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RESEARCH ARTICLE

TEACHING VOLUME CONCEPT USING B-LEARNING STRATEGY IN HIGH SCHOOL ON HUASTECA SUR POTOSINA, MEXICO

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ABSTRACT

We show results from b-learning strategy used to teach volume concept in high school for several geometric figure. We applied a conceptual volume test (pretest) and we found that high percentage of students had several misconception and low knowledge about prism and pyramids. We work with a control group (traditional) and, experimental group (b-learning); this methodology includes conceptual activities and use of Khan academy tool. Population was 50 students divided in two similar groups; distinction gender was no made. At the end of the course, we applied posttest; results indicate that Hake gain in experimental group (0.69) was larger than control group (0.45). In addition, hypothesis test for two sample indicate there are statistically differences between traditional and b-learning strategy which we can assume students in experimental group have better academic performance than students in control group ($t = 3.018 > t_c = 1.684$).

INTRODUCTION

UNESCO (2005), in its proposal Introduction of Communication and Information Technology establishesthat, the use of new technologies is a very important factor in the new Education context and, can improve the acquisition of abilities neededto driveon the new era. In Mexico, formal education is a tool to allow people toachievea better lifestyle. Unfortunately,even when curriculum, free textbooks and evaluation criteria for teachers are similar for all schools there is a gap in academic infrastructurearound the country. For example, Huasteca Sur in San Luis Potosi is a marginal zone and has adeep social lag. Accordingto the results in math of the standard test (ENLACE) applied for the Education Secretary in Mexico, between 23% and 36% of students obtained a very low level (insufficient), between 32% and 40% obtained basic level, between 15% and 26% obtained good level, and between 4% and 16% of them obtained excellent level (ENLACE, 2013). In high school math learning (SEP, 2011), itis very importantto consider topics such as numeric sense (NS) and algebraic thinking (AT); shapes and measure (SM); and information management (MI). When analyzingthat content, it was found that students have to explore characteristics and properties of several geometric figures, identifyvertices and edges, designplanes of certain geometric bodies, compute cubes, prism and pyramids volumes. Besides having to work analyzing and describing prisms, it is pretended students to have the abilities to link the geometric work with numeric sense and algebraic thinking. The Secretary of Public Education in Mexico has one aim challenge: to develop in students abilities toimprove their learning and digital skills. Morán (2012) points out “blended instruction is an excellent complement for presential instruction because it canincrease the strengths on each space and minimizeweaknesses in both methodologies”. The idea to create a virtual space of teaching and learning, and integrate them using the technology in those spaces is not easy to carry out and to adequate conditions is needin order to work properly within classrooms. A good tool is Khan Academy platform, which havehigh international recognition and which aim is to give free education around the world for any people in any place of the planet (Khan and Slavitt, 2013; Thompson, 2011; Rosen, 2012). It has been rated as a resource that has transformed the education (Pinkus, 2015), additionally, it has educative alliances with no-governmental institutions in order to support the learning among children and young people in some developing countries (León and Rehina, 2013). Considering that nowadays global teaching is toward

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develop proffesional skills, we have to accept that education totally on line is not adecuate because few people could develop skills for business or manage a team only by interacting with a computer. Arranz and Virginia (2005) point out there are not enough evidence that online course can develop those abilities in our students.

For this reason, there are a lot of researchers on education that suggest the use of mixed models, like b-learning which use new technology and multimedia resources, and furthermore the presential environment where interaction between teacher and his students provide academic support in any moment. At the moment of developing a mixed process, it is necessary to identify students´ needs in order toorganize and use resources that give clear information in the platform of learning (González, *et al*, 2012).

Teaching by B-learning

Heinze and Procter (2006) point out that "implementing a teaching hybrid process, makes possible to improve the process and education quality, in comparison with a instruction purely presential or virtual". Gonzalez and Bodicka (2012) defined it as: b-learning= mobile learning + eLearning + classroom learning. Cabero and Gisbert (2005) carry out a comparative synthesis about significant differences between classroom teaching and virtual teaching, see Table 1. A key point in blended learning is the selection of adequated resources for each educative needsand their possible application (Adell and Area, 2009; Bartolomé, 2004).

