v. 3, n. 35, 2023

Journal of
Engineering
Research

MUSIFISIMAT AND INCREASING STUDENTS' PERCEPTION OF THE RELATIONSHIP BETWEEN MUSIC, PHYSICS AND MATHEMATICS

José Carlos Teixeira Pistilli
CBNB/ COMAER
Rio de Janeiro - RJ
http://lattes.cnpq.br/1532187548265953

Carmen Lúcia Crespo Pinto
CBNB/ COMAER
Rio de Janeiro - RJ
http://lattes.cnpq.br/2519505525037113

Fabiana Mabel Azevedo de Oliveira
LabEspaço/ IPPUR/UFRJ
Rio de Janeiro - RJ
http://lattes.cnpq.br/8050292666249089

Tamara Tania Cohen Egler
LabEspaço/ IPPUR/UFRJ
Rio de Janeiro - RJ
http://lattes.cnpq.br/0153108968139259

Abstract: The present study was carried out at Colégio Brigadeiro Newton Braga (CBNB), part of the Federal Public Network belonging to Aeronautics through the MusiFisiMat Teaching, Extension and Research Project. This research focused on identifying, through the perceptions of its students, the improvement of teaching-learning and behavioral patterns based on the interdisciplinary relationship associated with the use of new technologies, between the disciplines of Arts, Physics and Mathematics, often stigmatized in the school imagination. To do so, we used answers obtained from a semi-open questionnaire applied to students participating in this Project. In its analysis, we draw comparative parallels of the results obtained over four academic years. The numerical responses to the questionnaire revealed growth curves representing the approval of the activities carried out by MusiFisiMat, in line with the statements of satisfaction and praise. The results indicated the importance of the work carried out by this Project in increasing students' perception of the relationship between music, physics and mathematics as a factor in improving school performance. Such results corroborate reflections by scholars who focus on the rapprochement between science, art and new technologies in the process of enriching school education (CURSINO, 2019; EGLER, 2014; GASPARETTO, 2014; MATOS,2003). This way, we reiterate, through MusiFisiMat, the urgency of making school education more accessible, dynamic and attractive, promoting a closer relationship between the student and the school, an essential movement for it to become more inclusive and complete.
Keywords: Music, Physics, Mathematics, new Technologies.

INTRODUCTION

Daily school life reveals to teachers in elementary and high school classes various difficulties involving learning issues and student behavioral problems, under the specter of outdatedness and the distance between the school and the student's real world. Difficulties often increase due to stigmas reproduced by both teachers and students. The most stigmatized subjects are Mathematics and Physics and on the ride are their teachers who bear the burden of disapproval and dissociation from reality and anachronism. From another angle of view, Art and its teachers, also victims of prejudice, are often associated with a secondary instance in the hierarchy outlined by the school imagination. This way, Arts teachers (music, visual and performing arts), in addition to underutilizing the immense potential of technological resources, accommodate themselves to the judgment that their functions are simply complementary, restricting themselves to simple entertainment. This entire problem often goes unnoticed and/or taken for granted, including by teachers themselves, who end up leaving aside opportunities to enrich their professional practices. Motivated to discuss ways to overcome the obstacles presented here, we carried out, at Colégio Brigadeiro Newton Braga (CBNB) of the Federal Public Network, belonging to the Air Force, a research linked to the interdisciplinary pedagogical project MusiFisiMat. The focus of the research was to increase students' perception of the relationship between music, physics and mathematics through interdisciplinarity and the use of new technologies to awaken students' interest in school studies and increase satisfaction in learning them.

Created in the 2008 academic year and existing until the end of the 2014 academic year at CBNB, the MusiFisiMat Teaching, Extension and Research Project was based on

the idea that physics, mathematics and music, as well as other artistic languages, through the appropriate use of new Technologies, they can merge in order to make teaching-learning more meaningful and enjoyable for students and teachers. Following this line of reasoning, MusiFisiMat became, in 2011, an offshoot of the Public Policies for Education Technologies Project developed at the Space Laboratory of the Institute for Research and Urban and Regional Planning at ``Universidade Federal do Rio de Janeiro`` (LabEspaço/IPPUR/UFRJ), coordinated by Professor Tamara Tania Cohen Egler. In accordance with thoughts advocated by LabEspaço, MusiFisiMat defends the integration of science-art-technology to improve the quality of school education. This integration presupposes the student as the protagonist in the school educational process, the encouragement of their freedom of expression and the appreciation of their identities, their diversities and contradictions, assumptions that underlie the humanizing school and stimulating the production of knowledge from the student.

