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Promoting mathematics teaching with real life scenarios in the context of COVID-19 pandemic

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STEM education provides students with 21st century skills considered critical to correspond to the increasing challenges of the real world, and to face an increasing demand for specialized STEM labor. However, there are several issues related to skills shortages in STEM fields, namely related to mathematics. In this regard, it is crucial to highlight the role of the M in STEM in order to innovate and improve the teaching of mathematics. This paper presents an integrated approach of STEM education highlighting the role of mathematics to understand a real-world problem in the context of COVID-19 pandemic. With a qualitative methodology and based on a case study, this research shows mathematical tasks to raise awareness of students of how the virus spreads and to understand the need for isolation measures, among others. Based on this research it is recommended to resort to mathematical tasks based on real world scenarios to promote meaningful learning in students.

Keywords: STEM education, mathematics education, hands-on, COVID-19 pandemic.

Introduction

To face an increasing demand for specialized STEM (Science, Technology, Engineering and Mathematics) labor, it is recommended to implement STEM education to provide students with 21st century skills considered critical to correspond to the challenges of the real world (e.g., Baker & Galanti, 2017). However, there are issues related to skills shortages in STEM fields, namely related to mathematics. For example, it is referred that mathematics contributes to the problem of insufficient STEM graduates (e.g., Beswick & Fraser, 2019). Therefore, there is a need to highlight the role of M in STEM in order to innovate and improve mathematics teaching (Stohlmann, 2018). In particular, a context that integrates M with Science, Technology and Engineering (STE) can provide meaningful connections between mathematics and STE subjects in students (Becker & Park, 2011).

This paper presents an integrated approach of STEM education highlighting the role of mathematics to understand a real-world problem. COVID-19 pandemic has invaded our world and conditioned our way of living (Padmanabhan et al., 2021). For example, students had to be isolated in their homes without going to face-to-face classes for several months. In addition, every day the news reveal the number deaths, of newly infected, and the total number of people infected, among other information related to the disease. The main research question is “How can mathematics be used to make students understand a real-life pandemic scenario?” To answer the research question, a case study of a 6th grade teacher, who participated in a Professional Development Programme (PDP) will be presented. Her example shows the implementation of integrated STEM tasks in class with focus on mathematics.

Literature Review

To face a fast-changing world and the complexity of modern societies, the literature advocates the need for motivating students to learn and gain skills related to STEM subjects (Kelley & Knowles,

2016; Roehrig et al., 2021). In addition, STEM education should make the transition from traditional lecture-based teaching strategies to more inquiry and project-based approaches (Breiner et al., 2012), with the aim of providing students with skills to solve real life challenges and improve their achievement (Beswick & Fraser, 2019; Geiger, 2019). In this regard, the introduction of STEM education, based on real life scenarios, motivates students to learn and promotes the development of 21st century skills (English, 2017; European Schoolnet, 2018; Maass et al., 2019). In Portugal, there are also increasing calls for innovative approaches, having recently emerged several guidelines, namely on Essential Learning (MEC, 2018) in conjunction with the Profile of Students When Completing Mandatory Schooling (ME/DGE, 2017). The last document mentions the need for educational systems that contribute for the development of skills that allow students to respond to the complex challenges of the 21st century, taking into account the evolution of knowledge and technology. In this sense, the curriculum must be interpreted by teachers to explore different themes that must be framed in everyday problems of both the students and the socio-cultural environment where they are inserted in (ME/DGE, 2017). In this regard, meaningful learning should be provided by relating the most important contents of the subject to be taught with relevant aspects of the student's cognitive structure including the environment where the student is inserted in (Ausubel, 2012).

An integrated approach of STEM education should include real-world scenarios with the aim of engaging students and providing them with meaningful learning (Kelley & Knowles, 2016; Maass et al., 2019). In fact, modern world face complex problems that involve interdisciplinary knowledge and skills to solve them, which requires for curricular integration in schools (Roehrig et al., 2021). In addition, mathematics should be more emphasized in STEM integration (Stohlmann, 2018). Moreover, STEM education can be a form of innovation for teaching mathematics (Fitzallen, 2015) and to increase mathematical performance (Stohlmann, 2018). Furthermore, there is a need to develop research to understand how STEM integration can promote mathematics education (Baker & Galanti, 2017). However, the role of mathematics is understated within the STEM field. Therefore, it is necessary to develop more research to make mathematics more meaningful across disciplines, and also to support teachers in this direction (Maass et al., 2019). In fact, teachers have a crucial role on adapting their practices to provide students with the contexts and strategies recommended to provide an effective STEM education in schools (Kelley & Knowles, 2016; Stohlmann et al., 2012). In addition, an increasing number of authors argue about the importance of integrating the four disciplines included in the STEM acronym (Costa et al., 2020; Kennedy & Odell, 2014).

