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Effect of Problem Based Learning through Differentiable Learning Styles in the Teaching of Statistics

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Abstract The goal of this study was to evaluate the effect of Problem Based Learning (PBL) using a strategy mediated by learning styles on variables of academic performance, attitude and motivation of students within a Statistics online course. Participants in the study were alumni of Statistics II subject course at the University of Guadalajara's Regional Campus in Autlan. Two groups were formed: an experimental one lead through online supported instructional PBL strategy, and a control one attended in a classroom (traditional way). Three questionnaires were applied: first one identified predominant learning styles of students (PEPS), the second one attitude (CUAC) and third one was to interpret motivation (CUMO) towards the proposed learning environment; which were applied at the beginning and at the end of the course. Results of T-test and ANOVA test showed that the learning styles are not related to the instructional strategy of PBL; no differences were found in variables, attitude nor motivation when learning styles were compared within the PBL group. However, such results showed differences in academic performance, attitude and motivation among students of the PBL online group compared to the one that participated in a traditional way.

Keywords: *problem based-learning, learning styles, teaching statistic*

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1. Introduction

A study was conducted on a bachelor's curriculum of engineering in natural-agricultural resources (Spanish acronym: IRNA) offered by the Department of Ecology and Natural Resources (DERN), at the regional campus (CUCSUR) from the University of Guadalajara (Mexico). Just like most any engineering curriculums, a graduate profile of such career implies an intense use of statistical tools within its activities, which mostly require decision-making on specific situations. IRNA is offered through a traditional teaching-learning model in classroom.

CUCSUR has an alumni population of 3150, from which, 10% belongs to rural communities; it also has the necessary telematic infrastructure to support needs of its university clanship. The influence area of this regional campus comprises approximately 19,000 square km which represents 24% from territory of the State of Jalisco, i.e. 23 municipalities; where the main activities are agriculture, fishing and forestry.

As in the case of different higher-education entities other than the UDG (University of Guadalajara), the CUCSUR (Spanish acronym for "Centro Universitario de la Región Costa-Sur") has implemented educational assessment on its curricular programs in order to find out whether these curricular meet students' formative goals or not; such assessment evaluates the effectiveness of local programs facing the needs of the region.

2. Justification

The selected topic was addressed at the area of teaching-learning processes online, based on a problem-solving strategy; influence of learning styles in the instructional environment was also taken into account [1,2]. Interest was focused on improving the academic performance of students in the area of statistics, for this, a web-based instructional strategy was implemented and supported by the theory of situated learning [3].

Teaching statistics in universities is a complicated labor demanding specific skills in the field of mathematics and involving decision making. Several reasons interfere with the teaching of statistics: the first one is that students' knowledge in a group mostly presents heterogeneity [4]; second one has to do with students' different learning styles [5]; and a the third one, no less important reason, is that statistics have been operationalized to instruction as a set of strategies related to the purpose of promoting statistical literacy, emphasizing the apprenticeship of concepts instead of calculations, procedures and formulas.

On the one hand, web-based learning environments improve the implementation of authentic learning activities [6]. On the other hand, the PBL is a strategy with possibilities to transform the teaching-learning system of statistics into a flexible system for achievement of skills and abilities [7]. This study circumscribed within constructivism and its purpose was to reveal the effect on the use of PBL strategy by differentiating the learning styles of students within an online course of statistics. Impact of strategy on variables of academic performance, attitude, and student motivation was evaluated by differentiating their learning styles within Statistics II online course. Moreover, this study addressed the problems related to instructional strategies used by teachers in the traditional courses of Statistics II which have not attended to the needs and learning styles of students [8]. Instructional activities integrated to the courses do not fit real context, being irrelevant, favoring low students' performance, lack of interest or motivation, and unfavorable attitudes towards the learning of statistics.

Statistics II is taught face-to-face in the third semester of IRNA curriculum. Previous studies highlight that students had not acquired enough skills to address real problems that require processing and statistical analysis of information. In the teaching of statistics, low scholastic performance, lack of students' motivation and satisfaction are the result of instructional strategies which are inconsistent with the intended graduate profile. Research related to students' performance within the PBL environment can be classified in three ways: (a) most of the studies conducted have focused on comparing the effect of PBL on the learning of concepts and quantitative problems in the field of sciences through traditional instructional strategies [9,10] based on problems and supported by Web [11]; (b) research has focused basically on students' performance in standardized tests, instead of focusing on performance of transfer to complex and authentic contexts; and (c) research generally records performance based on outcome measures rather than measures of the performance process.

Literature reports that the use of PBL has a positive effect on the increase of content knowledge [12]. According to Hsieh & Knight [13] the effect of PBL was more significant when the preferred learning styles were incorporated by students; instructors and researchers have reported the importance of learning styles by pointing out the effect they have on student performance in a learning environment [14]. Morrison, Ross, & Kemp [15] stated that learning styles are an important support in the planning process of a teaching-learning environment. The consideration of learning styles improves motivation, satisfaction, and promotes favorable attitudes towards the learning of statistics [5,16].

