PODIUM
Journal of Science and Technology in Physical Culture

Volume 19
Issue 1
2024

University of Pinar del Río "Hermanos Saíz Montes de Oca"

ISSN: 1996–2452 RNPS: 2148
PODIUM Journal, January-April 2024; 19(1): e1549

Translated from the original in spanish **Original article**

Formation of metrological culture from the potential of sports and Physical Education

Formación de la cultura metrológica desde las potencialidades del deporte y la Educación Física

Formação da cultura metrológica a partir das potencialidades do esporte e da Educação Física

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Received: *07/22/2023.*
Approved: *12/13/2023.*

ABSTRACT

This article deals with the formation of metrological culture in Pre-University Education students, from the potential of sports and Physical Education classes, as one of the elements that must be prioritized in the teaching-learning process of Physics and as part of preparing students for life. The objective of this work was to design a system of integrative teaching tasks that allows taking advantage of the potential of sport, in general, and Physical Education classes, in particular, for the formation of metrological culture in tenth grade students. To develop the research, the following methods were used: analytical-synthetic, inductive-deductive, modeling, observation, documentary analysis, survey, interview and descriptive statistics that allowed the processing of information regarding the topic under investigation; as well as determine the causes of the insufficiencies that arise in the teaching-learning process of Physics, for the formation of the metrological culture of tenth grade students. The proposed system of integrative teaching tasks was characterized by harmonizing basic conceptual cores for the treatment of metrological content such as the estimation and measurement of magnitudes and the conversion of measurement units; in addition to taking advantage of potential of the sports and Physical Education classes.

Keywords: metrological culture, formation, potential, integrative teaching tasks.

RESUMEN

Este artículo trata la formación de la cultura metrológica, en los estudiantes de la Educación Preuniversitaria, desde las potencialidades del deporte y las clases de Educación Física, como uno de los elementos que debe ser priorizado en el proceso de enseñanza-aprendizaje de la Física y como parte de la preparación de los estudiantes para la vida. El objetivo de este trabajo consistió en diseñar un sistema de tareas docentes integradoras que permita aprovechar las potencialidades del deporte, en general, y las clases de Educación Física, en particular para la formación de la cultura metrológica en los estudiantes de décimo grado. Para el desarrollo de la investigación se utilizaron los métodos: analítico-sintético, inductivo-deductivo, modelación, observación, análisis documental, encuesta, entrevista y estadística descriptiva que permitieron procesar la información referente al tema objeto de

investigación; así como determinar las causas de las insuficiencias que se presentan en el proceso de enseñanza-aprendizaje de la Física, para la formación de la cultura metrológica de los estudiantes de décimo grado. El sistema de tareas docentes integradoras propuesto se caracterizó por armonizar núcleos conceptuales básicos para el tratamiento a los contenidos metrológicos como son la estimación y medición de magnitudes y la conversión de unidades de medida; además de aprovechar las potencialidades del deporte y las clases de Educación Física.

Palabras clave: cultura metrológica, formación, potencialidades, tareas docentes integradoras.

RESUMO

Este artigo trata da formação da cultura metrológica em alunos da Educação Pré-Universitária, a partir das potencialidades das aulas de esportes e de Educação Física, como um dos elementos que devem ser priorizados no processo de ensino-aprendizagem de Física e como parte da preparação dos alunos para a vida. O objetivo deste trabalho foi conceber um sistema de tarefas didáticas integradoras que permita aproveitar as potencialidades do esporte, em geral, e das aulas de Educação Física, em particular, para a formação da cultura metrológica em alunos do décimo ano. Para desenvolver a pesquisa foram utilizados os seguintes métodos: analítico-sintético, indutivo-dedutivo, modelagem, observação, análise documental, levantamento, entrevista e estatística descritiva que permitiram o tratamento das informações referentes ao tema sob investigação; bem como determinar as causas das insuficiências que surgem no processo de ensino-aprendizagem de Física, para a formação da cultura metrológica dos alunos do décimo ano. O sistema de tarefas de ensino integrativo proposto caracterizou-se por harmonizar núcleos conceituais básicos para o tratamento de conteúdos metrológicos como a estimativa e medição de grandezas e a conversão de unidades de medida; além de aproveitar o potencial das aulas de esportes e Educação Física.