In 2020, COVID -19 pandemic, caused by coronavirus SARS-COV-2, seriously affected all life in the world (Meehan et al., 2020). The pandemic reminded us that the future is uncertain and consequently there is a need for preparing citizens and education systems for what may come, which can include changes that we are not expecting (OECD, 2020). Therefore, virulent communicable diseases are one of the global challenges that must be addressed in the context of STEM education (Maass et al., 2019). More information about modelling COVID-19 pandemic can be provided by Meehan et al. (2019) and Padmanabhan et al. (2021).

Methodology

In this paper, we use a qualitative research methodology and an interpretative approach by resorting to a case study (Cohen, Lawrence, & Keith, 2007). A case study is an empirical research that observes

a phenomenon within its real-life context, allowing a generalization of the results obtained, and requiring skills and expertise from the researchers (Yin, 2014).

First authors of this paper designed a PDP that includes several workshops with the aim of providing teachers with knowledge and skills to develop and implement STEM hands-on practices in class. In the school year 2020/2021 the programme occurred exclusively online because of the COVID-19 pandemic. Despite being online, the educators tried to preserve the hands-on practices by exemplifying them through videos and interactive sessions through the Zoom platform. Teacher Elisa (fictitious name) case study was chosen to exemplify how to develop an integrated approach of STEM education based on real life scenarios such as COVID-19 pandemic. She is a Mathematics and Natural Sciences teacher who participated in the referred PDP, aged 55 years old, 30 years of in-service experience and in charge of two 6th grade classes (10 to 11 years old). At the end of the PDP (2021 January), Elisa (like all the other teachers) presented a final report that includes a critical account and her perceptions about the programme, and also proposals of tasks to implement, as well as evidence of the activities developed in class. Data collected include participant observation that occurred during the workshops of the PDP (first author was present in all the workshops, where focus group was promoted) and content analysis of Elisa's final report. In addition, five interviews were conducted with the teacher by phone to better interpret the case.

Data analysis, results and discussion

In this section, it is analyzed Elisa's case study that shows the development and implementation of mathematical tasks within the context of COVID-19 pandemic. Elisa was very participative in the workshops. In addition, in the interviews she mentioned that she wanted to develop activities that were within the curricula she was lecturing and that had meaning for her students. It was not easy to choose a theme that was appropriate for her students and included in the curricula of their grade level. However, after several discussions with the educators, she finally opted by an interdisciplinary theme in the context of COVID-19 pandemic, in order to use mathematics to help interpret and predict the evolution of the pandemic according to various possible contagion scenarios Inspired on Providência (2020) paper, Elisa planned and developed several tasks to be implemented in class.

Table 1: Tasks implemented in the mathematics class

Tasks	Scenario of infection
1	Each student infects two colleagues
2	Each student infects three colleagues
3	Each student only infects one colleague
4	Probability to infect someone is less than one
5	80% of students are vaccinated

In a first stage, she introduced COVID-19 thematic in the Natural Sciences class because the virus context is part of the curricular contents of this discipline, in the field of Environmental Aggressions and Integrity of the Organism. In a second stage, she developed several tasks to be implemented in the mathematics' class. Table 1 describes some possible scenario of infection proposed to the students to help them understand the need for isolation or vaccination measures. It is important to notice that in the 6th grade level it is not possible to resort to advanced mathematics to model the pandemic.

In task 1, Elisa explained the scenario where “Each student infects two colleagues” and that “Sick students are isolated at home and no longer infect colleagues”. She also constructed a grid with 12 lines and 12 columns, where each square represents one student from a school (Figure 1). In addition, a table with the “Day” in the first column, the “Number of students who gets sick” in the second column and the “Total number of sick students” in the third column was constructed (Table 2). After, she asked the students to paint the number of sick students on the grid.

