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PROBLEMATIZING THE TEACHING OF PHYSICS IN PUBLIC SCHOOLS THROUGH THE PHYSICS IN SPORT EXTENSION PROJECT

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Abstract
The present work analyzes the implications of the extension project: Physics in Sports, for the students learning from public schools in Joinville/SC. The project consisted of a pedagogical intervention with Physics content for classes in high school final year through an interactive lecture interspersed with practical demonstrations. During the execution of the project, 2016-2019, the coordinator, 12 undergraduate students from engineering courses and approximately 500 high school students participated, with a total of 8 schools covered. To evaluate the project, questionnaires were applied at the end of each intervention. The analysis of the results led to the improvement of the lecture year after year, impacting the student's learning and, above all, strengthening the link between university and society.
Keywords: University Extension; High School; Physics; Sports.

PROBLEMATIZANDO O ENSINO DA FÍSICA NAS ESCOLAS PÚBLICAS POR MEIO DO PROJETO DE EXTENSÃO FÍSICA NO ESPORTE

Resumo
O presente trabalho buscou analisar as implicações do projeto de extensão Física no Esporte para o aprendizado de estudantes das escolas públicas de Joinville/SC. O projeto consistiu em uma intervenção pedagógica com conteúdo de Física para turmas do último ano do ensino médio, por meio de uma palestra interativa intercalada com demonstrações práticas. Ao longo da execução do projeto, 2016-2019, participaram a coordenadora, 12 estudantes de graduação dos cursos de engenharia e aproximadamente 500 estudantes de ensino médio, com um total de 8 escolas contempladas. Para avaliar o projeto, foram aplicados questionários ao final de cada intervenção. A análise dos resultados levou ao aprimoramento da palestra ano a ano, repercutindo na aprendizagem do educando e sobretudo estreitando o vínculo universidade sociedade.
Palavras-chave: Extensão Universitária; Ensino Médio; Física; Esporte.

PROBLEMATIZANDO LA EDUCACIÓN DE LA FÍSICA EN LAS ESCUELAS PÚBLICAS POR MEDIO DEL PROYECTO DE EXTENSIÓN FÍSICA EN EL DEPORTE

Resumen
El siguiente trabajo buscó analizar los resultados del proyecto de extensión Física en el Deporte para el proceso de aprendizaje de estudiantes de las escuelas públicas de Joinville/SC. El proyecto consistió en una intervención pedagógica con contenidos de Física para clases del último año de la educación media, por medio de una conferencia interactiva intercalada con demostraciones prácticas. A lo largo de la ejecución del proyecto, 2016-2019, participaron la coordinadora, 12 estudiantes de graduación de los cursos de ingeniería y aproximadamente 500 estudiantes de la educación media, con un total de 8 escuelas contempladas. Para evaluar el proyecto, fueron aplicados cuestionarios al final de cada intervención. El análisis de los resultados llevó a mejorar la conferencia año a año, repercutiendo en el aprendizaje de los estudiantes y sobre todo estrechando el vínculo universidad sociedad.
Palabras clave: Extensión Universitaria; Educación Media; Física; Deporte.

INTRODUCTION

It is a current narrative in different articles of the science of education, which deal with precariousness in Brazilian public education, that a significant portion of the difficulties in the learning teaching process, do not depend on the relationship between the teacher/student, but on the conditions they both encounter to mediate the learning process.

With glorious exceptions, the conditions are not favorable to Brazilian public education, which comes from advances and setbacks, as evidenced by the goals of the National Education Plan (BRASIL, 2020).

Despite the difficulties of the learning teaching process, we find approaches such as that of Evadio Filho, Tenório and Silva (2017) that highlight how one of the points that collaborate in the learning teaching process is the use of teaching methods applied to experimentation, as a practice of theoretical understanding. According to Giordan (1999), the practice of experimentation has been going on for more than 2300 years, since Aristóteles, who stated that "whoever has the notion without experience and knows the universal ignoring the particular contained in it, will be often deceived in the treatment" (ARISTOTELES, 1979 apud GIORDAN, 1999).

In the learning teaching process, experimentation is found in different disciplines, markedly in the disciplines of chemistry, biology, and physics. It is common for the curriculum structure of schools, public or private, to have science classes in laboratories for chemistry and biology subjects, leaving the teaching of physics strictly to exhibition classes inside classrooms, a situation that can be exemplified by the reality of high schools in the municipality of Parintins, Amazonas (GOMES *et al*, 2015), not far from the reality of many other Brazilian schools.

The performance of high school students is significantly critical in the discipline of physics, as revealed in the Brazil Report in PISA (BRASIL, 2018). This fact made us think about interventions, in the form of an extension project, in this discipline. The objective of this extension project is not to discuss the origins and such difficulty, but to contribute to the Joinville school community in offering experiences that can contribute to the learning of the discipline of physics.

The extension project of the Joinville Technological Center, entitled "Physics in Sport" is carried out by undergraduate students at the Federal University of Santa Catarina (UFSC) whose scope is to act in public schools, from the classes of the last year of high school, through physics classes with dynamics that merge lectures, practical demonstrations phenomenological

interaction. Thus, this article seeks, through the analysis of the applications used by the project and its results, to evidence the playful motivating character of experimentation and its effectiveness as an ally for teaching the contents of the physics discipline, stimulating the desire to learn, and promoting the transformation of teaching and its students.

MATERIALS AND METHODS

The extension project presented here began from the first semester of 2016, using the Rio 2016 Olympic Games as a pretext to bring university extension to Joinville public high schools, in order to contribute to the learning of some contents of the physics discipline, in addition to promoting university and society interaction.