According to Felder & Brent [17] when the student's learning styles are compatible with the way an instructor teaches, student tends to retain the information for a longer time. Kamuche [18] in his research reported a high correlation between students' preferred learning styles and instructor's teaching styles in a basic statistics course. The above suggests to pay more attention to the effect of online instruction on the psychological characteristics of the student such as learning styles

2.1. Problem Based Learning (PBL)

Constructivist orientation is consistent with the pedagogical strategy of PBL in a way in which students restructure knowledge by themselves in the curriculum [19,20]. Recently, statistical instructors have been involved in a reform change on the teaching of statistics. Moore [21] described the reform in terms of three elements: The first one is related to changes in content, it considers what students want to learn; they consider a greater number of activities that involve more data analysis and less learning of probabilistic concepts. The second element includes pedagogy, i.e. what is needed to be done for helping students to learn, less reading and more active learning. The third element was related to technology, designed to reinforce or balance the previous two, data analysis and simulations. Such reform is currently valid in many schools where efforts are made to improve the learning not only of statistics, but also in other areas of science.

Hsieh & Knight [13] as well as Sendag & Odabas [22] highlighted the use of technology to be more effective when it is based on constructivist approaches which point out problem solving, concept development and critical thinking. According to Vidic [7], PBL gives students the opportunity to analyze and test what they know how to do; it allows students to discover what they need to learn, and it enables them to develop skills needed to obtain better performance in collaborative work. Students who participate in a PBL process improve their oral and written communication skills and defend their ideas with arguments and evidence [23].

2.2. Learning Styles

Theories promoted to improve the efficiency of learning are learning styles. Such theories argue that people learn best when their learning styles are adapted to the learning environment [24,25]. These theories propose a way to improve the teaching-learning process through the personal awareness of teacher and student, and their learning styles; such styles are considered indicators of how students like to learn but also how the instructor teaches and guides the individual needs of students [26,27]. There are several definitions of learning styles, these vary according to the terms of behavior construction, stability over time, contexts, and the degree of biological or social influence of these constructions [28].

Individual differences in patterns of student learning are multiple, including cultural, intellectual and affective traits [29]. Such differences make learning styles an extensive and interesting area of research for behavioral researchers and theorists in the area. Dunn & Dunn [1] described learning styles through 18 different elements to which 6 were added later, adding a total of 24; these elements come from 4 basic stimuli that affect the ability of a person to collect and retain information, values, facts and concepts.

2.3. Web-based Learning Environments

Rapid development of technology has allowed instruction to gain important spaces in the labor of universities and institutes. There is no doubt on the rise of Web-based learning environments (WBLE) that significantly contributed in recognizing the need for a better understanding of conditions and means to achieve effective learning [30,31,32,33].

When educational processes are ICT mediated, special attention should be paid to students' preferences towards these learning environments [34,35]. Paying attention to students' learning preferences facilitates that instructional processes, to which they will be exposed, result in better performances and abilities [36].

To design WBLE tailored to student preferences, students' learning styles must first be identified [37,38,39]. The effect on apprenticeship when learning styles are considered in a WBLE, have been supported by several investigations [36,40,41]. Moreover, Sun, Lin, &Yu [42] investigated the effect of learning in a web-based virtual science lab on elementary students; their results showed that the students who used the virtual laboratory achieved better performances than the students who received instruction in the classroom.

Statistical processes supported by fictitious or hypothetical data are less effective than those situations where real data are used. In this sense, Connor, Davies, & Holmes [43] alluded to the experience of the Royal Statistical Society for Statistical Education when they stated that students who concentrate on obtaining their data supported by the Internet tool or by using statistical software generate greater enthusiasm and motivation.

Understanding students' attitudes towards the use of technology and their orientations towards new learning environments are key elements for the design of effective learning environments [44,45]. Therefore, the use of the Web as an educational tool is considered to provide students and instructors with an interesting variety of teaching-learning experiences which are rarely possible in a traditional instructional setting. This implies an evolution in the development of web-based courses and therefore in their pedagogical intension [46,47]. The foregoing implies that more attention should be paid to self-control of learning process; in the social context where it happens, and in the development of activities.

Another students' characteristic of interest in the study of learning environments has been motivation [48,49]. Motivation is considered a fundamental element in any educational learning environment [50,51,52]. The improvement of learning and academic performance depends on the consideration of both cognitive components and motivational aspects [35,53]. Therefore, knowledge and regulation of procedures should focus on keeping students motivated and interested in academic activities.

Likewise, the constructivist learning environment's conception suggests to encourage students to solve real problems in contexts which are familiar to students. The so-called authentic activities have become the focus of some researchers who use social constructivism as a theoretical basis for WBLE [54,55,56]. In this sense, assignments should be oriented towards the selection of significant tasks of constructivist application as the representation of contents from different perspectives.

