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Article

Promoting gender equality through experiments with water rockets in distance physics class between the Technological University of Jalisco, Mexico and the Technological University of Bolívar, Colombia

Fomentando la equidad de género a través de cohetes de agua en clase de física a distancia entre la Universidad Tecnológica de Jalisco, México y la Universidad Tecnológica de Bolívar, Colombia

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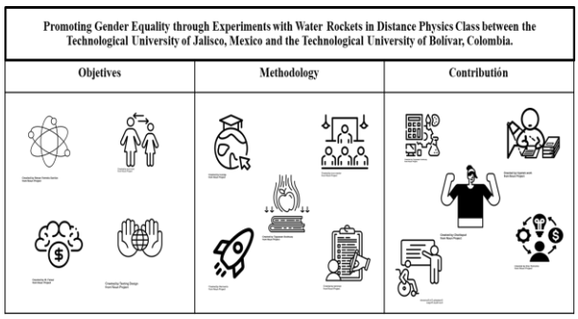
Abstract

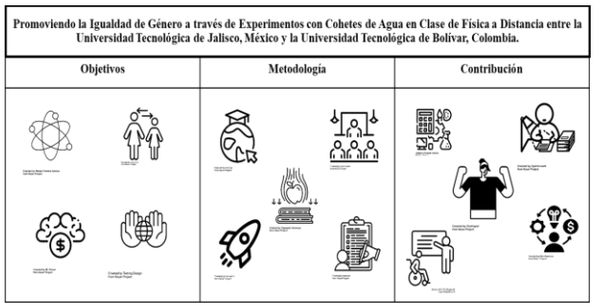
This article presents a study on the promotion of gender equality in distance learning physics, using experiments with water rockets as a pedagogical tool. A collaboration was carried out between the Technological University of Jalisco in Mexico and the Technological University of Bolívar in Colombia. Through this research, we seek to identify how the implementation of practical activities can influence the participation and interest of students of different genders in the field of physics. The results of the applied methodology are presented, as well as the implications of these findings for future educational practices.



STEAM, Water rocket, Gender equality

Resumen

Este artículo busca analizar cómo fomentar la equidad de género en la educación de la física a distancia usando el experimento de cohetes de agua como instrumento pedagógico. Para ello, se realizó un trabajo conjunto entre la Universidad Tecnológica de Jalisco en México y la Universidad Tecnológica de Bolívar en Colombia. La finalidad es conocer en qué medida la implementación de la experimentación puede tener efecto en la participación y el desempeño del alumnado de distinto sexo en la enseñanza de la física. Consecuentemente se presentan los resultados obtenidos de la aplicación de la metodología y las consecuencias que de estos se derivan respecto de sus aplicaciones futuras



STEAM, Cohete de agua, Equidad de genero

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Introduction

The limited participation of women in sciences such as physics and mathematics has been a constant concern throughout history. According to Serway and Jewett (2018), despite efforts, women's interest in STEAM disciplines remains low. Therefore, it is critical to promote the equal participation of women in the education and exploitation of science, technology, engineering, arts and mathematics concepts in order to promote inclusion.

To this end, it is vitally important to make use of water rockets. The use of water rockets in STEAM education has proven to be an effective educational tool to engage students in the exploration of science, technology, engineering, arts and mathematics concepts.

Inviting students to design and launch water rockets allows them to experience, rather than passively learn, their content. Physical concepts that are exploited during the creation of water rockets include Newton's third law and rocket propulsion, while those related to mathematics emphasise trajectory and velocity.

Thus, by designing and building rockets, students acquire creativity and problem solving, critical aspects of steam education. In terms of collaboration and teamwork, the use of water rockets engages students in teams. Collaboration reflects the interdisciplinary nature of steam education by using multiple content areas in a collaborative project.

Students apply their knowledge of number theory to the calculation of water pressure, design skills to the creation of aerodynamic rockets, and science to the flight of the rocket. Using water rockets for STEAM in education also promotes critical thinking as students reflect on the results of their launches, adjust their designs and make improvements in an iterative process. This experimental approach teaches them through real-world experience and challenges, which strengthens their conceptual understanding of science and their ability to apply it effectively in practical contexts.

Problem definition

Despite advances in education and the promotion of gender equity, barriers persist that limit women's participation in scientific fields.

In the context of distance education, these barriers may be amplified by a lack of practical interaction and the perception that science is a male domain.

This study seeks to address these issues by implementing a hands-on experiment involving water rockets in order to assess its impact on gender equity in physics education.

