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Guided-Lecture Team Based Learning at Work: Teaching Differential Calculus to Part-time Engineering Students in Latin America.

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Introduction

The United States Department of Education identified the so called “non-traditional student”, as a student with at least one of the following characteristics: attends school part time, works full time or is financially independent, among others [1]. In contrast, a student is called “traditional” when the student enrolls full time immediately after finishing high school, is financially dependent, and does not have a formal job during the academic year [2]. As reported by Hussar and Bailey, the enrollment of non-traditional students is expected to increase twice as fast as that of traditional students during the period 2012 to 2022 [3]. As a result, this kind of student will reach a number where they will form a “new majority” in higher education, at least in certain programs [4]. Therefore, it is becoming very important to focus our attention on studying this particular group of students.

The literature commonly associates non-traditional students with a higher risk of dropout in comparison with traditional students. Johnson [5] identified: age, qualifications, attendance, hours of paid employment, and hours of academic study as the most influential variables causing non-traditional students to dropout of college during the freshmen year. Moreover, many educational institutions encourage non-traditional students to enroll in the university system, but they do not seem to be concerned about their specific needs and circumstances [1]. If we turn our attention to the particular case of non-traditional students enrolled in engineering and science degrees, the dropout rates are also considerably high. According to the Conference Board of the Mathematical Sciences, in the United States, about 300,000 students (including traditional and non-traditional students) enroll in the first calculus course in college during each fall semester, and about a quarter of them fail such a course. As a consequence, many of those students who are not able to pass the calculus course decide to abandon school. In this paper, we report our efforts to mitigate the dropout of non-traditional students enrolled in engineering degrees by designing a calculus course taking into account important characteristics of the non-traditional students.

In Universidad Galileo, Guatemala, most of the non-traditional students who are enrolled in engineering degrees take courses with schedules specially designed for those persons who are not able to pursue a career as a full-time student. Hereafter, we will refer to this subset of non-traditional students simply as ”part-time students”. Our experience with the first calculus course offered to part-time students is very similar to the scenario described in the previous paragraph, namely that many dropout or fail. Hence, in recent years, Universidad Galileo has put a lot of effort in reducing the dropout rate of part-time engineering students, particularly focusing on dropout that occurs during the freshmen year. With this objective in mind and knowing that the students’ experience with the first calculus course is an important variable that may lead a student to abandon his career plan, we decided to implement active learning methodologies [6] to teach that course to part-time students. As [7] states, active learning methodologies may directly influence social integration and indirectly affect the student's dropout decision.

In this paper, we introduce what we call Guided-Lecture Team Based Learning (GL-TBL), which is a learning methodology whose core relies on the well-known Team Based Learning (TBL). We refer the interested reader to [8] for a complete survey of TBL. It is worth to mention that there are many reasons why TBL is considered a particularly effective methodology to teach mathematics. More precisely Paterson and Sneddon [9] state that TBL helps to promote and develop a mathematical disposition and that it provides learning opportunities that are aligned with social-constructivist learning theories. Due to its format, TBL also facilitates the application of mathematical thinking while solving daily life problems. In the opinion of Paterson, Sheryn and Sneddon [10], TBL changes the classroom culture in that students begin to view mathematics as an actively constructed knowledge. As a result, TBL seems to be a suitable approach to address our problem.

This paper discusses the details of the proposed GL-TBL methodology including its main characteristics, how it deviates from the classical TBL, and how those changes make it suitable for teaching courses for non-traditional students. We also present the main results of implementing the aforementioned methodology to teach a differential calculus course to part-time students, and we contrast those outcomes with those obtained by teaching the same course using the traditional lecture-based methodology.

This paper is organized as follows. In section 2 we discuss the proposed methodology. The statistical analysis of the results obtained from the implementation of the GL-TBL are presented in Section 3. Finally, we draw the conclusions and discuss our future research plans in section 4.

Experiment Design

It is well-known that, in the last decades, universities offering engineering degrees have made a dramatic change in the way they are instructing their students. More precisely, these engineering institutions are moving from purely lecture based teaching methodologies towards active learning styles. This is in part due to the initiative of developing higher order cognitive skills, in addition to the technical skills required for the engineering field [11]. As already mentioned, we selected a TBL-based methodology to teach a first calculus course to part-time students enrolled in engineering programs due to several reasons. First, active learning methodologies may enhance the students' knowledge and understanding of the course content [7]. Second, it has been shown that TBL-based methodologies promote some of the skills desired for engineering students, including teamwork, communication, and creative thinking [12]. Third, since we are interested in part-time students, whose time is limited, it has been shown that TBL-based methodologies make students feel that they do not need as much time for course preparation since they do most of the required work in class. Finally, all the activities involved in active learning methodologies help students create a support network that translates into a stronger sense of membership in their university, which in turn, may influence indirectly any departure decision that the student may make [7].