Table 1. Differences between instruction by websites and traditional instruction

Instruction base on web	Traditionalinstruction
Let students learn in his steadily way	Students must have a background in the topic of study
It is an instruction basedon the concept *Just-in-time training*.	Teachers decide when and how students will obtain the materials
It let use different materials (auditory, visual y audiovisual)	Students are passive participants
With one session, it is possible to teach a large number of students	It tends to use printed materials and the teacher is the knowledge source
The acquisition of knowledge is an active process	Linear communicationmodel.
It tends to reduce the time spent by people in their vocational training	Communication is only between teacher and students
It tends to be interactive between participants (teacher and students). Thecontent are interactivetoo.	Generally, learning is in short groups
Students can use the materials all the time	Learning is in classroom and time is limited
Flexible	Not flexible
Low experiences teaching on internet	A lot experience in this model
Usually, there are structural problems to start up	There are a lot of structural resource to execute the instruction

In Mexico, some universities have adopted blended method; there are several reasons for which each institution accept to implement this methodology and they obtain different results. For example, the Centro de Estudios Universitarios used b-learning with the idea to offer their students the possibility to access to the material needed for their class in any place and any moment, the aim was that larger number of students could finish their professional career. Universidad delAltiplano mentions that b-learning was favorable for their students regarding to motivation and self-commitment (Ocampo, *et al* 2015). Centro Universitario de los Valles implemented a proposal in order to work with problem-based learning together with b-learning, it was found that this methodology offers the background for an active, cooperative, and focused system to develop the students' skills (Santillán, 2006).

MATERIALS AND METHODS

A descriptive study on students' learning environment and aquantification of knowledge level aboutvolumeconcept was performed. This work focused on knowing the impact of b-learning (didactic planning and Khan academy) to teach volume concept and its applications on geometric problems. Didactic sequence was divided in two parts: a) Working in classroom (didactic planning), and b) Online sessions (Khan Academy). Hake gain was used in order to quantify the effectiveness of the strategy proposed, and t-student distribution was used to determine if there are meaningful differences between both, traditional and B-learning strategy. We designed a didactic sequence according to secretary of education´s curriculum in Mexico (SEP, 2015) including several activities both classroom and homework. We applied a pretest at the beginning of the course and a posttest at the end of the curse to measure the level of learning achieved.The test is a multiple-choice questionnaire with 24 items related to area and volume of different geometric figures; the authors of this paper designed it.

Population

We worked with 50 students formed into two groups.Group A (control): they worked with traditional instruction.Group B (experimental): they workedin 4-students teams with b-learning model; for each activity, they spent 20min (in class), for online activities they could spent the necessary time until they understand clearly the concept in study.Students had 13 years old, enrolled in 2nd year at the high schoolJusto Sierra Méndez onregion Huasteca Sur, San Luis Potosí, Mexico. The population was composed of 46% of women and 54% of men. We did not make gender distinction.

Learning strategy design

We designed the activities considering the abilities needed to promote geometric learning (García and López, 2008), students had the opportunity to observe, to touch, to build, to make deductions, to validate conjectures and to justify procedures. Session 1 focused on studentsidentifying perimeter and area formulas of some figures, studentswould work with mental maps, domino and other printed materials. Session 2 focused on students identifying characteristics about prism and pyramids, this session could begin with brainstorm about prism and pyramid shapes. Session 3 focused on students realizing thatthe product*basexhigh* is useful to compute rectangular prism volume. Table 2 shows didactic planning to develop in class (session 4); you can see the content, main topics, skill to develop, learning objective and objective of activities for each session.