Palavras-chave: cultura metrológica, formação, potencialidades, tarefas docentes integradoras.

INTRODUCTION

Education plays a fundamental role in preparing students to live in harmony with the natural and social environment, since it is responsible for preparing man for life.

It is in this context where the contents related to metrology acquire special relevance, based on its direct link with the lives of students "(...) it is almost impossible to describe an activity in which man or nature is linked without referring to metrology: (it) is present in practically all activities of life" (Reyes, *et al.*, 2009, p. 21).

In line, Arias (2021) points out that "(…) metrology applied to daily life allows us to relate to our environment, in addition to knowing and controlling it. To do this, we continually carry out measurements that help us in our daily lives" (p. 1). Correspondingly, it can be stated that measurements play a fundamental role in people's lives and "(...) are found in any of the daily or work activities that we can imagine, from the estimation of a distance with the naked eye, to a process control in basic research" (Vector zero metrology, 2022, p. 1).

Therefore, it is an inseparable part of the life of human beings; every day we carry out different measurements "(…) we measure from the time we wake up in the morning, the time it takes us to get to work, to the gasoline that the vehicles require" (Secretary of Economy, 2019, p. 1). However, "(…) it is surprising how little interest metrology arouses" (Extremera, 2022).

Thus, metrology is directly related to measurements and their applications in human activities. One of the areas in which measurements have a varied application is in sports, so much so that there is no sporting activity in which metrology is not present in one way or another. Measurements in sport make it possible to guarantee that competitions are carried out as fairly as possible, that the results achieved by athletes are superior and that the conditions for the development of sports competitions are adequate, among other issues.

This is why the role of metrology in the study presented "(…) focuses on ensuring that the measurements of the multiple elements that make up the sport are in complete harmony with the regulations set forth" (García, 2019, p. 1). In summary, measurements are made during the development of any sporting activity, whether in training or competition as such.

By virtue of this, knowledge about the application of metrology "(…) is fundamental in the practice of all professions with a scientific substrate" (López, *et al.,* 2021, p. 143). Sports is one of those professions, hence precisely the need to use metrology.

From the analysis carried out, it is clear that for the development of any sporting competition it is necessary to measure different physical quantities (length, mass, time, speed, among others). Example of them are:

- The measurement of the mass of athletes and sports equipment, in sports such as boxing, wrestling, karate, taekwondo and weights, among others.
- The measurement of length in various athletics specialties, such as jumping and throwing, among others.
- The measurement of time in sports such as athletics, swimming, basketball, soccer, chess and cycling, among others.
- The measurement of speed in sports such as baseball, athletics and cycling, among others.

However, despite the presence and importance of metrology in sports, it has not been sufficiently used to contribute to the formation of metrological culture in students at different educational levels, a situation that was appreciated in Pre-University Education from the potential of Physics and Physical Education classes.

In this same direction, it is stated that "(...) metrology is probably the oldest science in the world and even today, few people know the relevance of this science and its impact on the economy and society" (Metrology Committee from the Engineering Institute of Spain, 2019, p. 7).

What has been expressed constitutes a deficiency in the educational sciences, so it is necessary to look for alternatives that allow this situation to be reversed. One of the alternatives is to design a system of integrative teaching tasks that allow taking advantage of the potential of sport, in general, and Physical Education classes, in particular, for the formation of metrological culture in tenth grade students, which is precisely the objective of this article.

MATERIALS AND METHODS

The general methodological basis is the materialist dialectical method that allowed to study and conceive the process of formation of metrological culture in tenth grade students as a complex and contradictory sociocultural phenomenon, in constant movement and evolution, in its relationship with sports and Physical Education classes, from an explanatory approach, for which the following research methods were used:

Analytical-synthetic: it was used to decompose the theoretical conception regarding the process of formation of metrological culture in tenth grade students, from the use of the potential of sports and Physical Education classes; as well as the multiple relationships that are established for their in-depth study and to identify characteristics, traits, regularities and essences. It was also used to evaluate the empirical findings obtained.

