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Use of Astronomy concepts within comics to motivate Physics classes

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Abstract. The aim of this work is to use Astronomy concepts within comics to motivate Physics classes. This work was applied at the Casimiro Silva State School, in the city of Boa Esperança, in Minas Gerais, with 40 high school students. For the development of the Learning Object, software for comics was used. The pre-test was applied on the dates of August 9th and 10th, 2021 and then interventions were carried out on the subject of electromagnetic wave, spectral bands, radio waves and microwaves and with the delivery and explanation of the Comics, as a Learning Object, addressing communication between planets and between Earth with Voyager 1 and 2. After a period of four months, the same questionnaire, the post-test, was repeated to verify the potential significant learning. Thus, it was verified that the methodological strategy applied during the intervention, with the Teaching of Astronomy and the Learning Object, reflected in the improvement of the performance obtained in the post-test, being observed in the group of 40 students the increase of the answers of the questions of 27 students, equivalent to 67.5% in relation to the pre-test. Statistical analysis verified significance, where the averages differ at the level of 5.0% of probability by Student's t-distribution.

Resumo. O objetivo deste trabalho é utilizar os conceitos de Astronomia dentro das Histórias em Quadrinhos (HQs) para motivar as aulas de Física. Este trabalho foi aplicado na Escola Estadual Casimiro Silva, na cidade Boa Esperança, em Minas Gerais, com 40 alunos do Ensino Médio. Para o desenvolvimento do Objeto de Aprendizagem foi utilizado um software para as Histórias em Quadrinhos. Foi aplicado o pré-teste nas datas de 9 e 10 de agosto de 2021 e em seguida foram realizadas as intervenções sobre o tema onda eletromagnética, faixas espectrais, as ondas de rádio e micro-ondas e com a entrega e explanação das Histórias em Quadrinhos, como Objeto de Aprendizagem, abordando comunicação entre planetas e entre a Terra com as Voyager 1 e 2. Após o período de quatro meses, foi repetido o mesmo questionário, o pós-teste, para verificar a potencial aprendizagem significativa. Assim, averiguou-se que a estratégia metodológica aplicada durante a intervenção, com o Ensino de Astronomia e o Objeto de Aprendizagem, refletiu na melhoria do desempenho obtido no pós-teste, sendo observada na turma de 40 alunos a elevação dos acertos das questões de 27 alunos, equivalente a 67,5% em relação ao pré-teste. Pela análise estatística verificou-se a significância, onde as médias diferem entre si ao nível de 5,0% de probabilidade pela distribuição t-Student.

Keywords. Meaningful Learning, Spatial Communication, Learning Object

1. Introduction

The great challenges of the Physics discipline pointed out by Silva et al. (2018) are of a pedagogical nature, lack of appropriate methodologies and lack of adequate material in schools for practical classes.

In this context, persistence in the use of traditional classes is presented by Bonadiman & Nonenmacher (2007); Lopes & Rodrigues (2017); Moreira (2018), who highlight the excess of abstract operations exercises or repetitive memorization, mechanical learning, with students focused on the exhaustive resolution of exercises. This teacher difficulty was also mentioned by Dantas (Ribeiro & Mercena).

The content of the Physics discipline from the students' point of view was mentioned by Martins et al. (2017); Moreira (2018); Silva et al. (2018) as difficult, discouraging, a discipline of calculations and memorization of formulas from books, solving exercises, a complex, boring and unmotivating discipline.

According to Oliveira & Harres (2017) the discipline of Physics, based on traditional exercises, does not fully allow the understanding of certain Physical concepts. Since, it causes the student to focus on mathematical resolution and not on understanding the phenomenon.

For Carvalho & Sasseron (2018) find strategies for analyzing scientific practices, recognizing that teaching and learning Science goes beyond memorizing events and concepts. But, how to make the student view the discipline of Physics in another way? What methodology should be used by the teacher? Looking for new methodologies? Build a Learning Object?