2.4. Research Questions for Pre-testing and Post-testing

The research questions related to the application of T-tests in the group that received the instructional strategy of the PBL supported by the Web, were the following:

1. Did attitude levels of students who participated in the Statistics II online course change after receiving the instruction under the PBL modality supported on the Web?
2. Did motivation levels of students who participated in Statistics II online course change after receiving the instruction under the PBL modality supported on the Web?

Research Questions for Post-test

The research questions in this study focused on evaluating effectiveness of PBL's instructional strategy broken down by students' preferred learning styles and their relation to academic performance, attitudes, and motivation toward the learning environment proposed for the course of Statistics II.

1. What differences exist in Academic Performance of students exposed to the PBL strategy (experimental group) and students who attended the subject under the traditional modality (control group) differentiating the learning styles?
2. What differences exist in Academic Performance obtained from learning styles preferred by students within the group that was exposed to the instructional strategy of the PBL, in the subject of Statistics II?
3. What is the relationship between attitude levels obtained from the learning styles preferred by students who were exposed to the PBL instructional strategy (experimental group), contrasting to students who attended the subject in a traditional way?
4. What is the relationship between levels of motivation obtained from the learning styles preferred by students who were exposed to the instructional strategy of the PBL?
5. What is the difference between levels of motivation achieved from learning styles preferred by students who were exposed to the instructional strategy of the ABP, contrasting to the students who attended the subject of Statistics II in a traditional way?

3. Methodology

Statistics II online course was attended during 2016A term, and consisted of eight instructional units: introduction to statistical inference, estimation theory, sampling inference, 4simple and multiple linear regression, 6elements of sampling problem, simple random sample, and 8stratified sampling. Topics worked within the PBL instructional strategy were four and were taken into account in a priority order for the course: Parameter estimation, Hypothesis test, Simple and multiple regression analysis, and Stratified sampling. Such topics represented 80% of course grading usually attended in a traditional modality and were delivered through the proposed instructional VLE. Moodle was used as a management platform for Statistics II because it has been implemented at the University Regional Campus (CUCSUR). Moodle is an adaptable platform that is consistent with the research goals and it will be addressed under the ABP strategy.

The activities conducted beheld doing problems contextualized to the task of students' future profession. Learning experiences were made available as a result of team projects conducted by DERN research professors. It was sought as learning experiences to serve as students' support material for the accomplishment of their assignments in the course.

3.1. Population and Sample

Target population consisted of university alumni who attended the subject of Statistics II within the career of Engineering in Natural and Agricultural Resources. Average age of participants was 20 and/or; 80% male and 20% female. Alumni came from different locations in Western Mexico; 95% from urban zones and the rest from rural communities. They had prior experience with courses in Statistical Methods I, Math I, as well as Office Automation, and possessed skills in the use of Internet browsers. Participants in the study were 51 alumni who attended Statistics II. A total of 31 students formed the experimental group that was subjected to the PBL instructional strategy supported by Web, and 20 students integrated the control group that received instruction in a traditional way. No randomization process was involved in the allocation of students in each group. Conformation of the experimental group was voluntary and was integrated by the first 31 participants interested in the study, they signed a document of consent for participating.

3.2. Instruments

In this study four questionnaires were established, three of those were designed by the first author. The first applied questionnaire was the PEPS (Productivity Environmental Preference Survey) of cognitive learning styles used in Dunn's model, et al. [24]. The use of Dunn & Dunn's [1] learning styles model basically involved two types of activities: determining learning styles, and planning and executing instruction to accommodate the individual learning styles or styles preferred. Both groups of activities make up a series of 24 items of learning styles according to Dunn & Dunn's definition [24,29]. According to Curry [57] the model has one of the highest levels of reliability and validity. This instrument has been widely accepted in research that evaluates students' learning styles.

PEPS learning styles' inventory focuses on motivational and environmental factors present in formal instructional environments. The PEPS areas with the highest reliability include visual, kinesthetic and auditory, structure, consumption, light, heat, and afternoon study preference. In the case of attitude questionnaires and motivation, as a basic activity, a literature review was made in relation to the configuration of constructs that answered the research questions. The two instruments designed as well as PEPS were based on a Likert scale of five: total disagree, 2 disagree, neutral, agree, and total agreement. The two instruments that were designed were applied to both control group and experimental group.

The second instrument, called an attitude questionnaire (CUAC), was applied to students to assess their attitudes towards the learning environment and towards the learning of statistics in the learning environment. This questionnaire was structured with 20 items. It consists of two sections: attitude towards the learning environment and towards the learning of statistics. The third instrument that was applied to the students was the motivation questionnaire (CUMO); which was formed by 13 items, four related to intrinsic motivation and nine with extrinsic motivation. Both questionnaires were applied at the beginning and at the end of instruction and measured the changes in levels of attitude and motivation of students before and after receiving the instruction in the environment of the instructional strategy of the ABP learning.