In the first edition of the project, 2016, the collaborating professor Ana Margarida Rodrigues Pinto and three students of the UFSC Joinville engineering courses participated voluntarily. Prior to the intervention in schools, the team conducted a survey with high school teachers in the physics area, ~~in order~~ to know the points of greatest difficulty of students in the learning process in the physics discipline with the purpose of structuring the didactic material to be worked on. In the same year, a lecture was held at the School of Basic Education (E.E.B.) Engineer Annes Gualberto, located in the municipality of Joinville.

The first team of scholarship holders of the project opted for the use of a video material, interspersed with time spaces for explanations about the phenomena evidenced there. One of the demonstrations performed by the team was about the "Magnus Effect", which we will detail later. At the end of each intervention, students were asked to write their impressions about the lecture and what they learned.

In 2017, based on feedback from the previous year, the new team formed by four new students from the campus engineering courses, chose to reformulate the entire presentation, using as a basis the work of Otaviano Helene, "A little of everyday physics" (HELENE, 2016), which has a chapter dedicated only to physics in sport, as well as consulting the author's blog.

In the year in question, we opted for a slideshow material, consisting of GIF's, images, and videos, as well as explanations using the blackboard and two practical demonstrations, performed by the fellows, one of which was the same as the previous year and the other one the "Effect" on table tennis.

The theoretical content was formulated associating a subject of high school physics with a sports modality, to make the correspondence between theory and sports practice more visual to the student, as can be seen in Chart 1 below.

Chart 1 - Modalities and their theoretical contents of 2017 and 2018.

Modality	Subject adresses	Subject representation
Soccer	Newton's three laws	Game plays
	Magnus Effect	Roberto Carlos' famous kick
Swimming	Newton's Third Law	Movement in the water
	Friction force	Movement in the water
Table tennis	Friction force	Effect (curved trajectory realizes by the table tennis ball)
	Oblique movement	Ball trajectory during the game
Long jump	Oblique movement	Maximum reach angle at jump
Basketball	Oblique movement	Shoot to the basket
Pole vault	Energies	Transformations performed during the jump

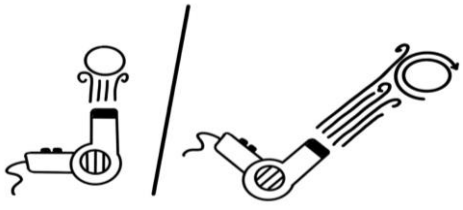
Source: The Authors (2020).

According to the presentation model mentioned, the experiments are demonstrated in soccer and table tennis activities and will be detailed below.

In soccer, for the visualization of the turnover performed by the ball and its support in the air during the action of the "Magnus Effect", detailed by Aguiar and Rubini (2004) and Almeida and Silva (2015), a hair dryer and a styrofoam ball are used.

With the purpose of the students to visualize how the ball was turned in the Roberto Carlos kick throw, explained theoretically, the team keeps the dryer on in unheated mode, sustains the ball with the air outlet in the vertical position, then tilts the dryer lightly until the ball starts a rotational movement still sustained in the air, as shown in Illustration 1.

Illustration 1 - Practice regarding the Magnus Effect.



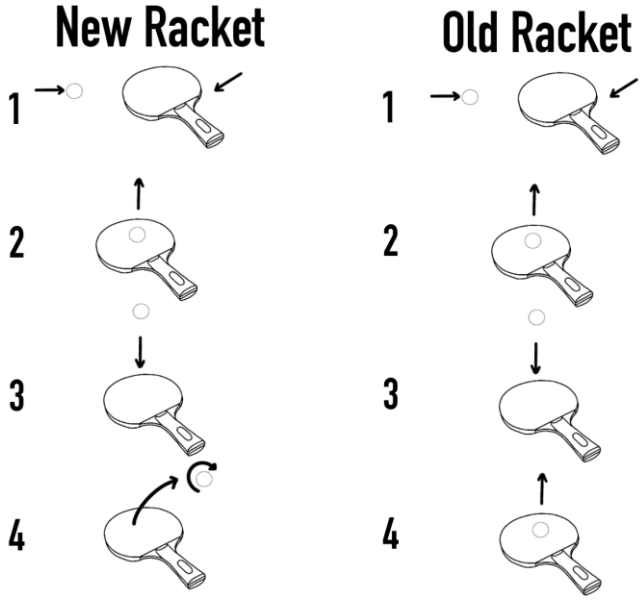
Source: The Authors (2020).

In table tennis, for the visualization of the turning performed by the ball due to the action of the friction force with the rubber, a professional racket with new rubbers, a professional racket with worn rubbers and a table tennis ball are used.

First, the racket with new rubbers is used. The ball is launched against the racket, and it is perceived that, after the second contact with the rubber, moves in the opposite direction to the initial movement of the racket. The same process is repeated with the worn rubber racket, and it is perceived that the trajectory of the ball does not change after the second contact, due to the smoother surface of the worn rubber, which generates less friction between it and the ball, causing less "effect". You can see the idea of demonstration in Illustration 2.

Thus, the student can notice the change in trajectory, that is, the "effect". This effect is caused by the action of the friction force due to the contact of the rubber roughness with those of the ball, thus, when there is no presence of roughness, there is no great action of the friction force and, finally, the "effect" does not occur (AVILEZ, 2006).

Illustration 2 - Practice ~~made~~ regarding friction in table tennis.



Source: The Authors (2020).