The feeling of humanization of the school is in line with education scholars who defend the influence of music, as well as other artistic languages, in improving school learning and generating diverse benefits in students' lives (BRITO, 2003; DOHME, 2004; DUARTE, 1988; ROMANELLI, 2009). It is worth noting that art, with its productive, creative and emancipatory potential, as well recognized in the literature, has a lot to contribute to the teaching-learning process, so that it can be realized in its greatest sense (ALVES, 1995; FREIRE, 1999). Like no other form of language, artistic language offers us, especially when enhanced by technological devices, concrete possibilities for building more enriching paths for school study, opening up spaces for dialogue with other curricular components (GASPARETTO, 2014). Daily activities driven by sound, calculations and physical movements in their causes and effects, dialogically, allow us to realize the presence of the magic of interdisciplinarity between sciences and arts.

The relationships between the areas of science and the arts involved in the experiences of our lives go far beyond the verbs of observing, counting and singing. In this context, it is worth remembering the magic pointed out by the Greeks, in ancient times, when they considered that music contained a hidden arithmetic and mediated and enriched the understanding of natural phenomena (CONDE, 2006). MusiFisiMat, in one of its motivating points, defended and encouraged the use of art associated with new Technologies (computers, cell phones, videos, interactive games, internet), at CBNB, as increasingly indispensable tools for learning in tune with students' life experiences. Much has been discussed in academic circles about pros and cons, about real limits and possibilities and about concerns about the systematic use of art and new technologies at school (MATOS, 2003; MORETTO & FEITOZA, 2021). We agree with scholars in these areas and are convinced that such resources are irreplaceable instruments in encouraging and helping school research that is essential to enriching their individual and/or group work. To this end, it is important that they are included in a systematic and complementary way to conventional didactic, pedagogical and student evaluation models, in classrooms and other educational spaces (CURSINO, 2019; MORETTO & FEITOZA, 2021). MusiFisiMat sought to regularly and judiciously employ interdisciplinarity at CBNB, employing new Technologies in the various artistic and scientific activities (arts, mathematics and physics workshops and laboratory experiments, in-person and virtual), in study spaces. These spaces were intended

to encourage the so-called exact sciences to adopt, in their pedagogical practices, greater freedom of expression and the establishment of dialogue with other areas, a fundamental point for the process of reconnecting human knowledge, a pressing challenge for the present and, more furthermore, for the future (MORIN, 2002). This is a starting point towards cutting-edge ideas in contemporary education advocated by thinkers who aim to enrich knowledge within the broadest academic spectrum and the most significant human activities (EGLER, 2014; FAZENDA, 1999; MORIN, 2000). This way, we envision a real possibility of bringing teachers and students together so that they become protagonists in the construction of a truly inclusive school. This is how this study seeks to contribute to reflections on the possibilities of enriching the school space, which urgently needs to become more accessible, dynamic and attractive.

METHODOLOGY

This research was carried out in the academic years 2011 to 2014, with the help of interns from the Arts and Physics disciplines, together with elementary school students, based on authorization granted in 2010 by the General Director of CBNB, Luiz Otávio Ebendinger Martins.

The work used a semi-open and unidentified questionnaire (Figure 1), applied to students participating in MusiFisiMat activities, at the beginning and end of the SEMESTERs of each academic year throughout the research. The research is characterized as mixed because it presents, at the same time, numerical information through percentages attributed by interviewees in response to the questions present in the questionnaire and comments suggested in each of them. The choice of this type of research is due to the fact that it opens up possibilities for interviewees to express opinions, evaluations and suggestions, which enriches and diversifies the deeper analysis of interviewees' perceptions (LUDKE & ANDRÉ, 1996).