The first enforcement was considered as a pre-test and the second application was considered as a post-test. Purpose of pre-tests was to measure attitude levels and motivation of participating students before starting instruction in the learning environment. The second application of questionnaires considered as proactive was done at the end of the course. The goal was to measure levels of attitude and motivation in students after completing the instruction. Finally, the comparison of pre-tests and post-tests was done to identify the effect of the PBL's instructional strategy in regards to variables. Academic performance of students was evaluated according to the instructional objectives and was the outcome of four learning assignments focused on assessing the process that students followed in their apprenticeship. Such academic performance was calculated as the average of scores from the different activities proposed in the course.

In attention to the hypotheses proposed in this study, the instructional strategy based on PBL Web-supported used in Statistics II online course was treated as an independent variable; learning styles were treated as an intervening variable assuming that those affect both the results of dependent variables and the learning environment itself. The intervening variable, also known as mediating variable, is defined as a characteristic that stands out among dependent and independent variables, influencing the behavior of dependent variable as from the independent variable [58]; i.e. the intervening variable transmits or mediates the effect of independent variable on the behavior of dependent variable.

The dependent variables were scholastic performance, attitude, motivation and the academic performance. In the case of variable scholastic performance, it was defined as the sum of products as from the grades obtained by students in different activities. Record scale contemplated a range of 0 to 100 points. The minimum approbatory grade according to the UDG's institutional regulation is 60 out of 100. The attitude of students who participated in the PBL instructional strategy and the attending of statistics, was operationally measured with the CUAC questionnaire. In the case of variable “motivation”, the operationalization was carried out using the CUMO questionnaire.

3.3. Analysis of Data

Taking all three instruments of study to the practice, the internal consistency of items was evaluated and the internal validity of the three questionnaires was estimated. Cronbach's alpha reliability coefficient was used. The results derived from PEPS instrument allowed the conformation of work teams within the experimental group and the control group. The teams were shaped according to students' prevalent learning styles. The statistical technique of factor analysis was applied to identify the participants' preference to learn, to concentrate and to develop their educational activities. This statistical technique generated an analysis of environmental, emotional, sociological and physical needs of the students. Statistical processing of information was done with SAS 9.4 statistical software.

Within each group, teams were formed based on classificatory results of learning styles obtained from PEPS. Table 1 shows how work teams were shaped within each group.

Table 1. Work Teams According to Learning Styles

Experimental	Visual	2 teams of 4
	Aural	4 teams of 4, 1 team of 3
	Kinesthetic	1 teams of 3
Control	Visual	3 teams of 3
	Aural	4 teams of 2
	Kinesthetic	1 team of 3

Scholastic performance variable was continuous, with a varied scale from 0 to 100 points. Since the data collected was based on an ordinal scale, it was necessary to transform them into ranges using the SAS ranking procedure. This transformation allowed solving the problem of measurement scale used in the questionnaires and thus avoiding the effect of non-compliance of the theoretical assumptions about the normality of observations, and the homogeneity of variances between and within the groups. Statistical pre-test-post-test techniques were used to shape significant differences in students' attitude and motivation levels before and after instruction within each group.

Through this analysis, it was sought to know if, indeed, the participation of students in the group that attended the subject of Statistics II under the PBL instructional strategy modified their attitude and motivation levels after concluding the course. Data collected for the dependent variables were analyzed separately. Two-way ANOVA techniques were used. Analysis included group factor (control and experimental) as well as learning styles factor (aural, visual and kinesthetic).

Research questions answered in this study were related to the impact of the PBL instructional strategy broken down by the learning styles on scholastic performance, attitude, motivation, and student satisfaction contrasting to those students who attended the Statistics II course in a traditional way. Data used for the two-factor ANOVA were made considering only post-tests of the experimental group and the control group. To answer the research questions, academic performance, attitudes, motivation and student satisfaction were compared between and within each group.

t-test was made for independent samples through the TTEST procedure, and two-factor ANOVAs were implemented, considering the independent variables, groups and learning styles. ANOVA was made within experimental group and means of learning styles were compared for the dependent variables. In the cases where significant differences were found between groups of learning styles, tests of means' multiple comparisons were applied using the technique of significant minimum differences (lsmeans) of SAS GLM procedure, this allowed to determine which learning style had the biggest contribution in the rejection of regarded hypothesis.

4. Results

In this study, the independent variable was the instructional strategy used in Statistics II online course under the PBL web-based strategy, treating the learning styles as an intervening variable linked to a VLE. The dependent variables were attitude, motivation, satisfaction and academic performance of the students who were exposed to the PBL instructional strategy.