During 2017, the team carried out the project in two schools, E.B.B. Giovani Pasqualini Faraco and the Joinville Youth and Adult Education Center. With the intention of seeing from the perspective of the students their opinion about the project, the team elaborated a questionnaire whose answers required a certain subjective/dissertation effort. The questions elaborated for the questionnaires were as follows:

1. In your opinion, did the lecture facilitate the understanding of the physics contents presented? Explain.
2. What did you like most about the lecture? Explain.

3. What do you think can be modified in the lecture, or that can be added, so that it becomes more attractive and didactic? Explain.
4. Why do you consider that in your daily physics classes, content becomes difficult to understand?
5. Do you intend to study engineering or any course in exact? Which and why?

The last question was included with the purpose of disseminating the UFSC Campus in Joinville and analyzing whether the way some concepts were presented by the scholars, that is, more dynamic and closer to the student, was able to awaken the interest of studying the subject in the future, with depth, in a public University, and thus contribute to transform the reality of the student who participated in the extension project.

In 2018, the same team was maintained, the problem of the dispersion of attention observed in previous years was sought to work. Thus, we chose to keep the presentation and invest in ways to analyze the effectiveness of the lecture after its application, through the multiple-choice questionnaire, with the intention of collecting more specific data to enable a graph analysis. The questions were elaborated to explore the efficiency of the lecture in general; and specifically, the efficiency of the link between sports and physics. Thus, as in previous editions of the project, we chose to keep the question regarding the interest of studying engineering at the UFSC campus in Joinville. It was also decided to keep a dissertation question, in order to give the students, the option of expressing themself freely about the lecture. Thus, the questionnaire was implemented as follows:

1. Did the lecture facilitate the understanding of the physics contents presented?

□ No □ A little □ Reasonably □ Too much

2. What did you like most about the lecture? (You can check more than one option)

□ Table tennis □ Soccer □ Swimming

□ Pole vault □ Basketball □ Long jump

3. What helped you to understand the issues better? (You can check more than one option)

□ Slides □ Practical demonstrations □ Explanation on the board

□ Answers to the questions □ Others

In the case of another, cite: ...

4. You consider that in your physics classes the content becomes difficult to understand because: (you can score more than one)

□ Lots of calculations □ Lack of demonstrations □ The subject is difficult

□ Lots of formulas □ I don't have difficulties

5. Do you intend to apply for a course at UFSC Joinville?

□ Yes □ No □ Maybe

6. In case of yes or maybe, which?

□ Naval Engineering □ Aerospace Engineering

□ Transportation Engineering and Logistics □ Automotive Engineering

□ Civil Engineering of Infrastructure □ Mechatronic Engineering

□ Railway and Subway Engineering □ Bachelor of Science and Technology

7. Field for comments and suggestions that help us improve the lecture:

In this year 2018, lectures were held in three different schools in the municipality of Joinville: E.E.B. Osvaldo Aranha (morning class), E.E.B. Antônia Alpaídes Cardoso (morning and night classes) and E.E.B. Jorge Lacerda (morning and night classes). Holding lectures in different shifts is important to analyze the different needs of students, since those who study at night, mostly, work in another shift, arriving more tired, which can facilitate the dispersion in classes.

In 2019, with the departure of three students from the previous team and the entry of two engineering students, the team, due to the analysis of the previous year, decided to focus on the application of more practical demonstrations, making changes in some sports of the lecture, which had not reached the desired results, adding demonstrations in the possible modalities. Thus, the subjects, their corresponding modalities, and the way they were addressed in 2019 are detailed below in Chart 2.

Chart 2 - Modalities and their theoretical contents of 2019.

Modality	Subject adresses	Subject representation
Soccer	Newton's three laws	Game plays
	Magnus Effect	Roberto Carlos' famous kick
Swimming	Newton's Third Law	Movement in the water
	Friction force	Movement in the water
Table tennis	Friction force	Effect (curved trajectory realizes by the table tennis ball)
	Oblique movement	Ball trajectory during the game
Jiu-jitsu	Torque	Lever blow
Basketball	Oblique movement	Shoot to the basket
Pole vault	Energies	Transformations performed during the jump

Source: The Authors (2020).

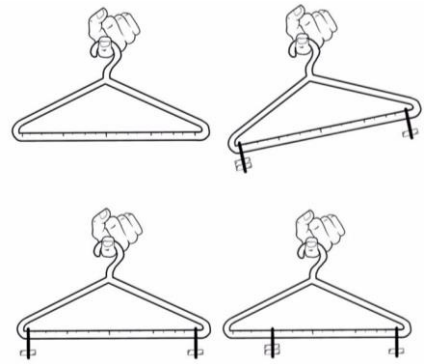
The experiments are demonstrated in soccer and table tennis activities, explained earlier; in swimming, jiu-jitsu, and pole vaulting, which will be detailed below.

In swimming, for the visualization of Newton's third law, a palmar is used, an instrument that, according to Gourgoulis *et al.* (2006), is used to increase the surface area of the hand, displacing a greater amount of water.

For better visualization of the use of palmar, a student is called in front of the class and is asked to perform the movement of the swim "crawl". It is then explained that in the same way that the swimmer pushes the water back with the surface of his hand, the water reacts by pushing him forward. The palmar is used to demonstrate that the larger the surface of contact with water, the greater the amount of water is pushed, and therefore more water reacts by pushing the swimmer.