Inductive-deductive: it made possible the analysis of the process of formation of metrological culture in tenth grade students, from the use of the potential of sports and Physical Education classes, from a harmonious articulation between the general, the particular and the singular, as ways of theoretical reasoning.

Modeling: it was used to make abstractions that made it possible to determine the components, structure and relationships of the system of integrative teaching tasks for the formation of metrological culture in tenth grade students, from the use of the potential of sports and Physical Education classes.

Observation: to verify to what extent Physics teachers take advantage of the potential of sports and Physical Education classes, for the formation of metrological culture in tenth grade students. This method allowed to evaluate the indicators of the methodological dimension of the variable studied: formation of metrological culture in tenth grade students. Twelf Physics classes were observed, two for each teacher of the investigated population. All indicators of the methodological dimension were evaluated and the following indicators, scale and decision rule were used:

Indicators

1.1. It is appreciated that the content under study promotes metrological content.
1.2. It is appreciated that the formation of metrological culture in students is contemplated in the objective of the class.
1.3. The use of teaching tasks for the treatment of metrological content is appreciated.
1.4. The use of teaching tasks that allow taking advantage of the potential of sports and Physical Education classes is appreciated, for the formation of metrological culture in students.
1.5. It is appreciated that the learning of metrological content is controlled.

Scale: __ appreciated (SA) __ not appreciated (NSA)

The indicators were measured, for all cases, from an ordinal scale that expresses the level at which they manifest themselves. This is: very high (MA); high (A); medium (M), low (B) and very low (MB).

For the application of the scale and the interpretation of the observation results, the following decision rule was established: very high (MA), if the indicator appears in 90% or more of the observed classes; high (A), if the indicator appears between 60 and 89%; medium (M), if the indicator appears between 31 and 59%; low (B), if the indicator appears between 11 and 30 % and very low (MB), if the indicator appears between 0 and 10 %.

Document review to verify the treatment given to the formation of metrological culture in tenth grade students, from the use of the potential of sports and Physical Education classes, in the lesson plans of Physics teachers. The 12 plans corresponding to the observed classes were analyzed, based on the indicators and scale that appear below:

Indicators

1.1. Evidence that the content under study encourages the treatment of metrological content
1.2. Evidence that the objective of the class includes the formation of metrological culture in students.
1.3. Evidence of the use of teaching tasks, for the treatment of metrological content.
1.4. Evidence of the use of teaching tasks that allow taking advantage of the potential of sports and Physical Education classes, for the formation of metrological culture in students.
1.5. Evidence that the learning of metrological content is controlled.

Scale**:** __ evident (SE) __ not evident (NSE)

For the interpretation of the results, the same decision rule used in the observation was used.

Survey: it was applied to the students to know the state of opinion they have about the knowledge they have of the basic elements of metrology and about the use of teaching tasks that allow them to take advantage of the potential of sports and Physical Education classes, for training. of metrological culture. The survey was applied to the 44 tenth grade students of the investigated sample and the following indicators were considered:

Indicators

2.1. Importance of measuring magnitudes.
2.2. Level of knowledge about metrology.
23. Level of knowledge about measuring magnitudes.
2.4. Level of knowledge about the conversion of units of measurement.
2.5. Level of knowledge about the estimation of magnitudes.
2.6. Guidance of teaching tasks related to the measurement of magnitudes.
2.7. Guidance on teaching tasks related to the measurement of magnitudes to be solved in

Physical Education classes.

2.8. Preference for solving teaching tasks in which the measurement of magnitudes is linked to sports and Physical Education classes.

To evaluate the survey indicators, the categories of good, fair and poor were used. Good, when the indicator manifests itself between 70 and 100 % of the possibilities; fair, when it occurs between 40 and 69% and poor when it occurs between 0 and 39 % of the possibilities.