The problem lies in the lack of interest and equal participation of students of all genders in science and technology. Women's participation in the sciences, such as physics and mathematics, has historically been limited, contributing to this disparity in participation (Serway & Jewett, 2018). The use of hands-on experiments such as water rockets is an effective tool to promote equal participation in science (TeachEngineering, 2023). Furthermore, NASA (2023) highlights how these activities encourage critical thinking and experimentation in physics.

In doing so, the programme promotes equal opportunities in science and technology, which could have a positive impact on society by addressing challenges in education and other fundamental aspects. It is crucial to work towards the inclusion and equal participation of women in these fields in order to promote a more diverse and enriching environment in science and technology.

Hypothesis

The implementation of water rocket experiments during online Physics classes will promote the participation and interest of students of both genders thus, contributing to the promotion of gender equality in education.

Water rocket experiments during physics lessons are expected to promote the participation of students of both genders, as mentioned in previous studies highlighting the importance of diversity in science (University of New South Wales, 2023).

'They contribute significantly to diversity and equal opportunities by enriching the scientific and technological landscape with a wide range of perspectives and innovative ideas' and best help to find solutions to fundamental physics challenges.

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Justification

The choice of water rockets as a didactic tool because of their ability to engage students in active, hands-on learning. In addition to simplifying the understanding of physics concepts, this approach can also contribute to breaking gender stereotypes linked to science.

Similarly, cooperation between organisations from different nations enriches the educational process and facilitates a cultural exchange that can be beneficial for all involved. Integrating water rocket practices into the physics curriculum provides an opportunity to challenge gender stereotypes and promote equal opportunities in the classroom.

The use of water rockets in STEAM teaching can contribute to breaking gender stereotypes, especially in male-dominated fields such as physics and engineering (NASA, 2023).

This is especially important for girls and young women who, in many cases, face additional challenges in accessing educational opportunities in science and technology.

Also, using the water rocket programme as an educational tool in the subject of physics allows students to investigate scientific and mathematical principles through an exciting hands-on experience.

By promoting the activities, the active participation and empowerment of all female students is encouraged, which helps to eliminate gender barriers and stereotypes in the field of science and technology.

Objective

The main purpose of this study is to analyse how water rocket experiments affect the participation and interest of physics distance learners, with a special focus on gender equality. It is essential to promote STEAM education by using a water rocket as a tool to detect and monitor various variables in physics and the environment.

In this way, it seeks to identify effective strategies that can be implemented in future classes in order to foster an inclusive and equitable environment.

Water rocket experiments offer a unique opportunity for students to develop technical and scientific skills in an equitable environment (Science Buddies, 2023), where students designed a water rocket using skills acquired during their school term. This approach promoted experiential learning and the development of technical and creative skills within this virtual distance learning modality.

In addition, the purpose of this project is to promote gender equality in universities by providing equal opportunities for both men and women to actively participate in the design of the rocket. This allows for the development of professional competencies and leadership skills in an inclusive and diverse environment.

Methodology

Within the field of distance education in physics, the main objective of this study is to promote gender equality by conducting hands-on experiments with water-powered rockets.

We worked with two groups of students: The first group, coming from the Technological University of Jalisco in Mexico, consists of 19 males and 3 females. On the other hand, the second group is from the Technological University of Bolivar in Colombia and includes 22 men and 5 women.

Selecting these groups will help us to investigate how practical activities can affect the interest and participation of men and women in scientific fields, which could contribute to closing the gender gap in technical and scientific education. This is followed by details of the approaches used to carry out this study and the techniques used to both collect and analyse the information obtained.

The workshop was conducted in 4 sessions on the development and launching of water rockets, with a focus on applied physics.

Gender Analysis
Percentage of men:
Total, men: 38
Percentage: (41 / 49) * 100 = 88.67%.
Percentage of women:
Total, women: 5
Percentage: (8 / 49) * 100 = 11.33%.

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Box 1

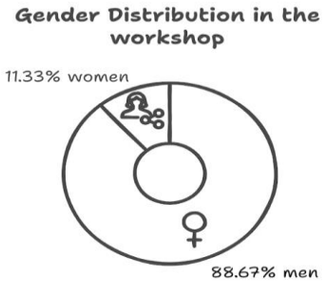

Figure 1

Gender distribution of the total number of workshop participants. Source: own Each session will last 45 minutes connected through the Microsoft teams platform

Sesión 1: Introducción a los cohetes de agua

Duration: 45 minutes

Topics to be covered:
Entry survey on basic knowledge and knowledge of distance learning classes.

STEAM Education: Introduce design and art concepts in the presentation of the history of rockets and their importance in space exploration.

Gender Equity: Include examples of women pioneers in science and space exploration to inspire all female students.

