Measuring the radius of the earth. Integration between didactic transposition and information and communication technologies

F Durán-Flórez¹, L C Caicedo¹, D A Prada²,³, A Acevedo³ and J Gómez⁵
¹ Grupo de investigación en Tecnología del Plasma, Universidad Pontificia Bolivariana, Bucaramanga, Colombia
² Grupo de Investigación en Materiales Universidad Pontificia Bolivariana, Bucaramanga, Colombia
³ Grupo de Investigación en Administración, Universidad Pontificia Bolivariana, Bucaramanga, Colombia
⁴ Grupo de Investigación Saber Educación y Docencia, Universidad Pontificia Bolivariana, Bucaramanga, Colombia
⁵ Centro de Gestión de Mercados, Logística y Tecnología de la Información, Servicio Nacional de Aprendizaje (SENA), Bogotá, Colombia

E-mail: fernando.duran@upb.edu.co, duwamg.prada@upb.edu.co

Abstract. The activities that foster a teaching mediation based on continuous reflection, involving didactic transposition and information and communication technologies, have generated a space for construction on the part of the student, which transcends outside the classroom and through the use of said technological tools is possible a meaningful and lasting learning. Said didactic transpositions, technological tools and integrating activities not only generate knowledge of value but also may involve the development of another type of competence and intelligences that are not the objective of the course, but that help in the integral formation of the student.

1. Introduction
Teacher mediation in the basic university cycle subjects is continuously strengthened with the different strategies proposed by teachers under the reflection of their pedagogical work. These strategies become significant when the environment is involved in the planned activities, which are useful to achieve the learning objective in the student. The information and communication technologies (ICT) have become a tool of great importance, not only for the support of presence or the development of technological devices, but because it allows the student to demonstrate what was analyzed in class through simulation, as well as everything what the teacher wants the student to understand so that he is competent both in the theoretical part, as the procedural part and in the argumentation of the observed. This type of activities in which the student is expected to learn a knowledge mediated by a didactic site and not through the use of analogies generates significant learning in the student, this process is known as didactic transposition [1]. The classes that integrate the didactic transposition with the use of technological tools frame a new idea of generating in the student a learning or knowledge transposed under a didactic site mediated by the ICT. An integrated class gives meaning and practical significance
to computer science, as it seeks the integration of knowledge in the education of the learner [2], without the use of it excludes the valuable contribution that implies to exchange in the classroom, not only knowledge but the same experiences and ideas [3].

The activities of each subject show the relevance of the didactic transposition based on the specific topics declared in the curriculum. Performing activities in which other subjects are articulated, which in some way are related to the thematic focus that is addressed in class, is a commitment to learning that is not only significant but lasting over time, because the mainstreaming based on the didactic transposition mediated with the ICT, demands both the student and the teacher a more detailed interaction with the learning process. The teaching and learning processes have been evolving as an activity whose objective should be formed in an integral way to people with aspirations to play a professional role within the society based on meaningful learning [4]. The activity developed is supported by the directed research seen as a bet to rethink teaching-learning processes [5], because to achieve conceptual, procedural and attitudinal changes in students, it is necessary to place them in a context of action that emulates the scientific activity always guided by the teacher [6]. The directed research defines as a goal to promote in the students changes in their systems or conceptual, procedural and attitudinal structures, where the curricular axis of the approach is the solution of problems generated in the knowledge of the discipline [7]. From this perspective, the incessant search for theoretical and methodological models that make it possible to understand implicit processes in quality education that call young people to participate actively in society and to engage professionally with it is relevant [8].

For the application of this activity with the students, it was determined to use the theory based on problematic situations which arise in those cases in which the lack of correspondence between the knowledge systems that the students already have and the requirements that it poses to the time to solve new tasks exposed by the teacher [9].