Reply and comment if necessary:

1) Question 1: Rate from zero to 100 the importance of relating Physics with Music (and other artistic languages), in MusiFisiMat. Answer:..... Comment on the answer:.....;

2) Question 2: Rate from zero to 100 the importance of relating Mathematics to Music (and other artistic languages) in MusiFisiMat. Answer:..... Comment on the answer:.....;

3) Question 3: Rate from zero to 100 the importance of relating Physics with new Technologies, in MusiFisiMat. Answer:..... Comment on the answer:.....;

4) Question 4: Rate from zero to 100 the importance of relating Mathematics to new Technologies, in MusiFisiMat. Answer:..... Comment on the answer:.....;

5) Question 5: Rate from zero to 100 the importance of relating Music (and other artistic languages) with new Technologies, in MusiFisiMat. Answer:..... Comment on the answer:.....

Figure 1 – Half-open questionnaire without student identification

RESULTS

The numerical information, obtained from the evaluations of interviewees when they assigned values from zero to one hundred as answers to the questions in the questionnaire, and the most expressive comments, regarding each of these questions, are shown below.

Question 1 sought to probe the interviewee's perception of the importance of having related Physics with Music in MusiFisiMat. We present the average ratings given by students to this question over the 4 academic years in Table 1.

MONTH	SEMESTER	YEAR			
		2011	2012	2013	2014
MARCH	1º	45	33	38	35
JUNE	1º	58	55	50	60
AUGUST	2º	68	60	65	65
NOVEMBER	2º	85	90	93	95
TOTAL ANNUAL AVERAGE		64	59,5	61,5	63,8

Table 1 – Importance of relating Physics to Music

Question 2 probed the interviewee's perception of the importance of the relationship between Mathematics and Music in MusiFisiMat. We present the average ratings given by students to this question over the 4 academic years in Table 2.

MONTH	SEMESTER	YEAR			
		2011	2012	2013	2014
MARCH	1º	35	38	35	40
JUNE	1º	40	43	43	55
AUGUST	2º	43	48	50	58
NOVEMBER	2º	63	65	70	78
TOTAL ANNUAL AVERAGE		45,3	48,5	49,5	57,8

Table 2 - Importance of relating Mathematics to Music

Regarding question 3, which probed the interviewee's perception of the importance of relating Physics with new Technologies in MusiFisiMat. The average student evaluations, in each of the interviews in the 4 academic years, are presented in Table 3.

MONTH	SEMESTER	YEAR			
		2011	2012	2013	2014
MARCH	1º	70	78	75	80
JUNE	1º	75	80	85	88
AUGUST	2º	78	83	88	90
NOVEMBER	2º	93	98	95	98
TOTAL ANNUAL AVERAGE		79	84,8	85,8	89

Table 3 - Importance of relating Physics with Technologies

Question 4 probed the interviewee's perception of the importance of relating Mathematics to new Technologies in MusiFisiMat. We present the average ratings given by students to this question over the 4 academic years in Table 4.

MONTH	SEMESTER	YEAR			
		2011	2012	2013	2014
MARCH	1º	60	55	63	65
JUNE	1º	68	65	73	75
AUGUST	2º	75	68	83	78
NOVEMBER	2º	90	85	90	88
TOTAL ANNUAL AVERAGE		73,3	68,3	77,3	76,5

Table 4 - Importance of relating Mathematics to Technologies

Regarding question 5, which probed the interviewee's perception of the importance of relating Music to new Technologies in MusiFisiMat. The average ratings of respondents in each of the 4 interviews in each of the 4 academic years are presented in Table 5.

MONTH	SEMESTER	YEAR			
		2011	2012	2013	2014
MARCH	1º	40	50	45	55
JUNE	1º	55	65	60	70
AUGUST	2º	70	75	78	80
NOVEMBER	2º	88	90	85	93
TOTAL ANNUAL AVERAGE		63,3	70	67	74.5

Table 5 - Importance of relating Music to new Technologies

We can observe that the five tables show numerical values with constant ascendance, from the beginning to the end of each semester of each academic year from 2011 to 2014. In relation to the total annual average, Table 1 shows a growth trend of this average, over the years. years, with the exception of 2012. Tables 2 and 3 show numerical data in constant growth. Table 4 shows, irregularly, a small

upward trend in the total annual averages. Table 5 shows a trend of annual numerical growth, with the exception of 2013.

