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Understanding our world in a time of crisis: Mathematics education pedagogy toward financial numeracy

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Abstract

This paper aims to address some implications for mathematics education regarding the financial and economic implications of the beginning of the COVID-19 pandemic. We use the term financial numeracy to refer to the quantitative aspect of financial education while also arguing for it to be considered a domain of mathematics education. Financial numeracy entails three dimensions: contextual, conceptual, and systemic. We bring three examples of financial implications of the crisis in different countries. Based on these examples, we constructed learning situations that reflect the distinct orientations of each dimension of financial numeracy to clarify the teaching of such a concept in school mathematics. Particularly in a time of crisis, mathematics education must address immediate needs of society as well as contribute to overcoming social challenges. We hope that financial numeracy brings innovative solutions to teach mathematics in a way that helps individuals and communities produce and manage resources while protecting the planet.

Keywords: COVID-19, Financial Education, Financial Literacy, Financial Mathematics, Financial Numeracy, Mathematics Pedagogy

Introduction

This paper aims to address some implications for mathematics education about the global crisis, in particular the recent health crisis, namely the pandemic caused by the COVID-19. The pandemic crisis caused by the COVID-19 started in December 2019 in Wuhan, China. The rest of the world was badly hurt in February and March 2020 and will continue to struggle until a vaccine is created. We do not know yet what the world will look like after that. This pandemic reminds us of other important crises in the past such as the 2008 financial meltdown, the Great

Depression of 1929, the Spanish flu in 1918, and the ongoing challenges of climate change and the refugee crisis.

Globally, those crises have affected people's lives at different levels and in different ways. Something common to all of them, though, is their economical or financial aspect. All of them have had a unique economic impact to individuals and communities. For instance, the 2008 financial crisis started off with a massive default on mortgages across the United States and impacted millions of individuals in terms of their jobs and housing situations. Once the contagion hit other parts of the economy, some countries were even close to bankruptcy (Iceland, for example). Many currencies devalued fast, which impacted the financial burden of many households. It is clear by now, that housing unaffordability has become extreme in many parts of the world as a consequence of the 2008 financial meltdown.

The current crisis shaped the world in a way that we are still discovering the effects. We argue that numeracy is absolutely necessary for all citizens in order to understand the complexity of the pandemic before, during and after the crisis. This health crisis has important economic consequences for countries, communities, and individuals. Therefore, financial numeracy is strongly needed for all to develop and sustain citizenship attitudes and behaviors. In this paper, our goal is to highlight how financial numeracy is important for students to make sense of some information shared by mainstream and social media. We argue that not only do we need to pay attention to the methods for teaching, but also to the content that we are teaching.

At this end, we propose three learning situations that will support students to understand more about the economic and financial impact of COVID-19 in terms of citizenship. The paper contributes to the research and practice communities by establishing a documentation of unique financial situations that happened at the beginning of the pandemic in the first semester of 2020, building on those situations to turn them into learning situations for use in mathematics classrooms, and contrasting those situations with an established theoretical framework of financial numeracy from the field of mathematics education. These financial situations offer a broader perspective by using examples coming from four continents: Asia, Europe, and North and South America.

A Definition of Financial Numeracy

We position financial numeracy within the field of mathematics education in order to address the need for financial education. This need has been growing both in research and among international organizations ever since the global financial crisis of 2008 (Arthur, 2012). The Organization for Economic Cooperation and Development (OECD), for example, recognizes the importance of financial education and has been evaluating students in this regard since 2012. The organization (OECD, 2019) uses the term financial literacy to refer to the "knowledge and understanding of financial concepts and risks, as well as the skills and attitudes to apply such knowledge and understanding in order to make effective decisions across a range of financial contexts, to improve the financial well-being of individuals and society, and to enable participation in economic life." (p. 18)

Despite many accounts of it's in the development of financial literacy (Althauser & Harter, 2016; Bansilal & Mkhwanazi, 2012; Lucey & Maxwell, 2011; Sole, 2014; Skagerlund, et al., 2018), the role played by mathematics in this process seems to be implicit. To make this role more explicit, we decided to use the term financial numeracy (Savard & Cavalcante, 2021). Here, numeracy means the knowledge, skills, confidence, and motivation to use mathematical concepts, procedures, and instruments to make sense of the world and actively participate in social life (Yasukawa et al., 2018). Therefore, we define financial numeracy as the mathematical, quantitative, numerical aspect of the production and the management of resources mediated by financial instruments (currencies, products, services). Production refers to developing actual and new resources (such as starting a small business or doing a fundraiser), while management refers to the use of existing individual and collective resources in order to promote well-being for oneself and their communities (such as keeping a family budget or saving for a larger purchase).

The use of financial instruments can also lead to assigning a value to an action (service) or an object (good). For example, currencies are used to establish the price of goods (such as a bicycle or a car) or services (such as public transportation). This use of financial instruments is always situated in a context; therefore, they include cognitive (knowledge) and social (values, tradition) aspects. For example, in many countries, it is possible to buy tea leaves from a local market or online. Local markets might expect consumers to engage in bargaining which requires specific knowledge of how to do so and how the local culture works. Purchasing tea leaves online does not involve bargaining, but it does require the consumer to know how to verify the safety of a website and avoid scams or fraud.