Teacher: Imagine that each square on a grid (Figure 1) represents a student from a school. One day, which we will call day 1, one of the students becomes sick with COVID-19. Represent him, painting a red square on the grid.

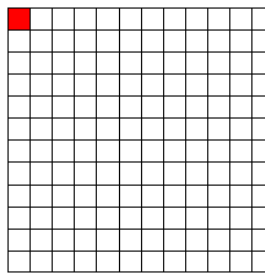


Figure 1: Grid where each square represents one student in a school with 144 students

She also asked students to fill in Table 2 with this information. Next, she gives information about how the sick student infects the others.

Teacher: Let’s now assume that each sick student infects two students on average. To say that it is on average means that it may be that only one person infects one colleague, but there is another that infects three. Therefore, on average, each person infects two colleagues. So, the next day, day 2, there are 2 more students with COVID-19 who were infected by the first student with this disease; in all, there are already 3 sick students. Therefore, paint two more squares on the grid, and fill in the table with this information: on day two, 2 in column two and 3 in column three.

Teacher: Again, sick students are isolated at home and no longer infect colleagues. Now, each of these two students is going to infect two other colleagues, and on the third day there are four more sick students. Therefore, paint four more squares on the grid, and fill in the table with this information.

Table 2: Each student infects two colleagues

Day	Number of students who gets sick	Total number of sick students
1	1	1
2	2	3
3	4	7
4	8	15
5	16	31
6	32	63
7	64	127
8	128	255

Next, she asks several questions:

- How many new students will be infected on the 4th day?
- And what is the total number of sick students?
- In what day is everyone sick?

- d) What if the school had 1000 students, after how many days would all students be sick?
 e) Can you write the numbers of column 2 in powers of two?

Table 2 is filled with the numbers until the day where all the squares on the grid (Figure 1) are red, which means that all 144 students are sick. As can be seen, on the 8th day all students are sick, in a school with a number of students bigger than 127 and smaller or equal to 255 students. Almost all students from two classes of Elisa presented the results as stated on Table 2.

Only two students, one from each class, considered that the school only had 144 students, and for this reason, in the 8th day only 17 students get sick and consequently the total number of sick students is 144 (Figure 2, table on the left). Below follows the answer of one of these two students.

Student: On the 8th day, only 17 students get sick because in total there are only 144 students in the school and 127 students are already infected, so only 17 students are missing.

The same student also presented the table on the right of Figure 2 to answer that at the 10th day all students from a school with 1000 students would be sick.

dia	n.º de alunos que adoecem	n.º total de alunos doentes
0	0	0
1	1	1
2	2	3
3	4	7
4	8	15
5	16	31
6	32	63
7	64	127
8	17	144
9		
10		

dia	n.º de alunos que adoecem	n.º total de alunos doentes
0	0	0
1	1	1
2	2	3
3	4	7
4	8	15
5	16	31
6	32	63
7	64	127
8	128	255
9	256	511
10	512	1023

Figure 2: Each student infects two colleagues

n.º de alunos que adoecem	Forma de potência	Continuação
1	(1) 2^0	64 2^6 ✓
2	(2) 2^1	128 2^7 ✓
4	2^2 ✓	256 2^8 ✓
8	2^3	512 2^9 ✓
16	2^4 ✓	
32	2^5 ✓	

$2^0 - 1$
 $2^1 - 2$
 $2^2 - 4$
 $2^3 - 8$
 $2^4 - 16$
 $2^5 - 32$
 $2^6 - 64$
 $17^1 - 17$

Figure 3: Writing the numbers in column 2 in powers of two

In addition, Elisa asked students to write the numbers in column 2 in powers of two. A power of two is a number of the form 2^n where n is an integer, that is, the result of exponentiation with number two as the base and integer n as the exponent. Based on this question, she explained to the students that “the growth of students sick with COVID-19 was exponential”. Figure 3 gives examples of answers given by students. On the left, the result given by most of the students and on the right one of the students who considered the total number of students on the school as 144.

After ending task 1, teacher Elisa introduced the following tasks as stated on table 1. During the task 2, where “Each student infects three colleagues” teacher Elisa observed excitement in her students:

At this stage, a high point of motivation of the students was visible in solving the task. They were excited because they understood the situation they are experiencing in their real life (Final report).