An activity that relates thematic axes of the subject of Mechanics or Physics I, with subjects such as Geometry, Trigonometry and Differential Calculus was applied to students of the Universidad Pontificia Bolivariana in Bucaramanga in 2017. The activity was based on radio measurement of the earth through a methodology used by Eratosthenes, 275 B. C., who taking measurements of the sun’s elevation in two different places, provided strong evidence that confirmed the spherical shape of our planet Earth and calculated its diameter with 99% accuracy [10]. Eratosthenes supposed that the rays of the Sun were parallel and that when this was on Alexandria, the rays formed an angle of 7.5° with respect to the horizontal in Siena city [11,12]. Being able to demonstrate the discovery of Eratosthenes through the use of technological tools, generates in the students diverse questions that will allow him to acquire a commitment with his own learning.

The basic study necessary to develop the activity proposed for the class, requires only one trigonometry course, Trigonometry is one of the courses of the area of mathematics of wider applicability in physics, engineering, chemistry, aeronautics, among others [13], the trigonometric functions because of their journal behavior has been used for modeling seismic waves, sounds, in medicine they have used trigonometry for several studies that involve the implant inclined to patients [14].

A basic principle of teaching mathematical methods is to start using examples, so students can easily follow the technique [15]. With the generation of these spaces, teaching mediation can become the canal’s construction of new theories, the use of known laws helps to discover others using basic methods such as algebraic substitution [16].

2. Methodology

In the subject Mechanics of the Physics Area, attached to the Department of Basic Sciences of the Pontifical Bolivarian University, the physics and mathematics teachers proposed an activity framed in the pedagogical strategy of problem-based learning, in which the students must measure the radius of the Earth. The students form working groups, of maximum 4 people, in order to improve the argumentation according to the calculation of the radius of the Earth through the use of a technological tool, among which are Google Earth, global positioning systems (GPS), cellular, among others.
Based on the idea of Eratosthenes, students choose two cities of their choice and calculate the distance between them with the help of any ICT tool, in this way it is possible to minimize the percentage of measurement error of the radius of the Earth. Basically, the process used by the groups was choice of the object to project the shadow, choice of cities to carry out the simultaneous experiment, measurement of shadows and angles present in the experiment and finally, measuring the distance between cities.

Regarding the choice of the object used by the members of each group, eight of the nine groups chose an object to project a wooden stick, whose measurements were between 1 m and 1.8 m, and a single group chose to make a scale building which had a height of 50 cm. Similarly, students in each group chose cities based on the fact that the experiment must be carried out simultaneously to avoid introducing a new error caused by the time factor, which used cities where students lived their relatives or friends. Once the cities were established, an hour was chosen for each group to carry out the experiment, in which known people interact with the members of each group at the same time. To guarantee the simultaneity of the experiment, cellular communication was established between people located in different cities, we proceeded to measure the height of the object located to the sun and the shadow projected by it, through these data we can know the angle of incidence of the sun’s rays. To measure the distance between the cities, some groups used the GPS of their cell phones to find the position in coordinates of the cities, with which it was possible to establish the distance between the cities with the help of Google Earth. Other groups made this measurement directly in Google Earth, for this positioned the mouse cursor in each of the cities with which the Google Earth platform shows the distance between them. Figure 1 is showing some of these distances,

![Image](a) Image of the department of Santander, Bucaramanga-San Gil. (b) Image of the department of Santander, Bucaramanga, Paipa. Taken from Google Earth.
3. Conclusion

The students who chose the cities of Bucaramanga, San Gil, evidenced a distance between the cities of 62.11km with an angle of 0°35′45″, perimeter of 37121.79km to find a radius of 5908.11km for a percentage error of 7.38%. The students who chose the cities of Bucaramanga to Paipa, showed a distance between the cities of 147.69km with an angle of 1°22′45″, perimeter of 38549.03km to find a radius of 6135.27km for a percentage error of 3.8%. With the integrating activity it was possible to show that the students’ learning was based on the didactic transposition that allowed the measurement of the Earth’s radius, however, as more people were involved in the mediation, through ICTs, other types of competencies were observed. Students developed, in which it can be asserted that meaningful learning involves more than the tools and techniques of learning, it also involves social competence.

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