It is necessary to provide the student with a differentiated methodology, which arouses interest and thus favors learning. About these questions, in this research, alternatives are sought in theory Ausubel (2003) when working with students' prior knowledge, becoming a bridge to connect to new information.

Based on theory of meaningful learning Ausubel (2003), the research carried out with High School (HS) students begins with a subject studied in Elementary School (ES), to facilitate the learning of new information. Within this theory, it is recommended to use previous organizers, that is, introductory materials, as anchors for new information.

The main objective of this work is to use Astronomy concepts within comics to motivate Physics classes.

Were the interactions between Physics Teaching, Astronomy Teaching and the Learning Object between previous and new knowledge sufficient to achieve significant student learning potential?

The contents of the comics present new information for HS based on rovers, landers and artificial satellites on Mars and the trajectory of Voyager 1 and 2.

The Curiosity and Perseverance rovers on the surface of Mars and the satellites orbiting this planet were used as content for scientific dissemination, using a comic book as a Learning Object. Low and high gain antennas and communication frequencies were presented in the comics.

NASA's Perseverance robotic vehicle, on the surface of Mars, has three antennas attached: one UHF that communicates with artificial satellites, one low-gain and one high-gain that communicate directly with Earth Greicius (2021). Next to the rover, NASA's Ingenuity Helicopter on Mars began flights. If a

dust storm occurs, particles in suspension can reach the solar panels. Yeah, they need to be fed by the Sun to survive during the cold nights of Mars Greicius (2021).

In the communication of the satellites around Mars and the rovers, among them, Curiosity, work with the use of high frequency antennas. Which send information by radio waves from the Martian surface to orbiting satellites. From satellites orbiting Mars, information is sent to antennas on the Earth's surface **?**. To this end, Mourão (1987) defines an artificial satellite: "A space vehicle, manned or not, set to rotate around the Sun, a planet or a satellite, generally with the aim of scientific investigation".

In addition to the rovers in the comics, the Voyager 1 and 2 spacecraft were explored, where they follow their paths to the interstellar medium, more than 40 years exploring the universe. According to Mourão (1987), "Voyager is the NASA Program to send unmanned vehicles, equipped with instruments, to the orbits of Mars, Venus, Jupiter, Saturn, Uranus and Neptune, possibly equipped with instruments on the surfaces planetary".

In the works of Ludwig & Taylor (2002); Gurnett et al. (2013); Gurnett et al. (2015); Burlaga et al. (2019) and Gurnett et al. (2019) the information from the Voyager 1 and 2 space probes was taken. Information on solar flares and their influence on the heliosphere up to the heliopause and measurements in the interstellar medium were presented. According to Mourão (1987) the "heliosphere is the sphere that delimits the field of influence of solar activity" and according to Gurnett et al. (2013); Gurnett et al. (2015) and Gurnett et al. (2019) in their work define the heliopause as the limit at which the solar wind from the Sun is interrupted by the interstellar medium.

According to Ludwig & Taylor (2002) the operation of the Voyager 1 and 2 probes was shown, with the scientific data transmitted by the coupled devices. Signals were sent by high-gain antennas, with a dish 3.7 m in diameter, with 23-watt transmitters pointed at Earth (Figure 1).

According to Ludwig & Taylor (2002), the Voyager 1 and 2 probes have very high frequency transmitters, 8.4 GHz, in the microwave range. Signals reduce due to the great distances traveled by both. On Earth, very weak signals (10–18 watts) are received, where the Deep Space Network DSN's gigantic satellite dishes use ultra-low noise amplifiers. Thus, they boost the signal to a usable level.

According to Gurnett et al. (2013) in their work, says that evidence is demonstrated that Voyager 1 crossed the heliopause in the interstellar medium on August 25, 2012 at a heliocentric radial distance of 121.6 Astronomical Units (AU). However, Burlaga et al. (2019) in their study states that Voyager 2 crossed the heliopause on November 5th, 2018 at a distance of 119.0 AU.

