that the average Hake factor was obtained by all (100%) of the female students and 95% of the men, while in the control group 13 students with a low Hake factor were observed, of 12 of them are men and only one female student. We have an evidently high percentage of students from the experimental group who benefited from the proposal, the difference between men and women being 5%. While for the control group, it is observed that male students have limited learning, since 55% obtained a low-level Hake factor and only 45% of men obtained a medium level factor. It is observed that in the experimental group, 100% of women took advantage of the Modellus Software application compared to 92% of women in the control group who worked in a traditional way.

In general, women show greater empathy with the Modellus software, observing greater commitment and discipline in the work sessions, which leads to favorable results in meaningful learning in mixed work groups.

TABLE V
LEVEL OF GAIN IN LEARNING ACCORDING TO THE ENROLLMENT NUMBER OF PARTICIPATING STUDENTS

Group	measurement factor	levels	Gender		
			1st	2nd	3rd
Exp.	Hack factor	Low	1 (3.57%)	0 (0.00%)	0 (0.00%)
		Medium	27 (96.42%)	2 (100%)	4 (100%)
	Total		22 (100%)	28 (100%)	2 (100%)
Control	Hack factor	Low	11 (36.66%)	1 (50.00%)	1 (50.00%)
		Medium	19 (63.33%)	1 (50.00%)	1 (50.00%)
	Total		22 (100%)	30 (100%)	2 (100%)
Total	Hack factor	Low	12 (20.68%)	1 (25.00%)	1 (16.66%)
		Medium	46 (79.31%)	3 (75.00%)	5 (83.33%)
	Total		44 (100%)	58 (100%)	4 (100%)

Table 5 shows a medium Hake factor for students in the first, second and third enrollment of the experimental group and the only low range is for a single student who enrolled for the first time in the subject. While in the control group there are 11 students in the first enrollment, one student in the second and one student in the third enrollment who obtained a low Hake factor.

We evidently note that in the experimental group, all the students in the second and third enrollment obtained a medium factor and 96% of the students in the first enrollment also obtained this average range in terms of the gain factor. While in the control group it is observed that only 50% of the second and third enrollment students obtained a medium factor while the other 50% had a low Hake factor.

In general, it is observed that the experimental group obtained better results in the Hake factor than the control group, appreciating that the second and third enrollment students took advantage of 100% while in the control group the students who reached the maximum 63% were in the first enrollment. These favorable results imply that the improvement in meaningful learning leads to a decrease in the percentage of repeating students of the Mechanical Physics subject.

When comparing the results obtained by the students participating in the experimental group in the modified TUG-K test, applied before and after the implementation of the Modellus software, the degree of success of the educational strategy can be appreciated (see Table 6):

TABLE VI
PARTICIPANTS HAKE FACTOR COMPARISON

# of students	Group	
	experimental	control
1	0.53	0.59
2	0.53	0.53
3	0.63	0.36
4	0.57	0.35
5	0.58	0.29
6	0.65	0.41
7	0.60	0.55
8	0.50	0.53
9	0.53	0.35
10	0.59	0.53
11	0.53	0.42
12	0.52	0.47
13	0.50	0.24
14	0.59	0.35
15	0.41	0.00
16	0.29	0.00
17	0.58	0.47
18	0.65	0.55
19	0.65	0.53
20	0.50	0.63
21	0.55	0.24
22	0.50	0.57
23	0.50	0.25
24	0.65	0.55
25	0.50	0.50
26	0.59	0.35
27	0.65	0.00
28	0.47	0.65
29	0.41	0.53
30	0.55	0.47
31	0.59	0.47
32	0.59	0.20
33	0.60	0.59
3. 4	0.53	0.60
Average	0.55	0.42

Table 6 shows the average value of the Hake factor, which indicates student learning with a significance of 0.05 (5%), being for the experimental group g=0.55, which corresponds to a level medium ($0.3 < g \leq 0.7$) which evidently indicates that after applying the Modellus software the results are satisfactory in comparison with the control group that only obtained a value of g = 0.42 that denotes an average result in the profit. Finding in both results a difference $\Delta g = 0.13$.