Descriptive statistics, specifically the percentage calculation, allowed to interpret the empirical results obtained in the research. The population investigated is six Physics teachers from pre-university education and 144 tenth grade students from the Sandino municipality. Of them, six teachers and 44 students were intentionally selected, representing 100 and 30.5% respectively.

RESULTS AND DISCUSSION

As a result of the application of research methods, as well as the analysis of scientific literature, deficiencies were detected in the use of Physical Education classes for the formation of metrological culture in tenth grade students; likewise, insufficiencies were detected in the use of integrative teaching tasks that promote the achievement of this purpose. The results obtained with the application of empirical methods are described below:

Observation of Physics classes

The following table includes the evaluation of the observed indicators and uses the assumed decision rule (Table 1).

Table 1. *-Results of observation in Physics classes*

Indicators	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**
Results	10	1	4	0	two
%	83.3	8.3	25.0	0.0	16.6
Category	**A**	**MB**	**B**	**MB**	**B**

The indicators reflected in the table show a low level of incidence, which shows the insufficiencies present in the indicators of the variable studied and therefore in the formation of metrological culture in tenth grade students from the use of the potential of sport and Physical Education classes, whose level is generally evaluated as low.

The most affected indicators are those referring to considering in the class objective the formation of metrological culture in students (1.2) and the use of teaching tasks that allow this potential to be taken advantage of for the formation of metrological culture (1.4). Thus, the deficient methodological preparation of Physics teachers to use teaching tasks in the teaching-learning process that allow taking advantage of these potentials for the formation of metrological culture is evident.

Documentary review of lesson plans

The following table includes the evaluation of the indicators of the variable studied, contemplated in the documentary review of the lesson plans, the assumed decision rule was used (Table 2).

Table 2. *- Results of the documentary review of the lesson plans*

Indicator	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**
Results	1	0	4	0	**4**
%	91.6	0.0	25.0	0.0	**25.0**
Category	**M.A.**	**M.B.**	**b**	**M.B.**	**b**

The analysis of the results obtained, in the application of this method, reveals that the measured indicators are generally not contemplated in the planning of the Physics class, which shows didactic insufficiencies in the teachers and manifests limitations in the formation of the metrological culture in students. Thus, the level of the methodological dimension of the investigated variable is evaluated as low.

The greatest affectations are found in the indicators referred to the fact of contemplating in the objective of the class the formation of metrological culture in students (1.2) and the use of teaching tasks (1.4), this coincides with those observed in the classes of Physics, so the results of the application of these methods revealed the insufficiencies present in the investigated population.

The analysis carried out corroborates the existence of the problem under investigation and consequently, the state of need present in the population investigated, this justifies the proposal of integrative teaching tasks that is carried out, for the formation of metrological culture in tenth grade students.

The results obtained with these two methods were complemented with the application of the survey that allowed to know the state of opinion that the students have. The results obtained with its application are described below.

Student survey

The table shows the evaluation of the indicators evaluated in the survey; the assumed criteria were used (Table 3).

Table 3.- *Evaluation of the indicators evaluated in the survey*

Indicators	Category					
	Good		Fair		Poor	
	c	%	c	%	c	%
2.1	38	86.3	4	9.0	2	4.5
2.2	15	34.0	20	45.4	9	20.4
23	14	31.8	21	47.7	9	20.4
2.4	12	27.2	22	50,0	10	22,7
2.5	9	20,4	20	45,4	15	34,0
2.6	15	34,0	22	50,0	7	15,9
2.7	0	0,0	0	0,0	44	100
2.8	39	88,6	2	4,5	3	6,8

The results contained in the previous table allow to appreciate that there are affectations on all the evaluated indicators, which is a sign of the insufficient knowledge that students have on essential issues related to metrology and, consequently, to metrological culture. The most affected indicators are those referring to the level of knowledge about the estimation of magnitudes (2.5) and the orientation of teaching tasks related to the measurement of magnitudes to be solved in Physical Education classes (2.7); although all are affected.