As for jiu-jitsu, for the visualization of the law of the lever present in the Arm Lock blow, a hanger, a paper ruler for marking the centimeters and weights of known mass is used. A student is called to support the hanger with his finger on the top, while the fellows perform the experiment, visualizing the horizontal balance of this. Two equal masses are placed at both ends of the object and it is perceived that it remains in balance, since the masses are at the same distance from the center. The mass is increased on one side, and it is perceived that the hanger leaves its equilibrium position, the same would occur if one of the weights of the same mass was approximated to the center. To return to balance, the highest weight of mass is approaching the center, as shown in Illustration 3. Thus, the student can perceive how the ratio between force and distance works, known as the Archimedes Lever Principle, and can understand how the Arm Lock coup works through this concept of physics (SANTOS *et al.*, 2016).

Illustration 3 - Practical demonstration of the Archimedes Lever Principle.



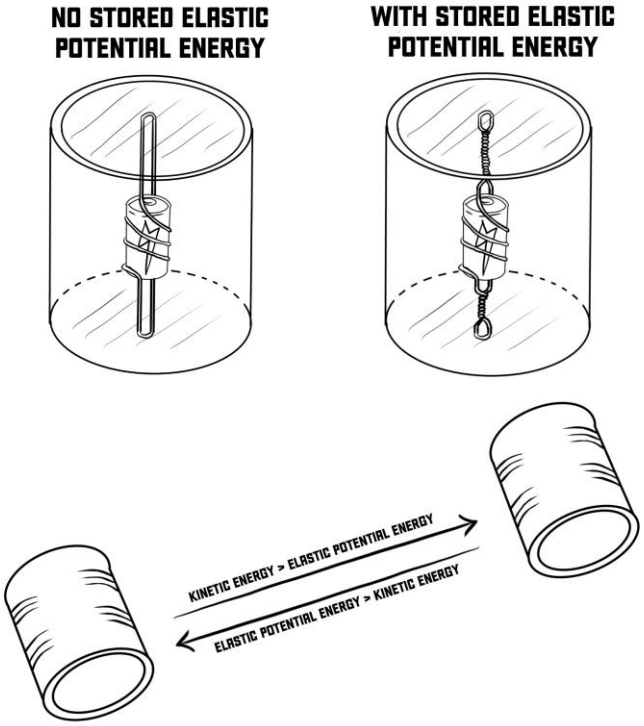
Source: The Authors (2020).

Finally, in pole vaulting, the energy transformation begins with the presentation of a race performed by the athlete, which has the work transformed into kinetic energy that is transferred to the stick in the form of elastic potential energy, later being transferred to the athlete in the form of kinetic energy and gravitational potential energy (GASPAR, 2013, p. 206).

For the visualization of the energy transformation process, a can, a rubber band and a battery are used. A hole is drilled into the central part of the cover and bottom of the can and secures the stretched elastic attached to a pile. A student is invited to come forward. The team asked the student to put the experiment on the ground and push it, thereby acquiring kinetic energy. It was explained that, conforming to the can moves, the kinetic energy is transformed into potential elastic energy, because the elastic is wound with the increase of tension by the battery. When all energy is transformed, the can ceases its movement and starts in the opposite direction, that is, the elastic potential energy is transformed again into kinetic energy, as shown in Illustration 4.

With the purpose of validating the way the project intervened in schools in 2019, the team applied the questionnaire of the previous year, replacing the sport long jump with jiu-jitsu.

Illustration 4 - Practical demonstration of energy transformations.



Source: The Authors (2020).

RESULTS AND ANALYSIS

To analyze the points that should be worked to improve the project, and in view of the informal feedback received from approximately 50 students, in 2016, the scholarship holders in 2017 decided to prepare a questionnaire to be answered by the students at the end of the lecture, as described in the section MATERIALS AND METHODS. This year, the lecture was presented to approximately 100 students.

When analyzing the answers obtained from question 4 (questionnaire 2017), it was possible to show that the students encounter difficulties with the discipline of physics, due to the amount of theoretical content without practical demonstration that allows them to attribute meaning to what is being addressed. The following are some answers written by the students who participated in the activities. The questionnaire was answered anonymously, so the answers are identified by numbers.

Student 1: "Because it is little practice, many theoretical classes and no practice, so we learn how it works in theory and do not know how to apply in practice".

Student 2: "Because it's boring how to explain the theory, everyone ends up not paying attention."

Student 3: "Because we don't usually relate to our daily life."
Student 4: "I don't think it's that hard to understand, but experiences make understanding much easier."

"Student 4" reveals the great importance of practical demonstrations. This notes that the subject is possibly not of great difficulty, however the way the contents are taught makes learning difficult. "Student 2" reveals that the way physics is taught has not contributed to him paying attention. In general, most students point out the absence of experimental activities, as one of the factors that increase the learning difficulty of the content of the physics discipline

The questionnaires also revealed many positive feedbacks, showing that the project activity with lectures and experiments was a didactic mean that facilitated the transmission of the contents to the students. Of the participants, 100% responded positively, and the justification for this result was the association of sport in the explanation and the practices used, as can be analyzed through the following answers:

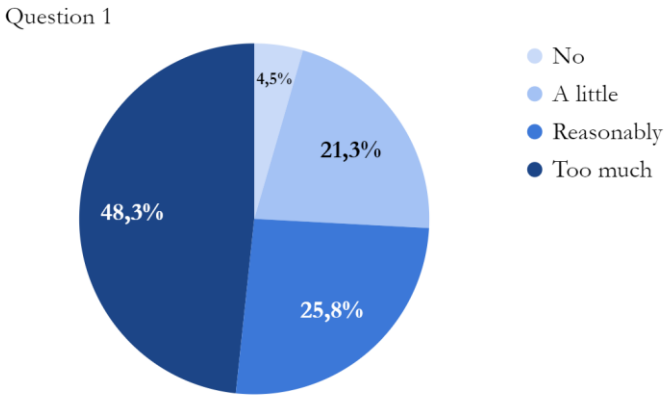
Student 5: "It made it much easier, they were able to put together the physics formulas with good examples of sports."
Student 6: "Yes, by the way it was explained differently, but without losing the focus that was to understand the content of physics, giving greater pleasure to the student when interested in the subject".
Student 7: "The content explained was well understood, because those who explained had patience and used practical examples to explain the situations."
Student 8: "Yes, because it was associated with something that is present in our daily lives. In addition to bringing many curiosities related to sports, it brought the theoretical part of physics to practice, making it more attractive and didactic".