An entrance survey was conducted, which asked the following questions:

1. Have you participated in distance learning classes with professors from different universities and countries?

Resulting in: Yes 5, no 32, ever 4 and never 0.

Box 2

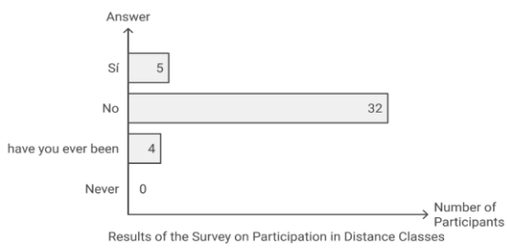

Figure 2

Survey on student participation in distance learning classes

2. Do you know Newton's 3rd law? Resulting in Yes 34, no 2, Don't remember 5.

Box 3

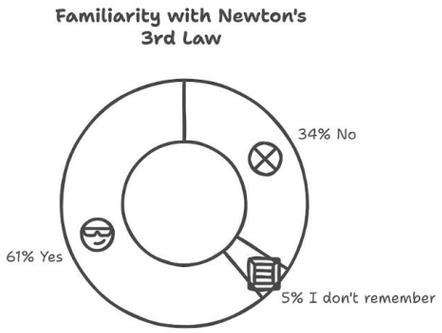

Figure 3

Result of the question on one of the concepts applied in the workshop

3. Have you interacted in educational activities with people from other cultures? Yes 0, no 41, ever 0.

Box 4

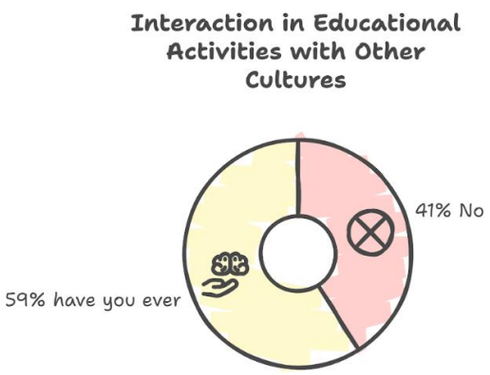

Figure 4

Result of the question on pupils' interaction with other cultures

4. Do you think that the UTB Linked Class contributes to the learning and development of intercultural competences in the Physics course Yes 39, no 0 maybe 2.

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Box 5

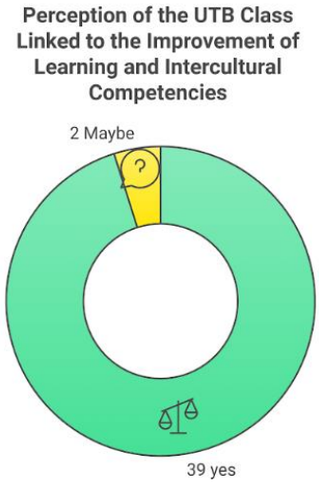

Figure 5

Perception of improvement with the workshop

5. Do you think that the UTB Linked Class offers the opportunity for an intercultural experience where the experiences, knowledge and culture of the participants are shared? Yes 41, no 0 , maybe 0.

Box 6

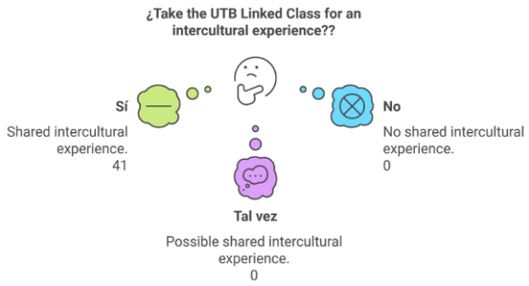

Figure 6

Factors that intervene in the workshop Own source

6. You know the water rockets Yes 27, no 14.

Box 7

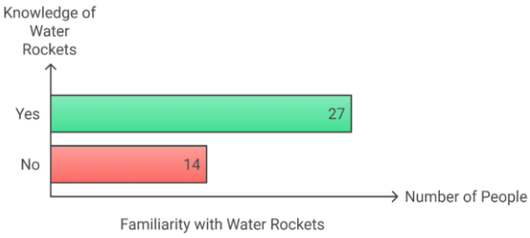

Figure 7

Question on knowledge of water rockets

7. Do you know the term gender equity and do you apply it? Yes and I apply it 32 I do not know it 9

Box 8

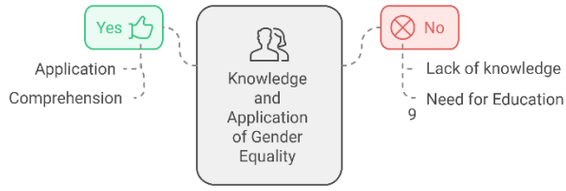

Figure 8

Representation of how much students know about gender equality

Box 9

Figure 9

Participation of students from group 7A of the IMA course at the Technological University of Jalisco in the subject of physics

Session 2: Newton's Laws and Water Rockets

Duration: 45 minutes Topics to be covered: STEAM education: Conduct hands-on experiments that encourage experimentation and the application of Newton's laws in rocket design and launch. Gender Equity: Promote equal participation in hands-on activities and highlight the achievements of women scientists who have contributed to the field of physics.