According to [13], Team-based learning (TBL), includes almost all the evidence-based best teaching practices. The typical TBL Cycle begins with the Readiness Assurance Process and ends with the Multiple Application Activities. The Readiness Assurance Process (RAP) consists of a reading assignment, the Individual Readiness Assurance Test and the Team Readiness Assurance Test. While in the Multiple Application Activities part, the students solve complex problems, based in the so-called 4s framework [13]. Based on these ideas, in this paper, we introduce a modified version of TBL, which we call Guided-Lecture TBL, whose details are given in the next subsection.

To test the proposed methodology, we chose one section of a differential calculus course (called for brevity Differential Calculus) offered for part-time students during the first semester of 2017. This section was comprised of 15 students from different specializations within engineering and it is offered in a suitable schedule (during evenings) for part-time students.

GL - TBL

In order to implement the GL-TBL, we created groups of five students which we formed taking into account the following characteristics:

a. Academic profile (measured using a diagnostic test [14])
b. Gender
c. Age
d. Years of enrollment in the university (some students may have been held back in the course)

In GL-TBL, group formation is crucial. This methodology requires that the students work interactively, with a common goal: to learn while helping other students in their learning process. As a result, students are encouraged to learn how to cooperate effectively [8] while they achieve their learning outcomes with respect to calculus.

Our Differential Calculus course consists of 13 sessions. Each session was taught in two separate days with the following structure:

Day 1 (100 minutes):

a. Introductory Lecture
b. Preparation Problems

Day 2 (100 minutes):

a. Individual Readiness Assurance Test
b. Team Readiness Assurance Test
c. Teams personal Feedback
d. Clarification Lecture
e. Appeals
f. Multiple Application Activities

The details of each session part are discussed next.

Introductory Lecture and Preparation Problems: One of the major differences we introduce in GL-TBL, compared to the traditional TBL, is that, the reading assignments are replaced by a short lecture; this was motivated by the lack of time that part-time students have to study outside the classroom. In this part, the instructor discusses with the class the definitions and theorems that are intended to be understood. In this lecture, student participation is of paramount importance; students are the center of the learning process.

Individual Readiness Assurance Test (iRAT): In a 20-minute period, we evaluate the students' learning outcomes using a multiple-choice test. The questions are based on the topics covered during the first part of the session. Each question is directly related to one of the specific learning objectives described in the course syllabus. It is important to emphasize that the answer selected by the students must be justified. An example of the questions used in the iRAT is presented in Figure 1.

3. Encuentre la derivada de la función $f(t) = (t^2 + 2t - 1)(t^3 - 5t^2 + 4)$.

a) $f'(t) = t^5 - 3t^4 - 11t^3 + 9t^2 + 8t - 4$. *c)* $f'(t) = 5t^4 - 12t^3 - 33t^2 + 18t + 8$.

b) $f'(t) = (2t + 2)(3t^2 - 10t)$. *d)* Ninguna de las anteriores.

3. Find the derivative of the function $f(t) = (t^2 + 2t - 1)(t^3 - 5t^2 + 4)$.

a) $f'(t) = t^5 - 3t^4 - 11t^3 + 9t^2 + 8t - 4$. *c)* $f'(t) = 5t^4 - 12t^3 - 33t^2 + 18t + 8$.

b) $f'(t) = (2t + 2)(3t^2 - 10t)$. *d)* None of the above.

Figure 1: Example of questions in iRAT.

Team Readiness Assurance Test (tRAT): Though the tRAT is comprised of the same questions presented in the iRAT, students have to solve it in teams using the Immediate Feedback Assessment Technique (IF-AT), this is, they have to answer the tRAT until all their answers are correct. The teams of students can request the presence of the instructor at any time to score a particular question in tRAT. If the answer is not correct or not correctly justified, students continue to try until they find the correct one. Each question in the tRAT has 4 choices, and the team loses 25% of the question score for every wrong answer.