With the analysis of the questionnaires, the scholarship holders promoted the improvement of future interventions. In 2018 the team incorporated new practical demonstrations and changed the format of the questionnaire to multiple choice.

Below we present the analysis of the issues raised in 2018. The data refer to the three schools in which the lecture was presented, adding up to approximately 180 students who answered the questionnaire presented in the previous section of this article.

Through the answers to the first question, expressed in Illustration 5, it can be concluded that, in general, the approach used by the scholars was efficient, it is now necessary to analyze specifically the parts of the lecture.

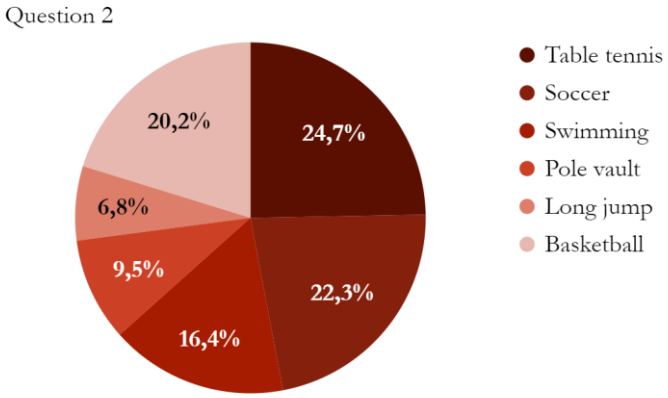
Illustration 5 - 2018 student results for Question 1.



Source: The Authors (2020).

The way the team found to analyze the specific parts of the lecture was through the analysis of sports separately. For this, Illustration 6 was elaborated, as follows.

Illustration 6 - 2018 student results for Question 2.



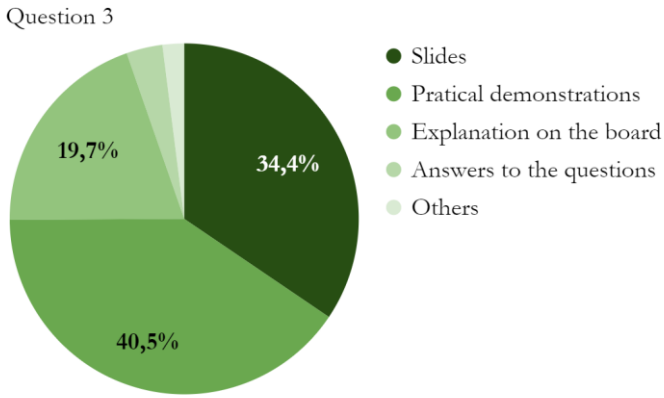
Source: The Authors (2020).

With this, it can be observed that table tennis, soccer and basketball are the modalities that most please. The team raised the fact that table tennis and soccer are, so far, the only modalities with demonstrations, based on the 2017 analysis. Basketball, in turn, also has a different material from other sports: a video analysis prepared by the fellows, which depicts an oblique throw from a basketball to the basket, highlighting all the vectors of strength,

acceleration and speed involved in the movement. This media resource approaches a practical demonstration and deviates from the traditional theoretical teaching process.

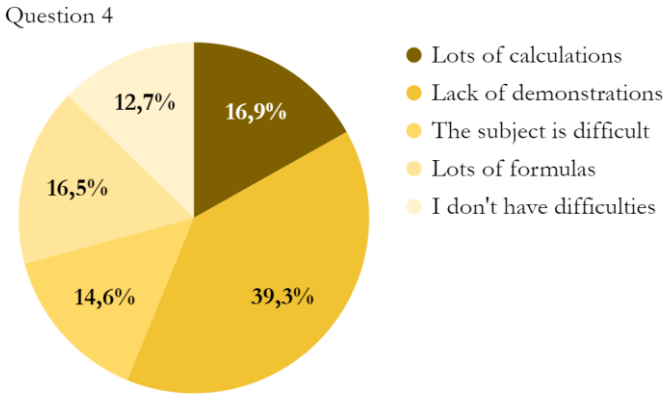
It should also be realized that swimming, pole vaulting and long jumping did not receive evaluations as expected. To investigate the cause of the student's lack of affinity with these modalities, questions number 3 and 4 of the 2018 questionnaire, highlighted in Illustrations 7 and 8, were once again analyzed by charting.

Illustration 7 - 2018 Student Results for Question 3



Source: The Authors (2020).

Illustration 8 - 2018 student results for Question 4.



Source: The Authors (2020).

Illustration 7 reveals that demonstrations and slides are the most important mechanisms for communication between the student and the project scholar. For 40.5% of the respondents, the practical demonstration acts as a complement, exerting the connection between theory and practice for the student in a playful and didactic way. The explanation on the board was also indispensable.

Illustration 8 shows the need for demonstrations in the explanations, besides highlighting the negative effect of too many formulas and calculations. Correlating with the observations made from Illustration 7, we understand the need for explanations in the board, because this is an efficient means, so far, to approach and elucidate the use of formulas.