Box 10

Figure 10

Students attending one of the online sessions

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Session 3: Pressure, volume and water rockets

Duration: 45 minutes

Topics to be covered:

STEAM Education: Conduct experiments that show the relationship between pressure, volume and temperature, integrating mathematical and scientific concepts.

Gender Equity: Include examples of women engineers and scientists who have made significant contributions to the field of physics and rocket engineering.

Session 4: Designing and launching water rockets

Duration: 45 minutes

Topics to be covered:

STEAM Education: Encourage creativity and design in the rocket building process, integrating engineering and art concepts.

Gender Equity: Highlight the role of women engineers and designers in rocket development and promote the active participation of all female students in hands-on rocket launches. Data Collection and Analysis

Data collection was carried out during the four one-hour sessions in which the water rocket experiments were conducted. Different instruments were used to collect relevant information, including pre- and post-experiment surveys, direct observations and participation logs. The surveys were designed to assess students' interest in physics, as well as their perceptions of gender equity in academia.

During the sessions, the active participation of each student was recorded, paying special attention to gender interaction. Observations focused on aspects such as group collaboration, decision-making and problem-solving. This information was documented through field notes and video recordings, which allowed for a more detailed analysis of group dynamics.

For data analysis, both quantitative and qualitative methods were used. Survey data were analysed using descriptive statistics, including means and percentages, to identify trends in students' interest and perception of gender equity. Qualitative analysis was conducted by coding observations and field notes to identify patterns and recurring themes in student interactions.

The results obtained were presented in graphs and tables to facilitate the visualisation of the findings, and were discussed in relation to the objectives of the study, providing valuable information on the effectiveness of the experiments in promoting gender equity in distance education.

Results

a) Increased interest and active participation of students as 8 students, 3 from the Technological University of Jalisco and 5 from the Technological University of Bolivar were involved in STEAM activities.
b) Empowerment and strengthening of skills in young women in the scientific and technological field.
c) Creation of an inclusive environment where gender equity and social commitment in STEAM education are promoted.

Box 11

Figure 11

Presentation of workshop results Own source Such social engagements in STEAM education are fundamental to promote an inclusive, sustainable and innovative future

Furthermore, the main objective of this programme is to foster the interest and equal participation of students of all genders in the development and launching of water rockets, promoting equal opportunities in science and technology.

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By the end of the project, students have strengthened their professional competences, acquired technical and creative skills, and experienced significant interdisciplinary learning, which will prepare them to face real-world challenges in their future careers.

Box 12

Figure 12

Presentation of students' results at the end of the 4 working sessions

Conclusions

This article is a first step towards understanding how practical activities can influence gender equity in science education. It is hoped that the findings of this research will serve as a basis for future educational initiatives that seek to promote a more inclusive and equitable learning environment in physics.

Declarations

Conflict of Interest

The authors declare that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have influenced the material reported in this article.

Authors' contributions

*Barrón-Balderas, Juan José***:** Contributed to the study design and implementation of hands-on experiments with water rockets, promoting gender equity in distance education in physics.

Ojeda-Caicedo, Vilma Viviana: Participated in the interdisciplinary collaboration, facilitating data analysis and evaluation of the impact of activities on the participation of students of different genders.

Fausto-Lepe, Gabriela Margarita: Contributed her expertise in pedagogy, helping to develop educational strategies that foster an inclusive and equitable environment, focused on teaching physics through innovative methods.

Availability of data and materials

The availability of data and materials from the study will be guaranteed for future research, facilitating access to educational resources and results obtained in the promotion of gender equity.

Funding

Funding for the project comes from collaborations between educational institutions, ensuring resources for the implementation of experiments and innovative pedagogical activities in physics teaching.

Acknowledgements

We thank the participating institutions and collaborators for their support and commitment to promoting gender equity in education.

Abbreviations

STEAM: In the educational context, “STEAM” is an acronym that refers to:

S: Science
T: Technology
E: Engineering
A: Arts
M: Mathematics

The STEAM approach integrates these disciplines to foster interdisciplinary learning, promoting skills such as problem solving, critical thinking and creativity.

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