It was also possible to verify that there are favorable conditions to eradicate the deficiencies present in the students investigated, since the majority of them consider the measurement of magnitudes important in their lives and report that they would like to solve teaching tasks in which it is linked the measurement of magnitudes with sports and Physical Education classes. The analysis of the results obtained in the diagnostic study made it possible to identify the following regularities in terms of strengths and weaknesses.

Strengths

- Existence of the material and organizational conditions for the development of the research.

- Existence of potential in sports and in Physical Education classes to contribute to the formation of metrological culture in tenth grade students.
- The interest of students in participating in research.

Weaknesses

- Low level of training of metrological culture in tenth grade students.
- Insufficiencies in the knowledge that students have of fundamental issues of metrology, such as the operations to carry out the conversion of units of measurement, the estimation and measurement of magnitudes.
- Insufficient use of the potential of sports and Physical Education classes to contribute to the formation of metrological culture in tenth grade students.
- Lack of a system of integrative teaching tasks that allows taking advantage of the potential of sports and Physical Education classes, for the formation of metrological culture in tenth grade students.

Based on the deficiencies corroborated in the results obtained, it is essential to develop a system of integrative teaching tasks that allows taking advantage of the potential of sports and Physical Education classes, to contribute to the formation of metrological culture in students of tenth grade.

Integrative teaching task system

With respect to the definition of teaching tasks, Zilberstein and Cruz (2015) state that they are "(…) those activities that are oriented so that the student can carry them out in class or outside of class, they involve the search and acquisition of knowledge, the development of skills and the comprehensive formation of their personality" (p. 54).

Correspondingly, teaching tasks must encourage students to learn about metrology to the same extent that they appropriate knowledge, skills and values from other branches of human knowledge; in the context of this research, it is about sport.

That is why teaching tasks must allow the integration of content related to the conversion of units of measurement, estimation and measurement of magnitudes, which are basic for the formation of metrological culture, as part of the preparation of the students for life.

This type of integrative teaching tasks "(...) lead to the emergence of a problem, for the solution of which the student requires the application of knowledge from two or more subjects of the curriculum." (Torres, *et al.*, 2021, p. 9), Ponce (2023). In this case Physics, Mathematics, History and Physical Education, among others.

Thus, the use of integrative teaching tasks in the teaching-learning process "(…) favors continuous and gradual changes in the student's way of acting, promoting the acquisition of traits and qualities that allow them to solve teaching tasks. in a creative, independent and conscious way" (Castillo y Padrón, 2021, p. 219). This implies that they must be flexible, contextualized and interdisciplinary so "(…) that the teacher can establish variants, incorporate new content without modifying the essence of the program." (Rodríguez, *et al.*, 2022, p. 141).

In correspondence with what was analyzed, the integrative teaching tasks that are proposed for the formation of metrological culture in tenth grade students, from the use of the potential of sport and Physical Education classes, encourage students to develop learning that allows its solution, as it favors "(…) the development of cognitive independence, the elevation of academic performance and the development of creativity" (Díaz and Chávez, 2021, p. 348).

Based on the previous assumptions, the integrative teaching tasks for the formation of metrological culture in students are defined from the use of the potential of sports and Physical Education classes, as those activities that are oriented in the teaching process. learning of Physics for students to carry out in Physical Education classes or in the practice of sports activities and that integrate the basic knowledge of metrology: conversion of units of measurement, estimation and measurement of magnitudes, as part of the preparation of students for life.

The previous definition includes three basic conceptual cores for the formation of metrological culture and which need to be specified for the context of this study, these are the conversion of units of measurement, estimation and measurement of magnitudes.

Conversion understood as "(…) the transformation of the numerical value of a physical magnitude, expressed in a certain unit of measurement, into another equivalent numerical value and expressed in another unit of measurement of the same nature" (Lorena, Castillo and Arzate , 2017, p. 8); estimation is the "(…) process of finding an approximation on a measurement" (Álvarez, 2021a, p. 1) and measurement is the "(…) process by which a given pattern is compared with a unit of measurement, **a**nd thus it is possible to know how many times this pattern is contained in that magnitude" (Álvarez, 2021b, p. 1).