Understanding financial instruments is an important aspect of financial numeracy. In many places in the world, cash is the only instrument accepted for payment. However, in other places, such as China, the use of cash in local markets has been decreasing over time: only apps on smartphones are accepted. This trend is growing faster with the pandemic because many governments suggest avoiding cash in store to control the pandemic (that is the case of the provincial government in Quebec). It is very important to understand how those instruments work and when to use them in a thoughtful manner. At this end, the cognitive and social aspects of financial numeracy are important for mathematics educators interested in promoting critical thinking and developing citizenship competencies among students (Savard, 2015).

Previous work has discussed how participation in social life is based, among other factors, on financial decisions (Căprioară et al., 2020), so we argue that financial numeracy requires citizenship competencies such as critical thinking (Lipman, 2003; Paul & Elder, 2001) and decision making (Savard, 2018). In the next section, we present a conceptual framework to mobilize financial numeracy as a lens for task design in mathematics classes.

Financial Numeracy as Part of Mathematics Education

For many authors who publish in mathematics education (e.g., Yasukawa et al., 2018; Goos et al., 2019), numeracy refers to social practices used daily regarding mathematics. Mathematics provides rationale based on measures and quantities to make sense and understand the world

we live in. Counting, estimating, measuring, looking for trends of patterns are some mathematical practices used by individuals in daily life. Mathematicians also used them when doing mathematics. Therefore, we argue that financial numeracy should be considered part of mathematics education. Some concepts are already included within mathematics education curricula, such as financial mathematics. Financial mathematics can be defined as concepts in mathematics that model financial phenomena (such as compound interest and annuities), but it also includes measurement since money can be interpreted as a unit of measurement of economic value (Roegiers, 2013). In fact, financial numeracy is connected to all areas of mathematics. Mathematics education research has identified three dimensions related to the teaching of financial numeracy in mathematics education: contextual, conceptual, and systemic (Cavalcante, 2020).

The contextual dimension refers to using financial contexts to provide a real-life application to mathematics. In this case, the central goal is to teach a mathematical concept with the help of a situation that is familiar and engaging for students. Studies within the contextual dimension develop arguments and provide evidence related to the approach mentioned above. They take the concept of numeracy (OECD, 2016) to highlight the idea that students learn mathematics according to the contexts in which math is presented, and therefore we should be focusing on providing authentic situations when having mathematical discussions. By doing so, teachers will be able to increase the levels of engagement among students. Within this relationship, studies whose focus is usually on mathematics teachers investigate how they develop their mathematical knowledge or engage with mathematics in financial contexts (Althauser & Harter, 2016; Bansilal & Mkhwanazi, 2012; Pournara, 2013; Wilburne et al., 2007). Pournara (2016), for instance, reports the results of his doctoral research with South African teachers and argues that engaging with financial numeracy provides an opportunity for teachers to make connections between different mathematical concepts, therefore deepening their content knowledge. For the author, a financial context can be a gateway to explore how different branches of mathematics can be explored in the classroom.

The conceptual dimension refers to the teaching and learning of financial concepts through mathematical explorations. Differently from the previous one, this dimension puts financial concepts at the center of the learning goals. This dimension reveals how mathematics is an important medium for exploring and modelling financial situations, which in turn provide students with better understanding of the world around them. Authors who attend to this dimension are concerned with evaluating the (generally low) levels of financial knowledge among groups such as university students (García-Santillán et al., 2016; Hasek & Petrásková, 2010; Sole, 2014) and mathematics teachers (Bansilal, 2016; Lucey & Maxwell, 2011). It is also within this relationship that most studies about the teaching of financial mathematics have been conducted.

Finally, the systemic dimension refers to unpacking financial situations in relation to other epistemological systems (ethical, political, social, cultural, economic). It is about questioning how certain financial measures are defined and portrayed in society, and how mathematics is often used to convey certain values. For example, Baron (2015, p. 84) "applied

a robust social justice research vision to develop a framework for describing how participating families benefited from [a] financial and mathematical literacy project". Similarly, Lucey and Tanase (2012) also developed frameworks that conceptualize the use of mathematics and financial education to address social justice. According to authors from this dimension, mathematics empowers people to engage in critical debates in society, which is crucial in a time of crisis.

Finally, it is important to note that these three dimensions are not mutually exclusive. It is possible for a teacher to pay attention to multiple aspects of financial numeracy in the same lesson. What they do provide us is a lens through which we can notice different emphases, or different approaches to incorporating financial situations in mathematics classes.

Methods

The idea of this paper emerged in March 2020, soon after the World Health Organization declared COVID-19 a pandemic and countries started to take lockdown measures. Currently, most countries in the world are already suffering from the pandemic consequences, which include social distancing, difficulties to have access food or supplies, and the beginning of an economic recession (with strong chances of becoming a depression). We were particularly concerned about how different social actors were addressing financial implications of the COVID-19 crisis, as reported in the media.