Description of Khan Academy platform

This virtual platform was designedin order to help students to learn math (Clive, 2011; Cargile, 2015; Kronhold, 2012)

Table 2. Didacticsequence

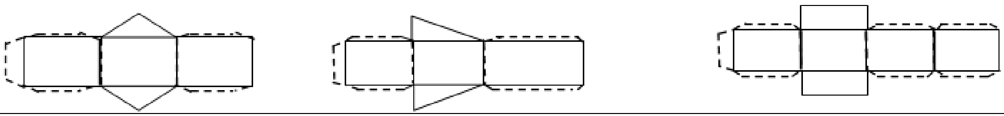
Sessionfour		
Aim: Identify volume formula of pyramids, rectangular prism and its relations with other prism.		
Opening	***Developing***	***Ending***
Activity 1.	Activity 2.	Activity 3
Students have to draw, cut and built some prisms and pyramids, using the measure indicated for the teacher.	Students will work in peers in order to compute the volume for each prism and pyramid built and then give an explanation how they computed.	Using prism and pyramid built, students have to identify those having similar base and high, and they have to find the relations between them.
Descriptions of activities		
Activity 1. Each students have to draw, cut and build some prisms and pyramids indicated by the teacher. 		
Activity 2. Students have to answer these questions:		
a) What is the volume of the square prism?		
b) What is the volume of triangle prism?		
c) What was your procedure?		
d) Is it possible to compute the volume using the formula V=(base area) (high)?		
Activity 3.		
Make teams of three students and perform the follow activities:		
1. Compare both, square prism and triangle prism. Are they similar ?		
2. Fill the pyramid with sand, then pour the sand in the square prism. At the end, answer the following questions:		
• How many times do you pour the sand of pyramid on the prism ?		
• Is there any relation between your procedure and volume formula ? $V = \frac{1}{3}A_{base}h$		

Table 3. Activities on Khan Academy

Aim: Improve students' analysis to use volume and area formulas for some geometric figures.

Opening	*Developing*	*Ending*
We consider the use some videos on the platform as introduction to the topic. Students can watch them as many times as they want.	We consider tasks referred to perimeter, area and volume about prism and pyramids located in Khan Academy. Students have to practice on the website.	We consider doing a grupal assessment of the activities. Students have to share their results and knowledge.

Descriptions of activities

Opening activities.

Khan Academy platform offers several tutorials so students can solve some doubts watching videos with the solution process for those topics. Teacher proposes a video, according to the content (pyramids and prism volume); students must analyze it.

Developing activities

We propose some activities and split them in three sections:

1st.-Perimeter concept: Find the perimeter, by square unit, solve problems about areas and perimeter of rectangles.

2nd.-Formula of areas: Triangle area, parallelogram area, trapeze area, composite figures areas.

3th.-Solids geometry: pyramids and prism volume.

Ending activities

Apply the survey to student participants, in order to know the degree of satisfaction using the platform and their point of view about different aspects about the website.

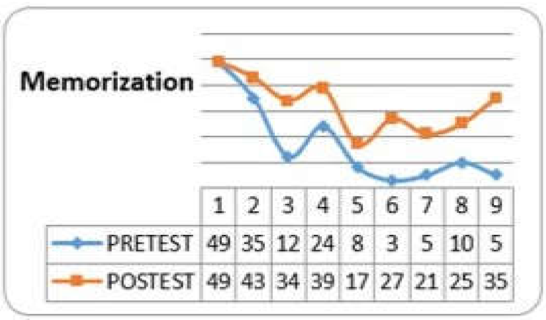


Figure 1a. Memorization

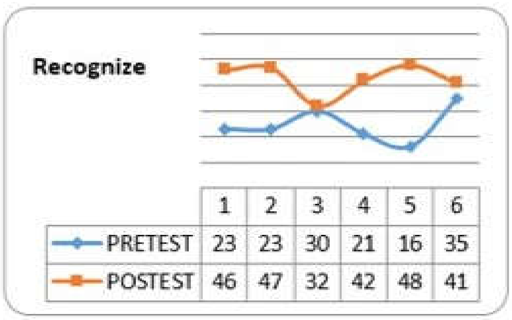


Figure 1b. Recognize

through a series of videos and activities designed carefully bythe author of the website. Nowadays, it containslots of material for several areas of science such as physics, chemistry and biology, as well as health and medicine, economy and computing. In this section, we shall describe the most important elements about our proposal and their application in the virtual platform. Table 3 shows activities to platform according to sessions early mentioned. Observe that Table 4 and Table 5 are consistent because both contain similar concepts according to our academic sequence, in this way, students who execute an activity in classroom could strengthen it in Khan Academy, and vice versa. Session 1, 2 and 3 have activities similar to Table 5.