Teams Personal Feedback: When each team finishes the tRAT, the instructor gives feedback in order to clarify the most relevant errors committed by each team. Needless to say, this part of the GL-TBL session complements perfectly the discussions maintained during the tRAT.

Clarification Lecture: This is the end of the RAP process, here the instructor conducts a brief discussion. Such discussion summarizes the topics of the session. It can be omitted if the instructor thinks it is not needed.

Appeals: If a student or a team believes that one of the questions is not correct or have some inquiries regarding the structure of the question, they can present an appeal. The instructor is in charge of presenting a clarification of the appeal during the next session.

Multiple Application Activities: Besides tRAT, this part is considered the most important part of the session. Here, teams apply the gained knowledge to solve carefully designed application activities. These activities are designed following the well-known 4-S Framework, i.e. Significant Problem, Same Problem, Specific Choice and Simultaneous Report. Michaelsen [13] describes the 4-S approach as follows:

a. Address a significant problem that demonstrates a use of a particular concept.

b. Make a specific choice among clear alternatives.

c. Work on the same problem as other teams, so each team will care about the conclusions and rationales of the other teams.

d. Simultaneously report their decisions, so differences among teams can be explored for the optimal instructional effect.

In this part, it is common to see challenges between groups, consequently more group knowledge is generated. An example of the application activities use in our course (Differential Calculus) is presented in the Figure 3.

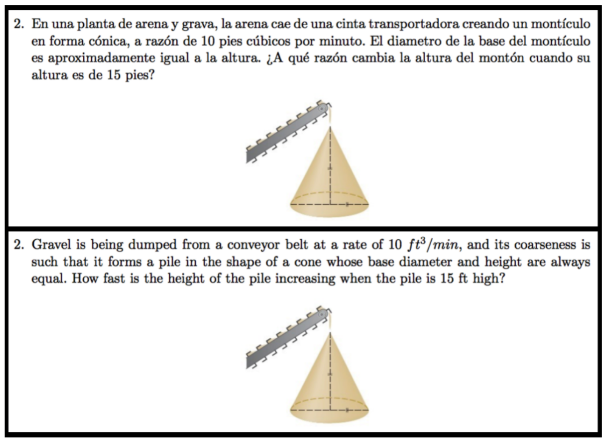

Figure 2: Multiple Application Activities (Problem taken from the course textbook [15]).

Results

In order to measure the performance of the proposed methodology (GL-TBL) to teach a differential calculus course to non-traditional students, we took into account three important variables: (i) average attendance during the course, (ii) average results in two tests called Midterm and Final, and (iii) percentage of students who pass the course. The GL-TBL group (experimental Group) obtained results were compared with a group of 23 part-time students enrolled in the Differential Calculus course during the first semester of 2016 (control group 2016) and another group of 16 part-time students enrolled in the same course during the first semester of 2017 (control group 2017). It is important to emphasize that, the students in the control groups were also part-time students and the course was taught using the traditional lecture-based methodology.

Table 1 shows the average attendance maintained by the experimental and the control groups. The average attendance of the experimental Group (87%) is particularly high compared with the average attendance of the control groups, 57% and 63%, respectively.
Table 2, summarizes the descriptive statistics of the grades obtained by the students of the experimental and control groups in the Midterm and Final exam, respectively.

	Group	n (number of students)	Average Attendance (% of enrolled students)
Experimental Group	GL-TBL 2017	15	87
Control Groups	Lecture-based 2016	23	57
	Lecture-based 2017	16	63

Table 1: Average attendance in each session of GL-TBL and control groups.

		n	Mean	Std. Deviation	Std. Error Mean
Midterm	GL-TBL Group 2017	15	63.73	18.04	4.66
	Lecture Based Group 2017	16	39.75	16.78	4.19
	Lecture Based Group 2016	23	46.87	24.02	5.01
Final	GL-TBL Group 2017	15	58.40	22.41	5.79
	Lecture Based Group 2017	16	71.38	23.22	5.81
	Lecture Based Group 2016	23	41.87	30.89	6.44

Table 2: Descriptive statistics of the grades in the Midterm and the Final exams of the experimental and control groups.

After performing a t-test with a level of significance of 0.05 between the experimental and control group, we found that the difference between the means in the midterm exam are statistically significant, however in the final exam that is not the case. The results are presented in Table 3 for the 2016 control group and in Table 4 for the 2017 control group, respectively.