According to Gurnett et al. (2019) the Voyager 1 and 2 instruments are used to detect plasma waves, solar winds and measure the density of electrons, the density of particles is increased in the heliopause. Thus, the instruments of the probes detected the variation in density and variation in the velocity of the particles, coming from the solar wind in relation to the particles of the interstellar wind.

According to Gurnett et al. (2015) and Gurnett et al. (2019) scientific data clearly show that, on the contact surface, which is the separation between the solar wind and the interstellar wind, there is an increase in particle density. Due to the collisions of electrons in the heliopause, the speed of particles in the solar wind drops close to zero. The space probes Voyager 1 and 2 are currently in interstellar space, where the density of particles has decreased in relation to that recorded in the heliopause.

Therefore, the Teaching of Astronomy and technology inserted in comics can support the study in Physics classes at HS. Since, the student visualizes through the illustration and

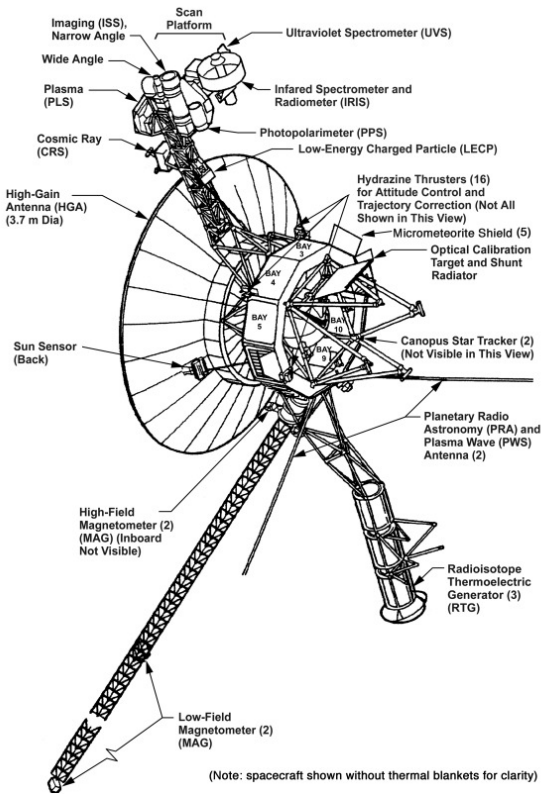

Figure 1. Devices attached to Voyager. Fonte: Ludwig & Taylor (2002, 4)

perceives in the arguments how the Physical phenomena occur. Therefore, as mentioned in Brazil (2018), in the construction of the strategy as scientific dissemination, the comic presented consistency of arguments and the use of the NASA website as a reliable source. For **?**, astronomy has a highly motivating degree in the means of scientific dissemination.

2. Methodology

This work was applied at the Casimiro Silva State School, in the city of Boa Esperança, in Minas Gerais. The target audience of this research were students from the 1st to the 3rd year.

The pre-test was applied on the dates of August 9th and 10th, 2021. For the production of the questionnaire, information from the 9th grade Godoy's textbook (2018) and from the NASA website that addresses topics in Astronomy were used.

The questionnaire used in this research was a closed type, a quantitative methodology instrument, containing 11 multiple-choice questions.

After applying the pre-test, interventions were carried out on the dates of August 11th and 12th. Initially, in "Class 1" the contents of the 9th grade ES were addressed. In "Lesson 2" topics of Astronomy were addressed in the interventions, including updated information on the explorations of probes in the universe (Table 1). All classes were worked on the skills of the Brazil (2018).

The production of comics with the Teaching of Astronomy, both for ES, is justified by the Brazil (2018). According to Peixoto et al. (2021) the BNCC document expanded the Astronomy content in ES. Making use of comics with astronomical content in new curricula that can be implemented at school, with contemporary themes such as Astrophysics.

Table 1. Lesson planning

Intervention	LBNCC Skill Codes	Topics covered
Lesson 1	EF09CI05 EF09CI06 EF09CI16	Radio waves; AM e FM and UHF. The ionosphere and the behavior of electromagnetic waves for communication. Microwaves and artificial satellites. Distribution of comics.
Lesson 2	EM13CNT303	UHF antennas. Low gain antennas. High gain antennas. Identification of Physics concepts in comics.