About the space for comments and suggestions, of the questionnaire, we will highlight the dissertation responses that deal with the above notes:

Student 9: "I really enjoyed the lecture, but in some parts I still find it difficult to learn, as in the part where it was spent on the board, but the most complicated doubts were taken."
Student 10: "One way to better understand would be to apply values in formulas. Very cool project! Congratulations!"

About the explanations in the board, there is a problem and a solution in the comments. Student 9 points out that he/she feels a little difficult to understand the part in the board, therefore, student 10 suggests the use of numerical values in the equations, which until then were only algebraic.

In view of the more detailed analysis of the 2018 results, the team came across a lot of data to substantiate the changes needed for the following year. After rigorous reading of the analyses, the 2019 team found that the practical demonstrations proved to be of great importance and may be the key to the improvement of other modalities. In view of this, it was decided to act in the modalities with less acceptance.

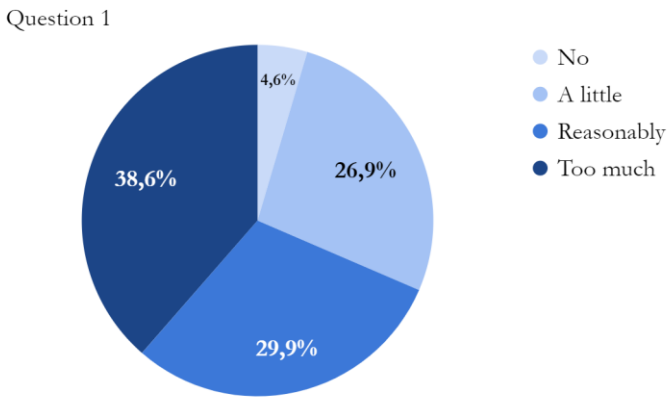
The first change was the substitution of the modality with the lowest percentage: the long jump. In addition to the low return it brought, the content approached by it could be explored in explaining the oblique release of the basketball. A new mode then might be added. It was decided to include jiu-jitsu, which addressed as content the "Law of the Lever" in a practical demonstration. Even with a low percentage, the team decided not to remove the pole vault, instead adding a practical demonstration to this modality.

Although swimming, even without a demonstrative activity, was a modality well accepted by the students of 2018, the team realized that it was possible to strengthen the student-speaker link, using the artifice of an exhibition activity with a practical content that appeals to the humorous attention of the students, as described in the previous topic. This occurs by coming to the front of the class, one of the classmates of the class, usually the most communicative and

extroverted, provoking laughter and making the student-speaker relationship more solid, which facilitates the transmission of shared information through the demonstration.

At the end of the 2019 lectures, the team counted the data of the questionnaires to test the changes made and provide improvements in the activities of the year 2020. The same previous questionnaire was used, with the exchange of long jump for jiu-jitsu. The following analysis refers to the presentation of the lecture in two schools, with approximately a total of 200 students who answered the questionnaire. The results are only for an exploratory analysis, since one has only the answers of two schools, and it is still not material enough to establish a standard, since the lectures are subject to external factors that cause impact on the data. One example is the change of members of the project, as was the case in 2019, in which two new scholarship holders were admitted. This change could be noticed by the students in the first lectures, as the new members were still getting familiar with the project, forming didactics and developing the oratory skills. Thus, in the first lectures, some students used the questionnaire to record the nervousness of some speakers, which may have impacted the result of the first graph. Illustration 9 is related to the first question of the questionnaire.

Illustration 9 - 2019 student results for Question 1.

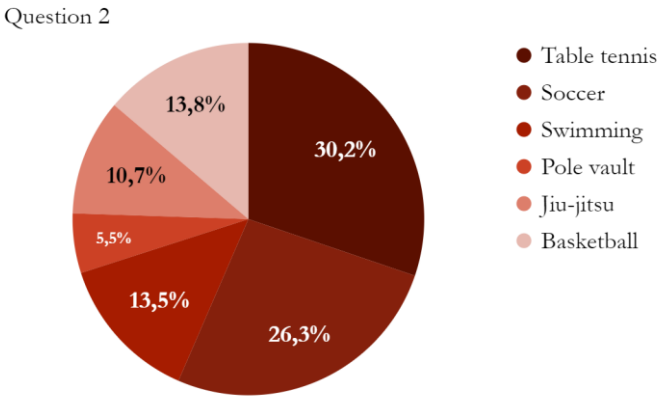


Source: The Authors (2020).

Even in the face of a drop in the percentage of the most optimistic response, the results are still positive, which demonstrates that the lecture has achieved its objective of facilitating the understanding of the topics addressed. In addition, one should take into consideration the note related to the change of members.

Illustration 10 illustrates the effectiveness of the strategy of relating each sport to a physics concept.

Illustration 10 - 2019 student results for Question 2.



Source: The Authors (2020).

Table tennis and soccer again contribute to the biggest percentage of the chart. The team associates this result with the fact that these are the two most complete modalities, recounting flashy slides, explanation in the board with drawings and formulas and practical demonstration, being this fundamental set to facilitate the didactics of the topics addressed.

Basketball continues to make a great contribution. Thus, the team considers that the addition of a demonstration in this modality would complete the didactic set mentioned.

Swimming, jiu-jitsu and pole vault are still part of the modalities of lower didactic-pedagogical contribution, and this may be related to some factors that will be addressed below.

At first, the team found it difficult to develop a practical demonstration possible to be performed in the classroom for swimming, a resource that has proved to be the key to effective teaching. Thus, the substitution of the modality by one that addresses the same content and enables a complete demonstration can provide a more positive response.