GL-TBL Group 2017 vs Lecture-based Group 2016		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Midterm	Equal variances assumed	2.3213	36	0.0250	16.8638	7.2647
	Equal variances not assumed	2.4657	35.17	0.0187	16.8638	6.8395
Final	Equal variances assumed	1.7853	36	0.0826	16.5304	9.2591
	Equal variances not assumed	1.9092	35.50	0.0643	16.5304	8.6585

Table 3: Comparison of the average grades in the midterm and the final exams of the GL-TBL Group versus Lecture Based Group 2016.

GL-TBL Group 2017 vs Lecture-based Group 2017		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Midterm	Equal variances assumed	3.8356	29	0.0006	23.9833	6.2528
	Equal variances not assumed	3.8264	28.45	0.0007	23.9833	6.2679
Final	Equal variances assumed	-1.5810	29	0.1247	-12.9750	8.2068
	Equal variances not assumed	-1.5829	28.97	0.1243	-12.9750	8.1971

Table 4: Comparison of the average grades in the midterm and the final exams of the GL-TBL Group versus Lecture Based Group 2017.

Table 5 summarizes the pass rate obtained by the different groups. Notice that the experimental group pass rate increased with respect to that obtained for the 2016 and 2017 control groups. Even more, the pass rate of the experimental group almost doubles that of the 2016 control group.

	Group	Pass Rate (%)
Experimental Group	GL-TBL 2017	67
Control Groups	Lecture-based 2016	36
	Lecture-based 2017	52

Table 5: Pass rate of the experimental and control groups.

Discussion

Given that part-time students combine their studies with other responsibilities, they make a great effort to attend a course session. Thus, one of the most relevant results obtained in the implementation of GL-TBL for teaching a differential calculus course to non-traditional students is the increment in the average attendance (see Table 1). As stated in the literature [7], we believe that this occurred because the students who experience active learning in their coursework may perceive an increment in their gained knowledge and understanding, and such students, may be more likely to view their course experience as rewarding.

To test the performance of the students at the middle and the end of the semester, we studied the midterm and final exams grades. The difference between the midterm grades of the experimental group and those of the control groups is statistically significant as shown in Table 3 and 4. Therefore, the grades obtained in the midterm by the students taught using the proposed methodology (GL-TBL) are better than those obtained by the 2016 and 2017 lectured-based groups (see Table 2). To our surprise, regarding the final exam, the grades are not statistically different for the experimental group and control groups (see Tables 3 and 4). Notice that, in the case of the final exam, the 2017 lectured-based group performed better than the other groups. It is important to mention that, the final exam is dedicated to word problems regarding the applications of the concept of derivative, which is a topic that in our experience presents difficulties to the students and it seems to be independent of the methodology used to teach the course. A related point to consider is that the midterm and final exams were challenging for the GL-TBL students, since these exams did not follow the multiple choice format used in all the RAP process tests.

According to Table 5, the final pass rate in the Differential Calculus course for the students in the experimental group was higher than that of the control groups. This result was expected since the experimental group had a great attendance rate and they had an acceptable performance (on average) in the midterm and final exams.

Based on the observations outlined above, we can conclude that the students taught using the proposed scheme (GL-TBL), performed better than those following the traditional methodology in terms of attendance, midterm grades and pass rate. Moreover, due to the structure of proposed methodology (GL-TBL), the transition from traditional to an active learning methodology is smooth, because the latter is not commonly implemented in high school.

As both the experimental and control group are comprised of non-traditional students, it seems that the GL-TBL is a suitable choice for teaching calculus to this kind of students.

In spite of the good results obtained in the implementation of GL-TBL to teach a calculus course to non-traditional students, it is worth mentioning that our experiment has some limitations. First, the sample size used in this study is small, therefore the t-test may not be accurate and the normality assumption may be violated. We chose the smallest section of the Differential Calculus course offered for non-traditional students due to the uncertainty of the outcomes that a change of methodology can cause. Second, in our analysis, we compared the experimental group with the students in 2016 and 2017. Even though, all of the students taken into account in our study are non-traditional, we cannot state that the groups in question are homogeneous; for example, the students may have a different academic background. Third, we did not measure the motivation and satisfaction levels with the course that the experimental group had. These factors are important in order to understand why the experimental group differ significantly (in terms of attendance rate and grades obtained) from the other groups. Hence, it would be interested, to find if the GL-TBL is correlated with the motivation and levels of satisfaction, which translates into the academic success showed by the experimental group. In our future work, we are going to address all the issues outlined above and we will report our findings.

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