Some student comments may corroborate the numerical results obtained, such as those set out below:

"We make our own study material in the classroom and at home with the help of teachers, using information from the internet that is not in books.";

"Websites about the subjects made us understand the topics of the subjects more and have more desire to participate in classes.";

"In addition to making studies fun, the project helped us not to be afraid of failure and improve our grades and as time goes by we realize that mathematics mustn't just teach how to count and music mustn't just teach to sing. Things are beyond what we think and they are all interconnected...";

"We helped teachers organize Fairs on "The relative movements between the Sun, Earth and Moon, we watched 3D videos and then we made models of the Seasons and Phases of the Moon.";

"We researched several websites and set up ambient rooms with African scenes and clothing at the Culture Fair on Astronomy in Africa, which had a lot of music and dancing.";

"At the Culture Fair, we organized work on Indigenous Astronomy and the culture of the Guarani people in a workshop environment, taking information from the internet.";

"We did a lot of research into Torricelli's life and his mathematical equation. We used interactive games showing the relationship between this equation and the free fall phenomenon and presented some cool work at the Fair.";

"Technologies increase our interest, imagination and creativity. It's school life that has lost its charm for most students. Music, Physics and Mathematics teachers need to always work with them together to improve general understanding and true interest.";

"The MusiFisiMat workshops using the internet were very important for the class to understand mathematics and physics through graphic literacy, the relationships between mathematics and physics graphs and the relationships between kinematic graphs between speed and time and space it's time.";

"In the project I studied physics and learned a lot about mathematics using the internet in classes on Optics, Thermology, Electricity and Mechanics. By making models and using the internet, my grades improved in Physics and Mathematics.";

"I learned Astronomy through research work on the solar system on the internet and we put together models with the planets showing the distance and size relationships between them. My grade improved in Physics and Mathematics."

DISCUSSION

To enrich the analyses, it was important to draw parallels between numerical results and some of the interviewees' statements throughout each of the four academic years, from the beginning of the first semester to the end of the second semester.

The students' statements reinforce the numerical data recorded in the tables that reveal a constant growth in the acceptance and recognition of MusiFisiMat by its participants, which reflects the increase in students' perception of the interdisciplinary relationships between Music, Physics, Mathematics and new Technologies : "So much happens in our lives and we didn't make the connection with what we studied at school in Music, Science, Mathematics, etc."; "[...] as time goes by we realize that the beauty of mathematics, which is not just using numbers, but when it is combined with physics and music it makes us learn more."; "[...] new technologies help us see that things are beyond

what we think and are all interconnected in science, arts and mathematics [...]." Such comments from the interviewees make us reflect on the fact that music, countless mathematical experiments and the most diverse physical phenomena were observed by students in MusiFisiMat. We highlight that throughout the process of association between music, physics and mathematics, we, teachers, were always present, reinforcing the humanization and socialization of students. In this regard, we quote the speech of one of the interviewees, when we worked on concepts of time fractionation through the symbols used in the musical stave and in the practice of solfeggio: "We study music through mathematics and mathematics through music using musical staves, with the help of our teachers, videos and the internet. Today I'm studying guitar because of the project."

The speeches of the interviewees we analyzed, about the use of the internet by students in the classroom and in their homes, made mention of the classes in which we worked on acoustic phenomena (mechanical waves, frequency, amplitude) associated with the elements of music (notes musical values, pitch, chords, harmony, musical interval), demonstrating the relationship between physics and music, as follows: "The teachers, with the help of the internet, helped me understand what each thing in music means and through music physics becomes clearer when studying mechanical waves, frequencies, amplitudes. Everything is connected with everything!"; "I never forgot that each musical note corresponds to a sound frequency. Today I'm teaching physics to my singing teacher." Regarding the relationship between mathematics and physics, we explored technological resources to highlight the decoding of kinematic phenomena associated with dynamic phenomena through graphic relations interacting with the respective mathematical expressions in a dynamic way. This work served as a form of graphic literacy, a method used in teaching Mathematics and Physics subjects, carrying interface elements between them. Very interesting in the use of new technologies, with the use of videos and interactive games, were the activities of studying Optics, Acoustics, Thermology, Electricity, Mechanics, Astronomy. We emphasize that new technologies are instruments that enhance and facilitate knowledge. They were used in MusiFisiMat to streamline relevant information and knowledge and to understand the basic content of the disciplines, contributing to the construction of pedagogical spaces that are richer and more differentiated from the conventional ones. In this regard, the following statements stand out: "Using the internet freely in Art, Physics and Mathematics classes was very important. It helped us to have more interest and value our studies and to have more respect at school with our teachers and colleagues." and "[...] made school life increasingly enjoyable for the majority of students."