Comparison of pre-test and post-test means were made through PROC means procedure for paired samples. The comparison of means between groups was based on the means' *t*-test for independent samples and the TTEST procedure of SAS was used. The results confirmed most of the work hypotheses raised in the study. The methodology described in the research proposal was carried out smoothly. The students participating in both the control group and the experimental group observed the instructions correctly, which facilitated the development of the research.

Research Questions Concerning Pre-testing and Post-testing.

The research questions related to the application of the pre-tests and post-tests in the group that attended the PBL web-based instructional strategy were the following:

1. Did the attitude levels of the students who participated in the Statistics II course change after receiving the instruction under the PBL modality supported on the Web?

2. Did the motivation levels of students who participated in the Statistics II course change after receiving the instruction under the PBL modality supported on the Web?

Contrast hypotheses for the Pre-test and Post-test

The first block of research questions was related to the changes in attitude and motivation of the participating students after receiving the instructional strategy in the course of Statistics II. The questions derived in the following hypotheses:

1. Ho: the attitude levels of students who were exposed to PBL instructional strategy are the same in the pre-test and the post-test.

2. Ho: the motivation levels of students who were exposed to the instructional strategy of PBL are equal in the pre-test and in the post-test.

Hypothesis on the attitude variable for the pre-tests and post-tests of the experimental group.

Table 2 contains basic statistics of variable attitude required for *t*-test. The next tables show means, standard errors, *t*-test statistics and their corresponding levels of significance (minimum probability of rejecting Ho:). It can be observed that, in the attitude variable within the experimental group, results did not show means significant differences of attitude levels in the pre-test and post-test: $t(30) = .000$; $p < .998$. This led to the non-rejection of the hypothesis provoking that the attitude levels of students exposed to PBL instructional strategy were equal in the pre-test and in the post-test.

Hypothesis on the variable motivation for the pre-tests and post-tests of the experimental group.

Statistics derived from application of the *t*-test for paired samples in the variable motivation are shown in Table 3. The results show that the difference between averages of the levels of motivation for pre-test and post-test was not relevant. Comparison of means within the experimental group did not report significant differences: $t(30) = .000$; $p < 1.000$; which led to the non-rejection of hypothesis. The students participating under PBL instructional strategy did not modify their levels of motivation after completing Statistics II.

Table 2. Basic Statistics of the Attitude in the Test and Post-Test of the Groups

Group	Test	*n*	$\bar{X}$	*SEM*	*t*	*p*
Experimental	Pre-test	31	310.50	10.493	29.59	<.0001
	Post-test	31	310.52	12.022	25.83	<.0001
	Difference (pre-post)	31	.020	12.891	.000	.998

n = Students; ($\bar{X}$ = Mean; *SEM* = Standard error of mean; *t* = Test statistics; *p* = Minimum Ho: probability rejection.

The results led to the non-rejection of the Ho: hypothesis that established that the levels of motivation of students who were exposed to the instructional strategy in the traditional modality are the same in the pre-test and post-test.

Table 3. Basic Statistics of the Motivation in the Test and Post-Test of the Groups

Group	Test	*n*	$\bar{X}$	*SEM*	*t*	*p*
Experimental	Pre-test	31	202.0	9.40	21.48	<.0001
	Post-test	31	202.0	9.65	20.9	<.0001
	Difference (pre-pos)	31	.00019	8.77	.000	1.0000

n = Students; $\bar{X}$= Mean; *SEM* = Standard error of mean; *t* = Test statistics; *p* = Minimum Ho: probability rejection

Although statistical analysis developed from pre-tests and post-tests did not show relevant differences in the average levels of variables attitude and motivation, it can be seen in Table 2 that the results in the attitude levels were higher in students of the experimental group ($\bar{X}$= 310.520, SEM = 12.022), regarding to students of the control group ($\bar{X}$= 200.250, *SEM* = 11.481). In the case of the variable motivation, it can also be seen in Table 3 that the mean levels of variable motivation were higher in students who participated in the experimental group ($\bar{X}$= 202,000, SEM = 9,652), regarding to the average levels of students from the control group ($\bar{X}$= 130.520, *SEM* = 9.244).

Research Questions for Post-test

Research questions in this study focused on evaluating the effectiveness of the PBL's instructional strategy, broken down by students' preferred learning styles and their relation to scholastic performance, attitudes, and motivation toward the proposed learning environment in the course of Statistics II.

What differences exist in the Academic Performance of students that were exposed to the PBL strategy (experimental group) and students who attended the subject under the traditional modality (control group), differentiating the learning styles?

What differences exist in the Academic Performance obtained from learning styles preferred by students within the group that was exposed to the PBL instructional strategy, in the subject of Statistics II?

What is the relationship between attitude levels obtained from the learning styles preferred by students who were exposed to the PBL instructional strategy (experimental group) regarding to the students who attended the subject in a traditional way?

What relationship exists between the levels of motivation obtained from the learning styles preferred by the students who were exposed to the instructional strategy of the PBL?