RESULTS AND DISCUSSION

Conceptual test was applied in two moments, as pretest at the beginning of the course and, as posttest at the end of the course; the test took 50min in both cases; students aware that the test has not impact in their grades but it was very important toanswer the questions with responsibility. Since primary school students has analyzed the compute of some important concept such as areas and volume, on high schoolthey have to obtain several mathematics abilities in order to recognize differences between prism and pyramids, including their formulas. So, pretest put in evidence that students:

- Recognized formula of rectangle and square area
- Did not identify the perimeter and area of some figures
- Did not identify prism and pyramids characteristics
- Have had deficiencies in volume conceptualization
- Did not know formulas about volume and its units

With this analysis, we could identify misconception about volume, and we used Bloom taxonomy in order to define the abilities that students must have in order to apply mathematics concepts (Luengo, 1998). For a deep analysis, we will describe results obtainedand sort them in four levels.

Level I. In this level, we divided the items in two sections. The first section have the objective to promote memorization of formulas, while the second one promote to remember correct name of geometric figures.

Memorization

In order to promote the memorization, students played "geometrics domino´s game". In this way, students could study square, rectangle, triangle and circle formulas. In Figure 1a, we show pretest and posttest results, item 1 is associated with square, item 2 with rectangle, item 3 with circle, item 4 with triangle, item 5 diamond, item 6 with rhomboid, item 7 with hexagon, item 8 with trapezium and item 9 with volume formula about prism. We can observe that memorization level in posttest is larger than pretest; data indicates that there are problems only with diamond formula.

Identify

Figure 1b shows comparative graphics between pretest and posttest results about identify level. Item 1 is associated with polyhedron height, item 2 with polyhedron base, item 3 with polyhedron faces, item 4 with arista, item 5 with vertices and item 6 with flat development of polyhedron. We observe a better identify level at the end of the course, there are just a few problems with item 3.

Level II. *Classification.* Activities were designed focused to improve students' comprehension level. It means, students haveto use polyhedron characteristics to do a correct classification of those figures. Figure 2a shows results about pre and posttest. Item 1 is associated with prism, item 2 with pyramids and item 3 with regular polyhedron; we can observe a better performance in this level.

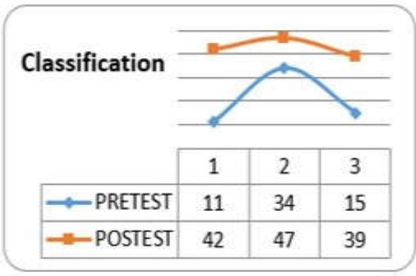


Figure 2a. Classification level

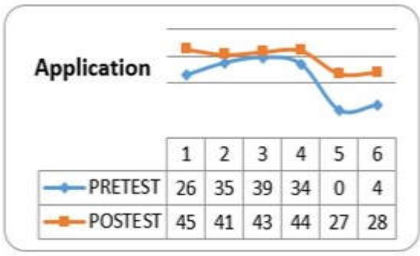


Figure 2b. Application level

Level III. *Application*. According to abilities applied on math taxonomy, the activities of our proposal were designed so our students can compute prism and pyramids volume. Figure 2b shows results obtained in tests applied. Items 1 and 2 are associated with perimeter, items 3 and 4 with areas of some figures, and finally items 5 and 6 with prism and pyramid volume. In these cases, results are better in posttest than pretest.

Level IV. *Analysis level.* Here we obtained the highest results. In this level, it is necessary to understand several concepts and use them in order to solve some problems (geometrics for our case). Figure 3 shows results of pretest and posttest; students have to apply the relation between prism and pyramids in some problems. We observe a big difference between initial and final results.