Example of integrative teaching tasks

Next, the system of integrative teaching tasks for the formation of metrological culture in tenth grade students is presented, from the potential of sports and Physical Education classes. This article is not intended to address the entire spectrum of possibilities that the topic offers, but rather it is a sample of the type of integrative teaching tasks that can be developed for this purpose.

1) In several sports, a measuring instrument called a stopwatch is used, which allows controlling the duration of a match or sports competition; as well as measuring the time spent by athletes in a race, among other issues.

a) Mention the sports in which the stopwatch is used and investigate some athletes who have stood out in them.
b) What physical magnitude is measured with the chronometer?
c) Suppose you are going to run races of 50, 100 and 200 m flat and estimate the time it would take to cover these distances.
d) Ask your Physical Education teacher for a stopwatch and measure the time you spend traveling those distances.
e) Compare the results of the measurements carried out with the estimated values and briefly assess the causes of the differences observed.

f) Converts the values of the measurements made to other units of measurement of that magnitude, for example, in cent second (cs) or millisecond (ms).

2) If you are observant, you will have noticed that there are sports that are played on a rectangular-shaped field called a court.

a) What sports are played on a court? Research some athletes who have excelled in these sports.
b) If you want to determine the area of a court, what physical quantities should you measure? Briefly explain how you can determine the area of the court.
c) Select one of your school's fields and estimate the value of the length and width of the playing rectangle.
d) Take a tape measure and measure the length and width of the playing rectangle and determine its area.
e) Compare the results of the measurements carried out with the estimated values and briefly assess the causes of the differences observed.
f) Converts the values of the measurements made to other units of measurement of that magnitude.

3) As you surely know, there are sports in which it is necessary to measure the mass of the athletes before competing to achieve a fairer competition.

a) Mention some of these sports.
b) Research some of the athletes who have excelled in these sports.
c) Select three of your classmates and estimate the approximate values of the mass of each of them.
d) Determine, with the help of a balance, the values of the masses of the three students.
e) Compare the results of the measurements carried out with the estimated values and briefly assess the causes of the differences observed.
f) Converts determined mass values to other units of measurement of that magnitude.

4) In athletics, there are several specialties in which when carrying out a sports competition it is necessary to measure the length to determine the winner.

a) Mention some of those specialties.

b) Research some athletes who have stood out in these specialties, as well as world and Olympic record holders and the best historical brands.

c) Select one of those specialties, ask three of your classmates to perform a single-round competition and estimate the approximate values of the length achieved by each of them.

d) Determine, with the help of a tape measure, the length values achieved by each of the students.

e) Compare the results of the measurements carried out with the estimated values and briefly assess the causes of the differences observed.

f) Converts the values of the measurements made to other units of measurement of that magnitude.

5) One of the most spectacular specialties in athletics is the 100 m dash race, in which the Jamaican athlete Usain Bolt stood out, who holds the world record and several of the best marks in history in this specialty.

a) Usain `s world record? Bolt in the 100m dash?

b) In what other athletics specialties did Usain Bolt excel? and what are his best results in these tests?

c) What physical magnitude is necessary to measure to determine athletes' marks?

d) Ask five of your classmates to run a 100 m dash and estimate the result of each of them.

e) Determine, with the help of your Physical Education teacher's stopwatch, the magnitude associated with the mark made by each of them.

f) Compare the results of the measurements carried out with the estimated values and briefly assess the causes of the differences observed.

g) Converts the values of the measurements made to other units of measurement of that magnitude.