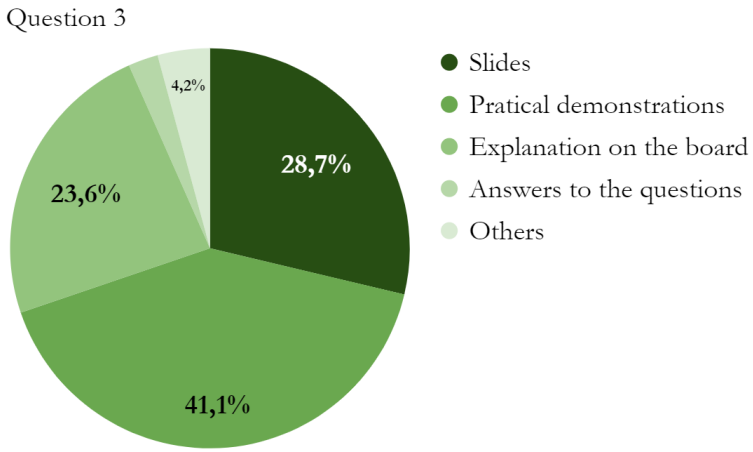
Jiu-jitsu was implemented in the 2019 lecture, being received positively by students, who identify with a mode of fighting. However, because it is a new sport in the presentation, it was possible to notice some points to be improved, such as the improvement of the demonstration presented, which relies on the use of formula and calculation. Therefore, care in didactics is necessary so that the student does not turn his attention at this moment and stop following the practice that follows. Therefore, jiu-jitsu is a modality with great potential for improvement and effectiveness in the transmission of information.

The pole vault requires greater attention and new tests to reach a conclusion, because, even presenting a low percentage, this modality is the one that the team found to associate the content of energy transformations in a didactic way. In addition, the practical demonstration was very well accepted by the students and their class teachers, as it was one that most caught the

students' attention. However, the low percentage of the modality needs to be investigated. The group raised some points to be changed the following year. The first is the didactics of the speaker, because this modality was presented by one of the new fellows in the project, who performed his first presentation in public. Thus, the improvement in oratory and affinity with the lecture can improve the understanding on the part of students. Therefore, the second point raised is the order of the presentation, because this is the last topic presented, a large part of the public was already dispersed. In view of this, an alternative is to place the jump in height at the beginning of the presentation and analyze whether there is an improvement in the percentage of learning because of this change.

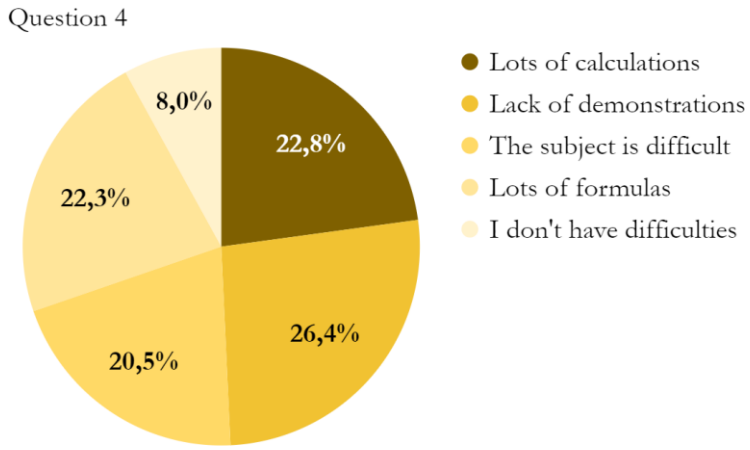
Illustrations 11 and 12 present, respectively, the data referring to the didactic resource that most helped the students to understand the subjects and referring to the reason causing difficulty in their daily physics classes.

Illustration 11 - 2019 student results for Question 3.



Source: The Authors (2020).

Illustration 12 - 2019 student results for Question 4.



Source: The Authors (2020).

As can be seen in Illustrations 11 and 12, as in the previous year, practical demonstrations are simultaneously the resource that most helps in understanding content and the one that students most miss in their weekly physics classes. Thus, it is possible to affirm that this resource can boost the didactics of teachers, provide a greater interest of students in classes, and strengthen the student-teacher relationship.

The importance of practical demonstrations for students was also revealed when answering the dissertation question of the questionnaire, as it can be seen below:

Student 11: "Very good, the practices helped a lot."
Student 12: "Great presentation, demonstrations help a lot, you go far."
Student 13: "A lot of demonstrations, this makes our learning much easier. Very dynamic lecture."
Student 14: "Very well explained, the girls clearly understand the subject. I liked the practical demonstrations as well."

One more comment also stands out, which also refers to the explanation on the board:

Student 15: "Practical demonstrations are easy to understand, but at the time of explanation on the board, I end up getting lost and having difficulties. But in general, it was a great explanation of the subject."

"Student 15" reveals a very frequent problem: the difficulty of understanding the content on the board. This problem occurs, because it is at this moment of the lecture in which the formulas are used, coinciding with the answers for which the student scored in question 4 of the questionnaire, which refers to the greater difficulty in understanding the subjects in the classroom, being: "lots of calculations", "the subject is difficult" and "lots of formulas". On the other hand, the student states that he/she felt ease of understanding by practical demonstrations. This leads us to think that the resources we use in lectures can contribute significantly to students absorbing the content presented, or at least part of them.

Regarding questions 5 and 6 of the 2018 and 2019 questionnaire, which sought to promote the UFSC campus in Joinville, and verify the interest of following one of the areas of engineering offered, most respondents, 60%, were interested. Results like this may show that disseminating the university in less favored media can facilitate access to the democratization of higher education in the country.