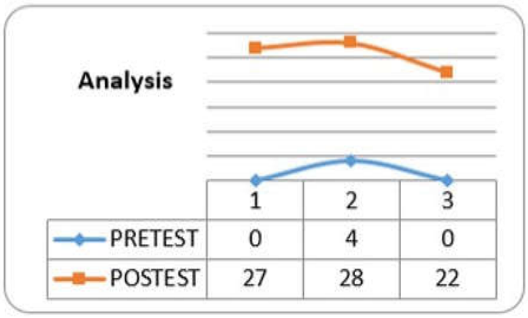


Figure 3. Analysis level

These results point out that using our strategy, students improve their abilities for memorize, identify and analyze to solve problems. Table 4 shows (just for experimental group) pretest results and indicate that most of population had a low-level knowledge about different mathematic concepts.We can observe on posttest that students have better performance in most items of the test.

Table 4. Comparison betweenpre and posttest of experimental group

Level	Pretest	Posttest
Memorization	16.67	32.22
To know	24.66	42.66
Comprehension	20	42
Application	23	38
Analysis	2	25
Average	17.26	35.97

Hake gain and hypothesis test

In order to measure theimpact ofinstructional design, we compute Hake gain (1998) for both groups under study and, in this waywe analyze students learning growthapplying this strategy. Hake gain consider three levels: 1. If G>=0.7 the gain is high it means instruction was successful. 2. If 0.3<G<0.7 the gain is medium, it means instruction was good. 3. If G<=0.3 the gain is low, it means instruction have to change.

$$G_i = \frac{(\%post) - (\%pretest)}{(1 - pretest)}$$

Average gain defined as:

$$Gprom = \frac{1}{N}\sum G_i$$

Table 5, shows average gain results of both control and experimental group. Analyzing experimental group results and comparing them with control group results, we can observethat a better performance exists in B-learning strategy than traditional course ($G_{exp} > G_{control}$). These results indicate that B-learning instruction has been very useful for those students who have participated in this course.

Table 5. Hakegain

Group	Hakeaveragegain
Experimental	0.69
Control	0.45

In addition, we made a hypothesis test for two-population using t-students distribution. The hypothesis was:

H_0: There are no meaningful differences between traditional teaching and B-learning for volume concept teaching ($\mu_1 = \mu_2$).
H_1: B-learning provoke better results in volume concept teaching than traditional instruction ($\mu_1 > \mu_2$).

Using a 5% of confidence level, 48 degree of freedom and t-value $t_c = 1.684$, the estimated standard error between control and experimental group was $t = 3.018$ (see Table 6), which is larger than t-value, so we reject null hypothesis. This indicates there are significant differences between both instruction, traditional and B-learning.

Tabla 6. Hypothesis test values

Group	Posttest	SDV	Standarized error
Experimental	0.816	0.2197	3.018
Control	0.628	0.2189	

As we can observe, Hake gain and hypothesis test($t > t_c$), show that there are better results in volume concept learning on experimental group. For this reason, we can assume that active learning strategies, as B-learning, are more attractive for our students and that their learning increase progressively and tend to obtain a better academic performance.

Conclusion

After establishing the B-learning instruction, we found that students'memorization level increased 16%; identify level increased 18%, comprehension level increased 22%, application level increased 15% and, finally, analysis level increased 23%. We can consider those values satisfactory, because at the beginning of the course those levels were very low (10/24 points, in pretest) and at the end of the course students reach 18/24 points in posttest. So, students' responses in pretest reached 42% but after instruction they reached 75% of correct answers; this is a good result from our methodology because students could achieve almost twice of their academic performance on the test. Hake gain indicates that B-learning has been a very good teaching strategy because its value was 0.69, while control group value was 0.45. In the other hands, hypothesis test values was 3.018 which is larger than t-value (1.648), this indicate there is statistical differences between traditional and B-learning strategy; we remark that B-learning promotes a higher learning about volume concept. Our results indicate that our proposal sequence is on a correct way; working with playful materials and Khan academy website, students could develop (step by step) specific math abilities such as memorization of formulas, identify and classify geometric figures and analyze to solve geometric problems, in general they understand in an easier way area and volume concept of prism, pyramids, etc. Another important fact is that our students worked in teams in order to give support one each other, they comment about each activity and share their knowledge. We have to point out, teacher have to make a feedback at the end of each activity in order to remark the most important process or concept studied in class. Finally, we have to recognize that using active learning methods (like B-learning) in or out classroom tend to improve students' performance on these topics, but in traditional teaching students did not obtain good results.

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