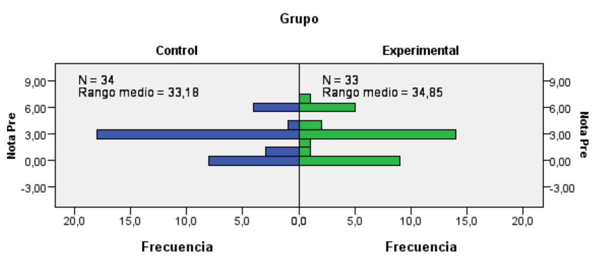
In Table 7, the degree of freedom (df) represents n=1, so the sample is made up of 34 students from the experimental group and 34 students from the control group; Sig. = true significance, shows the percentage of error in the treatment of the data. This table shows that before applying the proposal, both groups were in similar conditions, as shown by the Shapiro-Wilk statistical data:

TABLE VII
NORMALITY TEST FOR THE PRE-TEST SCORES OF THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Group		Kolmogorov–Smirnova			Shapiro-Wilk		
		Statistical	gl	Sig.	Statistical	gl	Sig.
Pre-Grade	Experimental	0.227	3. 4	0.000	0.854	3. 4	0.000
	Control	0.283	3. 4	0.000	0.827	3. 4	0.000

[a]Lilliefors significance correction.

Between the comparison of the results of the Pre-Test of the control group and the experimental group there is no significant difference at a probability level of 0.707 of error greater than 0.05; that is, both the experimental group and the control group obtain similar scores in the Pre-Test (see Figure 1). In short, the Pre-Test scores are the same between both groups for the Mann Whitney U test, therefore, the null hypothesis is retained, there is no significant difference represented by 99.293% certainty.



N total	67
U de Mann-Whitney	533,000
W de Wilcoxon	1.128,000
Estadístico de contraste	533,000
Error estándar	74,469
Estadístico de contraste estandarizado	-,376
Sig. asintótica (prueba bilateral)	,707

Fig. 1 Mann-Whitney U test to compare independent samples of the Pre-Test Scores of the control group and the experimental group.

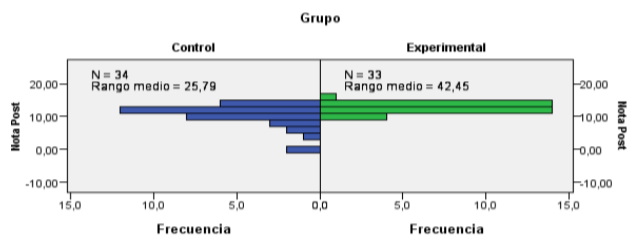
In Table 8, the degree of freedom (df) represents n=1, so the sample is made up of 34 students from the control group and 34 students from the experimental group, Sig. = true significance.

TABLE VIII
RESULT OF THE NORMALITY TEST FOR THE POST TEST SCORES OF THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Group		Kolmogorov–Smirnova			Shapiro-Wilk		
		Statistical	gl	Sig.	Statistical	gl	Sig.
Post Grade	Exp.	0.216	34	0.000	0.887	34	0.002
	Control	0.182	34	0.006	0.873	34	0.001

[a]Lilliefors significance correction.

Between the comparison of the results of the Pre-Test and the Post-Test there is a significant difference at a probability level of 0.00 of error less than 0.05; that is, the experimental group obtains better grades than the control group in the Post Test.



N total	67
U de Mann-Whitney	282,000
W de Wilcoxon	877,000
Estadístico de contraste	282,000
Error estándar	78,370
Estadístico de contraste estandarizado	-3,560
Sig. asintótica (prueba bilateral)	,000

Fig. 2 Mann Whitney U test for independent samples of the Post Test Grades of the control group and the experimental group.