*Source: Elaborated by the author

For the development of the Learning Object, for the production of comics, the HagáQuê software by Langhi & Nardi (2009) from UNICAMP-SP was used, gathering drawings, figures and information from Greicius (2018, 2020, 2021); Wild (2021), editors of the NASA website in the context of history finding the information in the scientific works of Ludwig & Taylor (2002); Gurnett et al. (2013); Gurnett et al. (2015); Burlaga et al. (2019) and Gurnett et al. (2019). The use of printed comics, for use in the classroom, was a wise choice, as the school does not have digital media, as well as the ease of acquiring the material in color by the teacher himself.

The comics were used as a motivation factor in Physics classes, to improve students' learning. The productions of the comics, with three episodes, were delivered during the interventions carried out in the classes, where each student showed interest in scientific stories.

Communication between Earth and Mars was evidenced in two episodes with 24 comics, with the Curiosity and Perseverance rovers on the surface of Mars and by the satellites in its orbit.

Electromagnetic waves were evidenced in an episode with 20 comics, along the trajectory of the Voyager 1 and 2 space probes.

After four months, the same questionnaire was reapplied on the 8th, 9th and 10th of December 2021, which is now called post-test, where the classes were reunited due to the reduction in cases of COVID-19 in the municipality, and maintained the alternating separation of a desk between students in the classrooms.

Then, after tabulating the data, Statistical Analysis was performed, using the t-Student test Araújo (2021), to verify the occurrence of potential significant learning in HS students. For this purpose, the spreadsheet Excel (2016) was used with its data analysis tool called: Hypothesis Test, the t-test for two paired samples for averages.

3. Results and discussion

It was exposed to the sequence of participating students A1 to A40, namely: the 1st year from A1 to A14; the 2nd year from A15 to A29 and the 3rd year from A30 to A40 (Figure 2). By colors, yellow is the pre-test and green is the post-test.

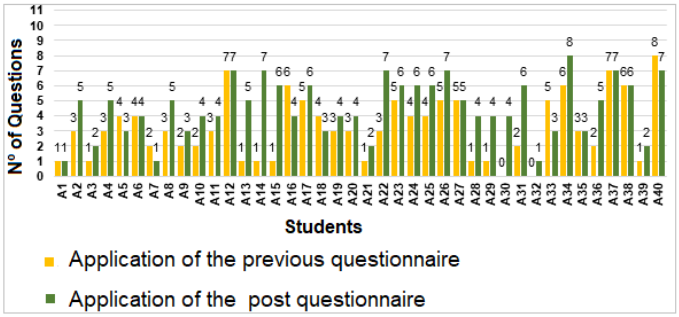

Figure 2. Correct answers by students

Table 2. Results: t-test, grouped classes

t-test: two paired samples for means	Before	Topics covered
Average	3,20	4,55
Variance	4,26	3,48
Sum	128	188
Observations (n)	40	40
Mean difference hypothesis	0	
Degree of freedom (n-1)	39	
STAT T	-4,62	
$t_{critical}$ to the left	-1,68	

*Source: Elaborated by the author

When applying the previous questionnaire, it was observed that Group 2 and Group 3 had higher numbers of correct answers than Group 1 (Figure 2). Based on Ausubel (2003) it can be seen that, in most 1st year students, the 9th grade information was not stored in the cognitive structure of these research participants.

In the two tests applied, an evolution of the indexes of the three classes was verified. It was observed that 14 students, in the post-test, reached six or more correct answers. Only five students, in the post-test, reached five correct answers and the others reached less than four correct answers, but most raised their correct answers in relation to the pre-test (Figure 2). Comparing the results of the 40 students in the two tests, it can be seen that the number of correct answers increased to 27 students. Due to the effect of the interventions in the expository class and the use of the Learning Object with the Teaching of Astronomy, the concepts were assimilated, according to Ausubel (2003) of meaningful learning. The rates of seven students were maintained and of six students falls were identified. Therefore, a positive index of 67.5% was obtained between tests. The rates of 17.5% were maintained and there were drops for 15.0% of the students. Most students found motivation in solving the test, although a small portion showed no evolution in the rate of correct answers. For those who did not improve in the post-test, that is, the strategy was not enough for learning and the comics were not clear.