What is the difference between the levels of motivation achieved from the learning styles preferred by the students who were exposed to the instructional strategy of the ABP with respect to the students who studied the subject of Statistics II in a traditional way?

Hypothesis on Academic Performance

Hypothesis Ho1: the students participating in the course of Statistics II with different learning styles (visual, auditory and kinesthetic) that were exposed under the instructional strategy of the PBL show the same academic performance as the students with different learning styles that took the course under the traditional mode.

The data obtained in the evaluation of variable scholastic performance in the control group and the experimental group were analyzed by the TTEST procedure of SAS. In this analysis, the results of the variance homogeneity test of the samples in the control group and the experimental group were met, $F(30,19) = 2.42$, $p < .054$.

Table 4 shows the basic statistics required to make a means' comparison from each group. Results led to the rejection of Ho1: hypothesis that stated 'the students with different learning styles (aural, visual, and kinesthetic), taking Statistics II under the PBL instructional strategy' to show lower academic performance than 'the students with different learning styles which attended the course under the traditional modality': $t(49) = -2.37$, $p < .0218$; this statistical result suggested that the students who participated in Statistics II without breaking up such learning styles and who were exposed to the instructional strategy of the PBL showed higher academic performance ($\bar{X}$ = 71.22, *S* = 7.013) to the students who attended the course under the traditional modality ($\bar{X}$ = 64.750, *S* = 12.510).

Table 4. Comparison of Means of Academic Performance Between Groups

Group	*n*	$\bar{X}$	*S*	*SEM*	*df*	*t*	*p*
Control	20	64.75	12.510	2.79	19	23.15	<.0001*
Experimental	31	71.23	7.01	1.26	30	56.55	<.0001*
Difference (Con-Exp)		-6.476	9.52	2.73	49	-2.37	.0218*

n = Sample size; $\bar{X}$ = Mean; *S* = Standard deviation; *SEM* = Standard error of mean; *df* = Degrees of freedom; *t* = Test statistics; *p* = minimum probability of rejection of Ho: **p* <.05.

To test Ho1:, a factorial ANOVA was applied to scholastic performance. Factorial designs among its main advantages emphasize that a single experiment may be enough for the analysis of two factors [59].

Factorial ANOVA design applied in the study was of two factors or two-way, and it consisted of simultaneously analyzing the group factor (experimental and control) referred to the instructional strategy and the learning styles' factor (aural, visual, kinesthetic) on the means of scholastic performance, and it also allowed to determine if the factors had a significant effect on the magnitude of the variable in the interaction of the two factors.

The ANOVA results presented in Table 5 considered the group factor and the learning styles on the academic performance variable. The results of Table 4, did not show significant differences $F(1, 50) = 1.81$, $p < .1309$.

Table 5. Two-factor ANOVA for Academic Performance Between Groups and Learning Styles

Source	*df*	*SS*	*MS*	*F*	*p*
Model	5	828.847059	165.769	1.81	.1309
Error	45	4130.133	91.781		
Fixed total	50	4958.980			

df = Degrees of freedom; *SS* = Sum of squares; *MS* = Mean square; *F* = Test statistics; *p* = Minimum probability of rejecting Ho.

However, the ANOVA model with sum of squares type III, like the *t*-test, indicated that the group factor presented significant differences $F(1, 50) = 5.92$, $p < .0190$. This result indicated that the average scholastic performance of students who participated in the PBL instructional strategy was higher ($\bar{X} = 71.226$, $S = 7.013$) than such performance achieved by students in the traditional group ($\bar{X} = 64.750$, $S = 12.510$), this can be seen in Table 6.

ANOVA breaking up the learning styles for both groups (control and experimental) is shown in Table 6. Results of comparing scholastic performance through learning styles led to non-rejection of learning styles' factor hypothesis $F(2.50) = 1.14$, $p < .3295$. This statistical result indicated that the effect of applied instructional strategy (Web-based or traditional PBL) did not influence students' learning styles on academic performance.

Table 6. ANOVA Type III Model for Academic Performance between Groups and Learning Styles

Source	*df*	Type III SS	*MS*	*F*	*p*
Group	1	542.995	542.995	5.92	.0190*
lsi	2	208.872	104.436	1.14	.3295
*lsi fix	2	87.205	43.602	.48	.6249

df = Degrees of freedom; *SS* = Sum of squares; *MS* = Mean square; F = Test statistics; *p* = Minimum probability of rejecting Ho; *$p < .05$.

Moreover, interaction between group factor and learning styles was not significant either $F(2, 50) = .48$, $p < .6249$, which implied that the instructional strategy has no relation with the learning styles of students, i.e. they do not have a significance in the scholastic performance independently of the instructional strategy used by the students.

Hypothesis Ho2: students participating in the course of Statistics II with different learning styles (visual, auditory and kinesthetic) that were exposed to the instructional strategy of the PBL show equal academic performance.