It should be noted that in the Wilcoxon rank test for comparative related samples between the Post Test and the Pre-Test of the control group, it is indicated that, of the 34 students in the sample, there are 31 positive differences, which indicates that these last cases improved. Under the same criterion, there are zero negative differences, which shows that there was no student who was worse than in their initial condition and the same statistic indicates 3 ties, which implies that three students did not learn anything, since their grade in the Pre-Test and in the Post Test it remained. Unlike the experimental group, which, from the sample of 34 students, under the same statistical criteria there are 34 positive differences, that is, they all improved after the application of the proposal, since there were zero ties (see Figure 2).

III. DISCUSSION

The purpose of the teaching work is to improve the procedures in the pedagogy used in the chair in all aspects, both theoretical and practical, systematizing the processing of data and analysis of the results to adapt the strategies and teaching materials in order to continuously improve the learning environments and evaluation criteria. Being Physics a subject that amalgamates logic with the mathematical model of each phenomenon and experimentation in such a way that the student builds explanatory models for each problematic situation, it is necessary to combine ICT with laboratory experiences such as simulators that allow reproducing phenomena challenging that lead the student to an understanding of the role of mathematical models in physical concepts.

Therefore, the objective of this research was to determine the effect of the application of the Software Modellus in the learning of Kinematics in students of the Professional School of Industrial Engineering of the Catholic University of Santa María.

This research was carried out with a population whose sample was 68 students of the second semester of the Professional School of Industrial Engineering of the academic period 2018 - II, who were randomly assigned into two groups; experimental group (34 students) and control group (34 students), between men and women. It should also be noted that the same number of women and men participated in both groups, in addition to the fact that these groups were made up of students in first, second and third enrollment.

For this purpose, a test of 14 questions (instrument) was applied, which is a variant of Beichner's TUG-K [11], before and after the implementation of the proposal, denoted as Pre-Test and Post Test, respectively. From this, a descriptive and qualitative analysis of the information was made, taking into account the following criteria: (a) Observe the initial conditions of the experimental group and the control group before the application of the proposal, using the Pre-Test. (b) The influence of student gender on Kinematics learning gain, through a cross table of Hake factor, gender, and group. (c) The influence of the student's enrollment number on the Kinematics learning gain, through a cross table of the Hake factor, enrollment number and group. (d) The effect in the application of Modellus as a complement in the laboratory practices -with the simulation of ULM, UALM and Parabolic Motion-, in the performance of the students of the experimental group in comparison with the control group, who did not work with the Modellus software, resulting in the gain in learning with respect to the initial state of knowledge of the students determined by the average Hake factor of both groups.

Regarding the initial conditions of the groups of students in this research, according to the comparative results shown in Table No. 7, the number of students per group is recorded, with 34 students for the experimental group and 34 students for the control group; It shows that before applying the proposal, both groups were in similar conditions as indicated by the Shapiro-Wilk statistics, having 34 positive differences, zero negative differences and zero ties, concluding that there is no statistically significant difference at a level of 0.707 probability of error greater than 0.05; which translates into a 99.293% similarity between the scores of both groups for the Mann-Whitney U test. As shown in Figure No. 13 before applying the proposal, both groups were in the same academic conditions as they obtained the same grade.

Regarding the gender of the students, the control and experimental groups are equitable in this aspect. Cross Table No. 4 shows that 100% of the women in the experimental group took advantage of the use of the Modellus software, obtaining the medium level Hake Factor gain, likewise only 5% of male students obtained a Hake factor. low level after implementation of the proposal. However, in the control group only 92% of women show a medium Hake factor. While in the control group, 13 students have a low Hake factor, of which 12 are men and 1 is a woman, while for a medium Hake factor there are 21 students, 10 men and 11 women, which implies that the proposal had better results in women in the experimental group since none had a low rank in the Hake factor, due to their greater commitment and discipline in the work sessions [12].