She continues, exemplifying students' discourse:

"Now I understand, now I understand everything, this is so fast, contagion, ... and we are not counting everyone, families are missing and other people who have contact with them!"

Based on the tasks performed in class, reflection and discussion about them, Elisa recognizes motivation in her students who finally understood “frightening spread of the virus”. Although she already introduced this theme previously, she reinforces that it was with these tasks that students finally understood the need for measures to prevent propagation of the disease:

I had already taught the content of “Microorganisms” and obviously had contextualized and integrated the whole problem of the pandemic, but it was with this activity that students finally understood the reason for measures to prevent the spread of the disease. (Final report)

This conclusion is in line with her goals, which was to raise awareness and understanding about the need for measures in the context of COVID-19 pandemic, such as social isolation or vaccination. In addition, Table 3 shows STEM contents included in the tasks developed and implemented by Elisa.

Table 3: STEM contents of the tasks implemented by teacher Elisa

Science	Technology	Engineering	Mathematics
Natural sciences	Computer	Planning, designing and performing the activities.	Powers, Exponential growth
Microorganisms	Internet		Mathematical model
Disease spread	Wikipedia		Variable, Iteration
Pandemic	Power Point		Functions, Graphics
	Excel.		Organization of tables and data visualization.

Also, she highlights the interdisciplinary approach provided in the tasks:

On the other hand, the interdisciplinary aspect of the task allowed the articulation of the disciplines of Natural Sciences, Mathematics and Information and Communication Technologies and, thus, to participate in the Domain of Curricular Autonomy and Flexibility, as well as in the School Educational Project.

Finally, Elisa identifies the importance of implementing this approach to better prepare students to the real-world challenges. Moreover, she intends to keep participating in this type of PDP:

In today's world, full of complex challenges, the development and integration of multiple literacies, inspired by real situations, will certainly allow for more meaningful learning in which talent, individual qualification, the scientific system and democratic citizenship are strengthened. We are grateful for the opportunity and we await other formative moments of undeniable value.

In summary, teacher Elisa case study exemplifies the implementation of interdisciplinary tasks related to STEM (Table 3), in particular highlighting the role of mathematics to understand real world problems such as the need for isolation measures or vaccination due to COVID-19 pandemic. As can

be seen in Table 3, mathematical contents include Powers, Exponential growth, Mathematical model, Functions, Graphics, Organization of tables and data visualization, amongst others.

Conclusions

It was verified that Elisa did develop STEM practices within an authentic context for the purpose of connecting these subjects to enhance students' meaningful learning (Ausubel, 2012; Kelley & Knowles, 2016). In fact, she used the real scenario of COVID_19 pandemic with the aim of introducing tasks with meaning for her students and related to the curricula of Natural Sciences, Mathematics, and Information and Communication Technologies. Moreover, she achieved one of her main objectives, which was to make students understand various virus propagation scenarios and be aware for the need of isolation or vaccination measures to face the COVID_19 pandemic (Table 1). In addition, her example shows the development and implementation of integrated STEM tasks in the class with an important focus on Mathematics (Table 3). Furthermore, Elisa recognized that it was based on this approach that students finally understood the problematic of exponential grow of infection and its impact on real life. Also, she identified critical thinking skills and meaningful learning as a consequence of this initiative. Her conclusion is in line with Stohlmann et al. (2012), who states that a strategic approach of STEM education provides students with higher levels of critical thinking skills, improves problem solving skills, and also increases learning retention. Moreover, relevant interdisciplinary learning environments were provided as recommended by some authors (Beswick, & Fraser, 2019; Geiger, 2019). In fact, Elisa highlights the interdisciplinary approach provided in the tasks she implemented in class and also the importance of implementing this approach that provides students with meaningful learning and better prepares them to the real-world challenges. Indeed, she promoted mathematics teaching with real life scenarios in the context of COVID-19 pandemic. Based on this research, it is recommended to resort to mathematical tasks based on real world scenarios to promote meaning learning in students.