For comparing scholastic performance within the experimental group, ANOVA was performed. The results of Table 7 indicate that there was not enough evidence to determine significant differences in the means of the learning styles of the students of experimental group. Therefore, the Ho2: hypothesis was not rejected.

Table 7. Two-Factor ANOVA for Academic Performance Among Experimental Group Learning

Source	*df*	*SS*	*MS*	*F*	*p*
Model	2	194.658	97.3291	1.21	.3130
Error	28	2250.342	80.3693		
Fixed total	30	2445.000			

df = Degrees of freedom; *SS* = sum of squares; *MS* = Mean square; *F* = test statistics; *p* = minimum probability of rejecting Ho:

Hypothesis about Attitude

Hypothesis Ho3: the students who participated in the course of Statistics II under the instructional strategy of the PBL showed the same attitude levels as the students who participated in the traditional modality under the different learning styles.

The analysis carried out to compare means in the attitude levels between students of the experimental group and the control group were based on the post-test carried out at the end of the course in each group. The results of making the two-way factorial ANOVA in Table 8 took into account the group factor (experimental and control) as well as learning styles factor (visual, aural, kinesthetic) on the variable attitude. Table 8 showed sufficient evidence to reject the hypothesis: $F(2, 50) = 8.91$, $p < .0001$. For this analysis, we used the model with sum of square Type III since it is more appropriate to test significance of factors in unbalanced situations (different number of observations in samples) as in our case.

Results in Table 9 indicated that the average of students' attitude levels was different between the experimental group and the control group. Therefore, there is a significant effect on the group factor: $F(1, 50) = 42.64$, $p < .0001$ on the attitude of the students, this without breaking down the learning styles factor. This meant that the attitude of students had a different behavior and varied according to the instructional strategy in which they participated. In this case, students participating in the instructional strategy based on the PBL showed higher levels of attitude ($\bar{X} = 310.520$, $S = 66.938$) than the students who participated in the group that traditionally took the course ($\bar{X} = 200.25$, $S = 51.344$).

Table 8. Two-factor ANOVA for Attitude Between Group and Learning Styles

Source	*df*	*SS*	*MS*	*F*	*p*
Model	5	165374.93	33074.9	8.91	<.0001*
Error	45	166952.07	3710.0		
Fixed total	50	332327.00			

df = Degrees of freedom; *SS* = Sum of squares; *MS* = Mean square; *F* = Test statistics; *p* = Min. probability of rejecting Ho; *$p < .0001$.

The two-way ANOVA in Table 8 allowed us to analyze learning styles by breaking them up by class. The factor learning styles for the control and experimental groups did not show significant differences in the means of attitude levels of the participants of both groups, $F(1, 50) = .289$, $p < .7565$. Results of comparing means in attitude levels of the different learning styles led to the rejection of the Ho3: hypothesis.

Table 9. ANOVA Model Type III for Attitude Between Group and Learning Styles

Source	*df*	Type III *SS*	*MS*	*F*	*p*
Group	1	158187.5	158187.5	42.6	<.0001*
lsi	2	2083.9	1041.9	.289	.7565
*lsi fix	2	14701.2	7350.6	1.98	.1497

lsi = Learning Styles; *df* = Degrees of freedom; *SS* = Sum of squares; MS = Average squares; *F* = Test statistics; *p* = Minimum probability of rejecting Ho :; $^*p$ <.05.

Likewise, the interaction between the application of the instructional strategy and the learning styles was not significant either $F(2,50)$ = 1.98, p <.1497. This result implied that the instructional strategy had no relationship with the learning styles of the students, at least for the attitude variable; this meant that the learning styles do not have an important significance in average levels of attitude, regardless of instructional strategy used by students.

Hypothesis Ho4: the levels of motivation achieved by the students who participated in the instructional strategy of the PBL are the same in each learning style.

According to the results of ANOVA in Table 10, statistic *F* showed that there were no significant differences between the means of motivation levels in the different learning styles of the students who participated in the instructional strategy of the PBL, $F(2, 30)$ = .46, p <.639. This statistical result led to the non-rejection of the Ho6: hypothesis.

Table 10. ANOVA for Variable Motivation Between Learning Styles Within the Experimental Group

Source	*df*	*SS*	*t*	*F*	*p*
Model	2	2589.269	1294.635	.46	.639
Error	28	79654.700	2844.811		
Fixed total	30	82243.811			

df = Degrees of freedom; *SS* = Sum of squares; *MS* = Mean square; F = Test statistics; *p* = Minimum probability of rejecting Ho; *p <.05.

Moreover, the results derived from the model of sum of squares Type III, provided by the two-way ANOVA that is shown in Table 11, allowed to judge the significance of the group factor and the learning styles factor. The group factor and the learning styles factor presented significant differences.