In reference to the enrollment number, it can be seen in Cross Table No. 5 that 100% of the students of the experimental group in the second and third enrollment obtained a medium Hake factor and that only 4% of the students in the first enrollment obtained a low level, compared to the control group in which only 50% of students in second and third enrollment obtained a Hake factor of medium level. This indicates that the use of Software Modellus contributes to students understanding the subject and therefore they would pass in first enrollment, generally reducing the number of students who failed the subject [13, 14].

Despite the experimental and control groups being at a medium level of the Hake factor ($0.3 < g \leq 0.7$) for learning gain as shown in Table No. 6, the experimental group obtained as a result a $g = 0.55$, which evidently indicates that after applying the Modellus software the results were satisfactory, compared to the control group that only obtained a value of $g = 0.42$ with a difference of $\Delta g = 0.13$. What is confirmed with the comparative statistical analysis of related tests and corroborated with independent tests as indicated by the Wilcoxon rank test that shows 34 positive differences in the experimental group, that is to say that all improved after the application of the proposal, because there were zero ties in contrast to the control group that shows 31 positive differences of 34 students, with 3 ties. It is possible that this number represents students in the first enrollment, so there was no change in their learning, since the number of students enrolled in the first enrollment is 64% of the students.

It should be noted that the gain in learning calculated with the Hake factor of this investigation is at a medium level compared to other investigations such as that of (Ochoa, 2012) whose result for the Hake factor was low, this result it is very encouraging as it shows that it will benefit our students in their learning process [4, 15].

In the case of female students, there was not a significant difference in the percentage between the control group (where approximately 92% achieved an average Hake factor level) and the experimental group (where 100% achieved an average Hake factor level). This minimal variation could be attributed to the commitment and discipline mentioned in the article, suggesting that female students may already have been performing well in both settings.

On the other hand, male students experienced a more substantial benefit from using the software. In the experimental group, over 95% of the male students achieved an average Hake factor level, while in the control group, the majority of male students (more than 54%) only obtained a low Hake factor level. This demonstrates that the use of the software was particularly advantageous for male students in enhancing their understanding of the subject matter.

For other authors, the use of Modellus is not important by itself, but must be done with an adequate didactic framework [5, 16, 17]. This study coincides with the mentioned authors since it is an especially useful tool to favor the significant learning of concepts of kinematics, mechanics and in a broader range in Physics, where the dynamic role of the student allows him to build his own knowledge [18].

IV. Conclusions

The study concludes that, in terms of the gain in learning given by the Hake factor with the application of Software Modellus in the learning of kinematics, it generates a significant difference in favor of the experimental group, which corresponds to a medium level above the value of the Hake factor of the control group that denotes a low result in learning gain.

On the other hand, the gender of the student with the best results in the post test is that of women due to their greater commitment and discipline in the work sessions, which led them to obtain a medium level for the Hake factor compared to men who obtained a low-level Hake factor with a higher incidence in the control group. In addition, the students in first enrollment were the ones who obtained the best results in the post test with a medium level in the Hake factor, which is favorable to the proposal since all the students of the experimental group show a better learning on the subjects of Kinematics. By contrasting the results obtained with the hypothesis, proposed objectives for the investigation, we can verify that it has been verified.

It is recommended to organize mixed groups of students for both theoretical study activities and laboratory practices where the number of female students is at least 50% of the members. Also, implement the use of the current version of the Software Modellus as a complement in the teaching of Physics subjects to improve the learning of the topics taught and reduce the percentage of failed students. And, finally, to develop hybrid laboratory guides that involve real and virtual experimentation to stimulate the analytical, comparative, and diagnostic abilities of students, leading to the development of their critical thinking and significantly improving their learning [19].

Acknowledgment

The authors declare that there is no conflict of interest. We thank the Universidad Católica de Santa María for providing us the easy access to scientific databases.

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