6) There are sports in which the size of the athletes is very important, so teachers and coaches monitor them in the different categories.

a) What physical magnitude is related to the height of athletes?

b) In which sports is the size of the athletes important?

c) Research some athletes who have excelled in these sports.

d) Select three of your classmates who have different sizes and estimate the value of the physical magnitude that is related to the height of the athletes.

e) Determine, with the help of a tape measure or graduated ruler, the physical magnitude that is related to the height of the athletes.

f) Compare the results of the measurements carried out with the estimated values and briefly assess the causes of the differences observed.

g) Converts the values of the measurements made to other units of measurement of that magnitude.

7) Your Physical Education teacher needs to develop a teaching aid to explain to students how to measure with the stopwatch and ask for your help. To do this you must carry out the following activities.

a) Design the scale of a stopwatch and give the value of the smallest division of it.

b) Place a needle that indicates a possible measurement and its value.

c) Converts the measured time value to other units of measurement of that magnitude.

8) The chess board is made up of 64 squares, 32 of one color and 32 of another, but all of the same size. Observe them and do the following activities.

a) Research the main exponents of this sport at all times, both in Cuba and internationally.

b) Estimate the values of the length and width of a square, and of the entire square formed by the 64 squares of the board.

c) Determine, with the help of a graduated ruler, the values of the length and width of a square, and of the entire square formed by the 64 squares of the board.

d) Calculate the area of a square and that of the entire board, using several methods.

e) Compare the values obtained in sections b and c, and briefly assess the causes of the differences observed.

f) Convert the values determined in part c to other average units of that magnitude.

9) In Greco-Roman wrestling, Cuba has one of its greatest sporting glories, which in turn constitutes one of the greatest exponents of the sport, with five world and four Olympic titles.

a) Which athlete is it? What do you know about him?
b) Consider that you want to follow in the footsteps of this phenomenal athlete and to start your sports career, you are going to fight with a partner in your group who also likes that sport. Select among the possible candidates the one that is closest to your weight (division).
c) Determine, with the help of a scale, your mass and that of your partner, and assess whether a wrestling match between the two is fair.
d) Converts the values of the determined masses to other units of measurement of this magnitude.

10) One of the athletics specialties that requires a harmonious combination of strength and technique is shot put. In this modality, Cuba has had excellent representatives, especially among the female sex.

a) Research which athletes have stood out the most in shot put, both internationally and nationally; as well as the five best brands in the history of this test.
b) During a shot-put competition, what physical magnitude is measured?
c) Ask five of your classmates to take a shot-put implement and propel it as far as they can. Estimate the result of each of them.
d) Determine, with the help of a tape measure, the result achieved by each of the students.
e) Compare the results of the measurements carried out with the estimated values and briefly assess the causes of the differences observed.
f) Converts the values of the measurements made to other units of measurement of that magnitude.

This system of integrative teaching tasks was applied in pedagogical practice in the 2022-2023 school year at the "Rafael María de Mendive" mixed center in the Sandino municipality, with a sample of 33 tenth grade students, who expressed a willingness to participate on the research. For this purpose, a booklet was prepared with the integrative teaching tasks, which facilitated the rational use of time and teams of three or four students of different

levels of performance were formed, which made it possible to provide the required levels of help.

The variable investigated was the formation of metrological culture in tenth grade students and the method used to measure it was the pedagogical test.

Prior to the application of the system of integrative teaching tasks, the pedagogical test was applied, with the objective of diagnosing the level of training of metrological culture in tenth grade students.

The application of the pedagogical test and the statistical processing applied to the data obtained allowed to appreciate the inadequacies presented by the students in the sample, in relation to the formation of metrological culture, manifested in the following findings:

It is significant that only 30.3 % of the students were evaluated well in terms of converting measurement units; 24.2%, in the estimation of magnitudes and 36.6%, in the measurement of magnitudes.

The analysis of the results obtained indicated the low level of incidence of all the indicators of the investigated variable in the students. These insufficiencies show the low level they have in the formation of metrological culture.

The analyzed results confirm the state of need present in the investigated variable, since there are affectations on all the indicators of said variable. This allows to propose that there is a low level of formation in metrological culture in the tenth-grade students of the "Rafael María de Mendive" mixed center in the Sandino municipality.