Table 11. ANOVA Type III Model for Motivation Considering Group and Learning Styles

Source	*df*	Type III SS	*MS*	*F*	*p*
Group	1	400247.9	400247.97	111.36	<.0001*
Lsi	2	25616.76	12808.804	3.60	.0353
group*lsi	2	1708.24	8541.210	.24	.7874

df = Degrees of freedom; *SS* = Sum of squares; *MS* = Mean square; *F* = Test statistics; *p* = Minimum probability of rejecting Ho:; *p <.05.

In the case of group factor, the result assumes that the average satisfaction levels among instructional groups was different. The group of students who participated under the instructional strategy of the PBL reached a higher average ($\bar{X}$ = 310,520, S = 66,938), regarding the control group ($\bar{X}$ = 200,250, S = 52,344).

The two-way ANOVA allowed the disaggregated analysis of the learning styles factor. The results of the significance are shown in Table 11. The test statistic *F* showed sufficient evidence to reject the hypothesis regarding the significance of the learning style factor, $F(2, 50)$ = 3.60, p <.0353. This meant that the average levels of motivation were different in the learning styles of the students. For the case of the interaction between the group factor and learning styles, no significant effect was found, $F(2, 50)$ = .24, p <.7874. This implied that the instructional strategy will not have any relationship with the levels of student motivation in the learning styles.

Motivation hypothesis

Hypothesis Ho5: the levels of motivation achieved from the learning styles by the participating students under the instructional strategy of the PBL are the same as those achieved by the students who took the course of Statistics II under the traditional modality.

The results of Table 12 show significant differences in the means of motivation levels between the learning styles of the experimental group and the control group, $F(2, 50)$ = 5.87, p <.0003.

Table 12. Two-factor ANOVA for Motivation Considering Group and Learning Styles

Source	*df*	*SS*	*MS*	*F*	*p*
Model	5	69829.533	13965.907	5.87	<.0003*
Error	45	107034.738	2378.550		
Fixed total	50	176864.271			

df = Degrees of freedom; *SS* = Sum of squares; *MS* = Mean square; *F* = Test statistics; *p* = Minimum probability of rejecting Ho; $^*p$ <.05.

Table 13 shows the results of the sum of squares Type III ANOVA for the factors and their interaction. The group factor presented significant differences in average levels of motivation from the students, $F(1, 50)$ = 27.24, p <.0001. The average levels of motivation were higher in the group of students that received the instructional strategy under the ABP ($\bar{X}$ = 202,000, S = 52,359) with respect to the students who worked under the traditional model ($\bar{X}$ = 130,000, S = 41,341).

Table 13. ANOVA Type III Model for Motivation Considering Group and Learning Styles

Fuente	df	Type III SS	*MS*	*F*	*p*
Group	1	64789.615	64789.615	27.24	<.0001*
lsi	2	474.371	237.185	.10	.9053
group*lsi	2	7405.209	3702.605	1.56	.2220

df = Degrees of freedom; *SS* = Sum of squares; *MS* = Mean squares; *F* = Test statistics; *p* = Min. probability of rejecting Ho; $^*p$ <.05.

The results of the two-way ANOVA in Table 13 also showed that the means of motivation levels disintegrating the learning styles of the students was not significant, $F(2.50)$ = .10, p <.9053. Therefore, learning styles of students, independently of the instructional strategy, did not show differences in the levels of motivation. The interaction between the instructional strategy factor and learning styles also did not report significant differences, $F(2, 50) = 1.56$, $p <.2220$, which does not imply any relation between the learning styles and the delivery of the instruction.

5. Conclusions

The results of this study assume that students who participated under instructional proposal of PBL achieved better academic performance in the subject of Statistics II. The learning and understanding of statistical concepts were achieved in the course, and the participation of the group in the solution of the proposed problems was promoted, which had the characteristic of being contextualized to the professional work of the student.

Although the learning styles did not show any type of intervention regarding the variables academic performance, attitude, and motivation with the instructional strategy, it is also true that the statistical analysis reported a significant intervention of instructional strategy of PBL on the satisfaction of students in the course. According to the principles of education, the best teaching method is one that is most adapted to the student's learning styles, and in this sense it can be said that in this study, in effect, the satisfaction variable was influenced by the strategy instructional through learning styles.

In this study, derived results do not support the belief that the learning styles have intervened or have any effect on the variables academic performance, attitude, and motivation, through the instructional strategy of the PBL. Results of the study are partially supported by some research such as the one developed by Harris, Dwyer, and Leeming [60] who investigated the impact of learning styles in a web-based learning environment. The authors stated that neither learning styles nor the course had an impact on student performance. Overall, the results derived from the instructional proposal of this study are encouraging in the sense that it allowed to improve the academic performance, attitude, and motivation of students towards the environment and the learning of statistics.

The Web-based PBL-based instructional strategy was an interesting proposal for the teaching of statistics to IRNA students. The results of the study showed the possibility of improving the scholastic performance, attitude, and motivation of students.

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