CONCLUSION

This work reinforces the idea that new technologies have been facilitating the process of reconnecting human knowledge, a pressing challenge for the present and, even more so, for the future, a unique possibility, as seen in rare other situations, of establishing effectively the relationship between reason and emotion at school (MORIN 2002).

We think that this school assumes its inclusive and humanizing role as it positions itself towards greater freedom of expression and the establishment of more dynamic and fruitful dialogue practices. The increase in students' perception of the relationship between music, physics and mathematics, as a factor in improving school performance, was an indication of MusiFisiMat's success in this

direction.

The numerical results and the interviewees' comments allowed us to observe that the interaction between music, physics and mathematics with the use of new Technologies in MusiFisiMat favored students' perception of the importance of interdisciplinarity for improving academic performance, regarding aspects of learning and behavioral, as well as socialization.

We reiterate, through MusiFisiMat, the urgency of making school education more accessible, dynamic and attractive, capable of promoting greater rapprochement between the student and the school, an essential movement for it to become more inclusive and complete. Based on this idea, reflections on the importance of inserting artistic languages enhanced by new technologies in the school education process have been encouraging Project teachers to carry out new research involving this theme.

REFERENCES

ALVES, Rubem. **Conversas com quem gosta de ensinar**. São Paulo: Ars Poética, 1995.

BRITO, Teca Alencar de. **Música na Educação Infantil:** proposta para a formação integral da criança. Editora São Paulo: Petrópolis, 2003.

CONDE, Carlos Basílio. **Pitágotras – Ciência e Magia na Antiga Grécia.** São Paulo: Editora Madras, 2006.

CURSINO, André Geraldo. **Tecnologias na Educação - Contribuições para uma aprendizagem significativa.** São Paulo: Appris Editora, 2019

DOHME, Vânia. **Atividades lúdicas na educação: o caminho de tijolos amarelos do aprendizado.** Petrópolis: Vozes, 2004.

DUARTE JR, João Francisco. **Por que Arte-Educação?** 5 ed. Campinas: Papirus, 1988.

EGLER, Tamara Tania Cohen (Org.). **De baixo para cima: Política e tecnologia na educação.** Rio de Janeiro: Letra Capital, 2014.

FAZENDA, Ivani Catarina Arantes. **Práticas interdisciplinares na escola**. São Paulo: Cortez, 1999.

FREIRE, Paulo. **Pedagogia da autonomia.** São Paulo: Paz e Terra, 1999.

GASPARETTO, Débora Aita (Org.). **Arte-Ciência-Tecnologia: o sistema da arte em perspectiva**. Santa Maria: Lab Piloto, 2014. Disponível em: http://artedigitalbr.wix.com/circuito. Acesso em julho de 2014.

LUDKE, Menga & ANDRÉ, Marli. **Pesquisa em educação: abordagens qualitativas.** São Paulo: EPU, 1996.

MATOS, Cauê (Org.). **Ciência e arte. Imaginário e descoberta.** São Paulo: Terceira margem, 2003.

MORETTO, Milena & FEITOZA, Claudia Abreu (Orgs.). **Tecnologias e Educação - Desafios e Possibilidades.** São Paulo: Paco Editorial, 2021.

MORIN, Edgar. **Os Sete saberes Necessários à educação do Futuro**. Rio de Janeiro: Cortez, 2000.

MORIN, Edgar (Org.). **A religação dos saberes: o desafio do século XXI**. Rio de Janeiro: Bertrand Brasil, 2002.

ROMANELLI, Guilherme. **Como a música conversa com as outras áreas do conhecimento.** Revista Aprendizagem. Pinhais, n.14, p.24-25, 2009.