Once the proposal was applied, the final results were evaluated. For this purpose, the pedagogical test was applied, which showed that 84.8% of the students were evaluated well in the conversion of measurement units; 87.8%, in the estimation of magnitudes and 90.09%, in the measurement of magnitudes.

The results obtained with the application of this method made it possible to evaluate well all the indicators of the investigated variable, so the level of development of the metrological culture in the tenth-grade students of the "Rafael María de Mendive" mixed center was evaluated, in general, as good.

The analysis of the behavior of the results of the pedagogical tests applied allowed to appreciate the effectiveness of the proposal and contributed to the formation of metrological culture in the students, which confirms the validity of the system of integrative teaching tasks proposed; likewise, it was possible to verify the motivation of the students who were emotionally involved in carrying them out and their commitment to delve deeper into this topic, once its implementation was completed. The results obtained in the research carried out are considered satisfactory, although susceptible to improvement, hence it is suggested that research on this topic be continued.

CONCLUSIONS

In the scientific literature consulted, no evidence was found of integrative teaching tasks similar to those proposed, mainly that they cover the use of the potential of sport and Physical Education classes for the formation of metrological culture.

The use of integrative teaching tasks that promote the formation of metrological culture in tenth grade students, from the use of the potential of sports and Physical Education classes, is still insufficient.

The system of integrative teaching tasks that was designed for the formation of metrological culture in students was characterized by harmonizing three basic conceptual cores for the treatment of metrological content: the estimation and measurement of magnitudes and the conversion of measurement units; in addition to taking advantage of the potential of sports and Physical Education classes for this purpose.

The results achieved in the research demonstrated that it is possible to achieve the formation of metrological culture in students, through the use of a system of integrative teaching tasks that take advantage of the potential of sports and Physical Education classes.

REFERENCES

Brito, A. D., & Amaro, D. M. C. (2021). La tarea docente. Una herramienta necesaria en la formación médica. *MediSur*, *19*(2), 346-348. https://www.redalyc.org/journal/1800/180068639023/

Comité de Metrología del Instituto de la Ingeniería de España. (2019). *La Metrología también existe* (1ª Edición). Centro Español de Metrología. https://www.cem.es/sites/default/files/30363_lametrologiatambienexiste_web.pdf

Cruz, M. D. T., León, M. R., & Sans, J. A. P. (2021). LAS TAREAS DOCENTES INTEGRADORAS EN EL PROCESO DE ENSEÑANZA APRENDIZAJE DE LA QUÍMICA INORGÁNICA: TAREAS DOCENTES INTEGRADORAS DE QUÍMICA INORGÁNICA. *Didáctica y Educación ISSN 2224-2643*, *12*(5), Article 5. https://revistas.ult.edu.cu/index.php/didascalia/article/view/1226

Padrón, Y. C., & Álvarez, L. M. B. (2021). Sistema de tareas docentes integradoras: Contribución a la formación ética profesional de los estudiantes contadores. *Revista Conrado*, *17*(80), Article 80. https://conrado.ucf.edu.cu/index.php/conrado/article/view/1834

Ponce, Y. R. (2023). *Metrología para la vida*. RUTH. https://books.google.com.cu/books/about/Metrolog%C3%ADa_para_la_vida.html?id=bz6oEAAAQBAJ&source=kp_book_description&redir_esc=y

Secretaria de economía. (2019). *El CENAM y el impacto de sus mediciones en la vida diaria y en los sectores de la economía, comercio, salud, industria e investigaciones.* Secretaria de economía.

Toruncha, J. Z., & Cruz, S. O. (2015). Didáctica desarrolladora: Posición desde el enfoque histórico cultural. *Educação e Filosofia*, *29*(57), Article 57. https://doi.org/10.14393/REVEDFIL.issn.0102-6801.v29n57a2015-p61a93

***Conflict of interests*:**

The authors declare not to have any interest conflicts.

***Authors' contribution*:**

The authors have participated in the writing of the work and analysis of the documents.