FINAL CONSIDERATIONS

Analyzing the entire trajectory of the project so far, it is evident the difficult mission of being a public-school teacher, and that the principle of every good result within the classroom assumes primarily the will to teach. During the project, receptive students were found, teachers who immediately demonstrated their determination to obtain good results and then, had their satisfaction in realizing that they were engaging the students. Only from this, it was possible to begin to analyze the hypotheses that were sought to evidence with this work.

The detailed analysis of the didactic methods used by the project "Physics in Sport", and its results expressed in the graphs, reveal that, even in the face of the changes still necessary to achieve more concrete results, the use of practical demonstrations and audiovisual resources within the classroom is one of the paths to be followed for the development of a more effective method for working with the discipline of physics with high school students and thus contribute to the way of teaching that is more welcoming to students of public schools.

In addition to the results expressed in the graphs, which explain the lack of demonstrations as the main cause of the difficult apprehension of the concepts involved in physical phenomena, and their use as the main means of understanding, the comments of the students on the dissertation questions indicate what was sought to evidence from the beginning of this work: theory when allied to practice is the key to more efficient teaching.

Even in the face of encouraging results, we still face points to be evaluated, such as low acceptance of certain sports practices for the presentation of the physical phenomena addressed. At first, it was believed that the ideal is the balance in the presentation between different sports modalities, however, the factors of change mentioned, such as the project time of the scholarship holders, the order of the presentations of each sport, the affinity of students with the modalities and even external factors to the project, still need to be investigated, collecting more data and increasing the number of attended schools, so that standards can be generated to be evaluated, also taking into account the reality of each community school.

In addition to the data evaluated in the work, we considered the students' feedback, personally and through the open question, as a humanized means of measuring the effectiveness of the project, because it is by the success in learning the students that this work was dedicated. Therefore, we can point out that this is the right direction, and it is rewarding to see how excited the student is after being able to absorb the contents covered.

The team continues to work on more resources to be taken to the classrooms, such as video analysis, board games related to the lecture, and other experiments, which make teaching even more practical, fun, and didactic. In addition, the desire to achieve good results and see the success of students, who come to see physics with other eyes, it is what drives the search for the improvement of physics teaching. Given everything analyzed, there is the realization that teaching needs to go together not only with theory, but also with practice, and that the humanization of teaching goes hand in hand with the art of teaching.

Finally, we consider that the indicator of interest (60%) of following one of the engineering areas offered by the UFSC Campus in Joinville, after the application of the project "Physics in Sport", shows that the communities of public schools, once having access to a learning teaching process that considers methodologies of practical demonstrations for phenomena of complex assimilation, access to the democratization of higher education in the country.

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REFERENCES

AGUIAR, C. E.; RUBINI, G. **A aerodinâmica da bola de futebol**. Revista Brasileira de Ensino de Física, v. 26, n. 4, p. 297 - 306, (2004).

ALMEIDA, B. S. G.; SILVA, R. C. **Aerodinâmica das bolas**. Revista Brasileira de Ensino de Física, v. 37, n. 3, 3505 (2015).

AVILEZ, O. V. **Borrachas rápidas sem solventes voláteis**. Associação de Tênis de Mesa de Campinas. Campinas, 2006. Disponível em: http://tmcampinas.com.br/ARTIGOS/ecospin1.pdf. Acesso em 23 de novembro de 2020.
BRASIL. **PISA 2018**. **Relatório Nacional**. Brasília/DF: Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP), 2018.

BRASIL. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). **Relatório do 3º ciclo de monitoramento das metas do Plano Nacional de Educação – 2020: sumário executivo**. Brasília, 2020.

EVADIO FILHO; TENÓRIO, F. A.; SILVA, J. R. **Oportunidades de Melhorias: qualidade do serviço prestado em escolas públicas**. Reice. Revista Iberoamericana Sobre Calidad, Eficacia y Cambio En Educación, [S.L.], v. 152, n. 2017, p. 31-51, dez. 2017. Servicio de Publicaciones de la Universidad Autonoma de Madrid. http://dx.doi.org/10.15366/reice2017.15.2.002.

GASPAR, A. **Compreendendo a Física**. 2ª edição. Volume 1 Mecânica. São Paulo: Ática, p.206, 2013.

GIORDAN, M. **O papel da experimentação no ensino de ciências**. Química Nova na Escola, n. 10, p. 43-49, 1999.

GOMES, E. B.; SANTOS, T. N.; PINHEIRO, A. C. A.; SOUZA, J. H. S. **Laboratório de ciências e física: ferramenta de ensino nas escolas de ensino médio no município de Paratins/AM**. Campina Grande, Vol. 1 Ed. 4, ISSN 2316-1086, Realize editora, 2015.

GOURGOULIS, V., et al. **Effect of two different sized hand paddles on front crawl stroke kinematics.** Journal of Sports Medicine and Physical Fitness; v. 46, p.232-237, 2006.

HELENE, O. **Um pouco da Física do Cotidiano**. 1ª. Edição. São Paulo: Livraria da Física, 2016.

SANTOS, C. F. A.; SANTOS, R. B.; RODRIGUES, S. R. C. R. **O ensino da física através do jiu-jitsu: uma proposta de ensino baseada na concepção de pessoa completa de Henri Wallon**. III Congresso Nacional de Educação. 2016. Disponível em: http://www.editorarealize.com.br/editora/anais/conedu/2016/TRABALHO_EV056_MD4_SA18_ID7417_19082016175906.pdf. Acesso em 23 de novembro de 2020.

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