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References

- Ausubel, D. P. (2012). *The acquisition and retention of knowledge: A cognitive view*. Springer Science & Business Media.
- Baker, C. K., Galanti, T. M. (2017). Integrating STEM in elementary classrooms using model-eliciting activities: responsive professional development for mathematics coaches and teachers. *International Journal of STEM Education*. 4(1), 1-15. <https://doi.org/10.1186/s40594-017-0066-3>
- Becker, K, Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education*, 12(5 & 6), 23-37.
- Beswick, K. & Fraser, S. (2019). Developing mathematics teachers' 21st century competence for teaching in STEM contexts. *ZDM Mathematics Education*, 51, 955–965. <https://doi.org/10.1007/s11858-019-01084-2>

- Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics, 112*(1), 3-11. <https://doi.org/10.1111/j.1949-8594.2011.00109.x>
- Cohen, L., Lawrence, M., & Keith, M. (2007). *Research Methods in Education*. 6th Edition. Taylor and Francis Group.
- Costa, M. C., Domingos, A., & Teodoro, V. (2020). Promoting integrated STEM tasks in the framework of teachers' professional development in Portugal. In Anderson, J. & Li, Y. (Eds.), *Integrated Approaches to STEM Education. Advances in STEM Education*. (pp. 511-532). Springer, Cham. https://doi.org/10.1007/978-3-030-52229-2_27
- English, L. D. (2017). Advancing Elementary and Middle School STEM Education. *International Journal of Science and Mathematics Education, 15*(1), 5-24. <https://doi.org/10.1007/s10763-017-9802-x>
- European Schoolnet (2018). Science, Technology, Engineering and Mathematics Education Policies in Europe. Scientix Observatory report. October 2018, European Schoolnet, Brussels.
- Fitzallen, N. (2015). STEM Education: What does mathematics have to offer? In M. Marshman (Eds.), *Mathematics Education in the Margins*. Proceedings of the 38th Annual Conference of the Mathematics Education Research Group of Australasia, Sunshine Coast, pp. 237-244.
- Geiger, V. (2019). Using mathematics as evidence supporting critical reasoning and enquiry in primary science classrooms. *ZDM-Mathematics Education, 51*(6), 929-940. <https://doi.org/10.1007/s11858-019-01068-2>
- Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*(1), 11. <https://doi.org/10.1186/s40594-016-0046-z>
- Kennedy, T. J., & Odell, M. R. L. (2014). Engaging students in STEM education. *Science Education International, 25*(3), 246-258.
- Maass, K., Geiger, V., Ariza, M. R., & Goos, M. (2019). The role of mathematics in interdisciplinary STEM education. *ZDM, 51*(6), 869-884. <https://doi.org/10.1007/s11858-019-01100-5>
- Meehan, M. T., Rojas, D. P., Adekunle, A. I., Adegboye, O. A., Caldwell, J. M., Turek, E., ... & McBryde, E. S. (2020). Modelling insights into the COVID-19 pandemic. *Paediatric respiratory reviews, 35*, 64-69. <https://doi.org/10.1016/j.prrv.2020.06.014>
- Ministério da Educação/Direção-Geral da Educação (MEC/DGE). (2017). *Perfil dos Alunos à Saída da Escolaridade Obrigatória*. Lisboa: Autor.
- Ministério da Educação e Ciência (MEC). (2018). *Aprendizagens Essenciais de Matemática – 7.º ano*. Lisboa: Autor.
- OECD (2020), *Back to the Future of Education: Four OECD Scenarios for Schooling*, Educational Research and Innovation, OECD. Publishing, Paris. <https://doi.org/10.1787/178ef527-en>.
- Padmanabhan, R., Abed, H. S., Meskin, N., Khattab, T., Shraim, M., & Al-Hitmi, M. A. (2021). A review of mathematical model-based scenario analysis and interventions for COVID-19. *Computer Methods and Programs in Biomedicine, 106301*. <https://doi.org/10.1016/j.cmpb.2021.106301>
- Providência, C. (2020). Quando estarão todos doentes? *Gazeta da Física: Vamos experimentar, 43*(2), 37-39.
- Roehrig, G., Dare, E., Ring-Whalen, E., & Wieselmann, J. (2021). Understanding coherence and integration in integrated STEM curriculum. *International Journal of STEM Education, 8*(1), 1-21. <https://doi.org/10.1186/s40594-020-00259-8>
- Stohlmann, M. (2018). A vision for future work to focus on the “M” in integrated STEM. *School Science and Mathematics, 1*-10. <https://doi.org/10.1111/ssm.12301>
- Yin, R. K. (2014). *Case study research: Design and methods*, (5th ed.,). Thousand Oaks: Sage Publishing.