Hypothesis Test, Grouped Classes (40 students):

For the t-test: two paired samples for averages of all classes were grouped and the averages were entered into an Excel spreadsheet for analysis of results (Table 2).

Table 2 above presents the data obtained by the Excel tool calculations. It is obtained, from the t-test for the samples and comparison in the pre-test and post-test, applied in the grouped classes, the STAT T < $t_{critical}$ (-4,62 < -1,68), SD = 1,80 e $S\overline{D}$ = 0,59 graphical representation (Figure 3).

Hypothesis H0 should be rejected, due to the result in the comparison of means which differed, statistically, with a probability of 5.0% of significance. Therefore, the second hypothesis H1 will be accepted, where the average in the pre-test ($\overline{X}$ ini-

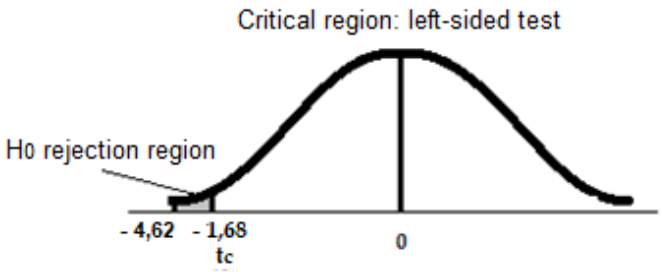

Figure 3. Hypothesis Test, (Grouped Classes)

tial) is lower than in the post-test ($\overline{X}$final). After the intervention strategies for the students, a better performance was presented than that observed in the first phase. Thus, it was indicated, statistically, that there was significant potential learning in line with Ausubel (2003) learning. Even with many post-pandemic adverse factors, the motivation with the use of Astronomy Teaching and the support of the Learning Object (Comics) were factors that positively interfered in the learning process.

4. Conclusion

The main objective of the research is to use Astronomy concepts within comics to motivate Physics classes. The comic is a learning object that works as a support for classes, arousing students' interest in understanding scientific concepts:

• With the result of the research, for those who evolved their success rates by understanding the new information, the comics moved away from the understanding of traditional classes, blackboard and chalk. It became a motivating instrument for the student, for the study of the behavior of electromagnetic waves, on the Physical phenomena in outer space.

• It supports the classes, which can be approached in more interesting ways. It was essential for the insertion of new information in the interaction with the students' previous knowledge.

Regarding the comparison of the first phase and the second phase:

• Where the intervention after the pre-test and the use of comics provoked the student, with a different class. With that, the interactions with the Teaching of Physics, Teaching of Astronomy and the Learning Object reached a potential significant learning of the students. Occurring changes in the question of the improvement of the correct answers between the two tests.

• Of the 40 students paired in the two tests, 27 students (67.5%) had better results. Thus, for most students, physical concepts were adequately assimilated.

• Those students who, in the second phase, obtained the same performance as in the first phase, or those who fell, did not affect the statistical result.

• It was statistically indicated that there was potentially significant learning in the three classes.

• In the grouped classes, it was observed, where the means of the two tests differ at a level of 5.0% of probability, by Student's t-distribution, it is concluded that the strategy with comics brought positive results for a potential significant learning.

• The research carried out showed positive contributions to Science teaching due to the interaction of Astronomy Teaching, technology and scientific dissemination, within a theme in Physics Teaching. This makes room for future research in other classes.

Therefore, the research question was answered by the statistical result. For a large number of HS students, when comparing the two tests, statistically, there was a difference in means, with potential significant student learning. In this way, the general objective and the specific objectives were achieved.

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