Three real and typical situations that happened in many countries were selected for discussion: access to face masks, the purchase of personal hygiene products such as hand sanitizer or toilet papers, and financial assistance provided by local and federal governments. We found these situations as they circulated in social media and generated discussions about the successes and failures of different societies in dealing with the pandemic. Each situation highlights the role played by different social levels: individuals, companies, and governments. In other words, each situation adopts the point of view of one social level. It appears to us that those different points of views should be understood in order to have a better democratic participation in society.

Based on these situations, we generated pedagogical approaches that intersect with financial numeracy to develop a deeper understanding of life in a moment of crisis. We created these approaches by dissecting the situations in terms of the three dimensions of financial numeracy (contextual, conceptual, and systemic). Furthermore, we decided to keep the financial data as it was collected in the first semester of 2020. We understand that COVID-19 has since evolved in unpredicted ways (rollout of vaccines, economic recession and recovery, recent trend of spikes in interest rates, etc.), but we argue that the first shock provides us with many opportunities to explore a context of crisis with students in mathematics classes.

In the next three sections, we present the pedagogical approaches as learning situations for mathematics educators. We first contextualize the situations according to the information gathered online from different sources. We explain where financial numeracy emerges and how it can be useful for mathematics teachers to offer deeper and complex understandings of this

crisis. These learning situations are complex enough to offer a range of potential directions to pursue with students. Thus, the learning situations focus not only on the problem, but also provide an opportunity to learn from creative solutions and what they reveal about consumption practices and public policies in everyday life around the world. Those creative solutions address the specific needs of a society, as well as respond to their cultural norms.

Since we decided to cover a wide range of contexts while collecting reports of financial implications at the beginning of the pandemic, we decided to not specify an age or grade level for these learning situations. The reasons are twofold. First, each of the countries involved in these situations has a unique mathematics curriculum in elementary and secondary school, making it hard to make specific recommendations based on the connections with other mathematical concepts. Second, there is currently no standard for the integration of financial numeracy (or literacy) in mathematics curricula worldwide. Even within the same country, such as Canada, there is little consistency. While some curricula introduce financial concepts in mathematics from grade 1 (such as the Canadian province of Ontario), others do not do that until the last year of secondary school (such as the Canadian province of Quebec).

Results and Discussion

Learning Situation #1 – The South Korean Masks

This learning situation highlights the important role played by the Government in responses to individuals and companies' behaviors. South Korea has been at the forefront of the combat against the novel coronavirus ever since the pathogen made its way to the country in January 2020. The response to this crisis was rapid and, as it seems, effective. One of the distinctive social features of this response is the widespread use of medical face masks to prevent contagion through social interaction. It is important to notice that the use of face masks is not a taboo in Korea, as people are used to them in everyday life when they are sick. Unsurprisingly, when the outbreak started, the supplies of face masks in pharmacies and other stores quickly vanished. People started lining up to buy them and prices skyrocketed (Figure 1).

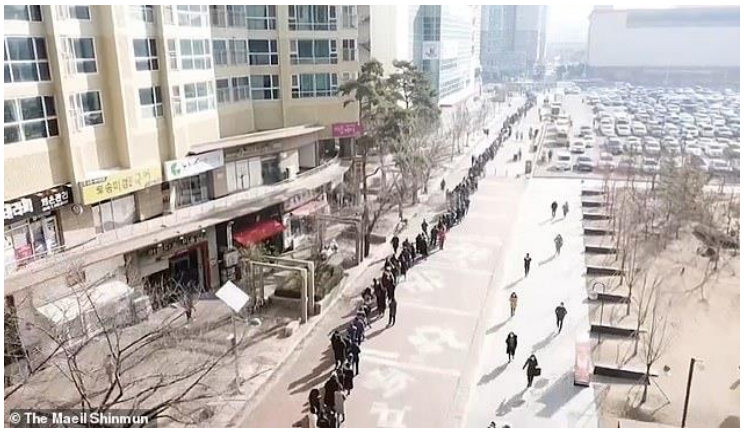

Figure 1. Line of Consumers to Purchase Face Masks in South Korea (Source: Maeil Shinmun)

Given this context, the government had to intervene in the supply chain in order to manage equitable access to this resource. The response came in the form of how the masks would be distributed and at what price. At the time of writing this article, the Korean government stipulated that 80% of the 10 million masks produced every week must go to pharmacies, post offices and community grocery stores. Their price is fixed at ₩1,500 each (around $1.23 USD as of April 15, 2020) and each person is allowed to buy only 2 masks per week. The schedule of purchasing the masks is also regulated: consumers can only go to the stores to buy them on the day of the week that corresponds to their year of birth (except for individuals with extenuating circumstances). Figure 2 represents such a schedule: on Mondays, for example, consumers whose birth year ends with 1 or 6 can purchase masks; on Tuesdays, birth years ending with 2 or 7, etc. Weekends are dedicated to people that, for some reason, were not able to purchase their quota of masks. Also, if someone tries to purchase more than they need or tries to resell at a much higher price, the government announced it would criminally prosecute them due the scarcity of supplies. The rest of the masks, 20%, could go to online marketplaces where the price varies freely according to supply and demand. Prices have reached around $7 USD for one individual mask by March 2020.

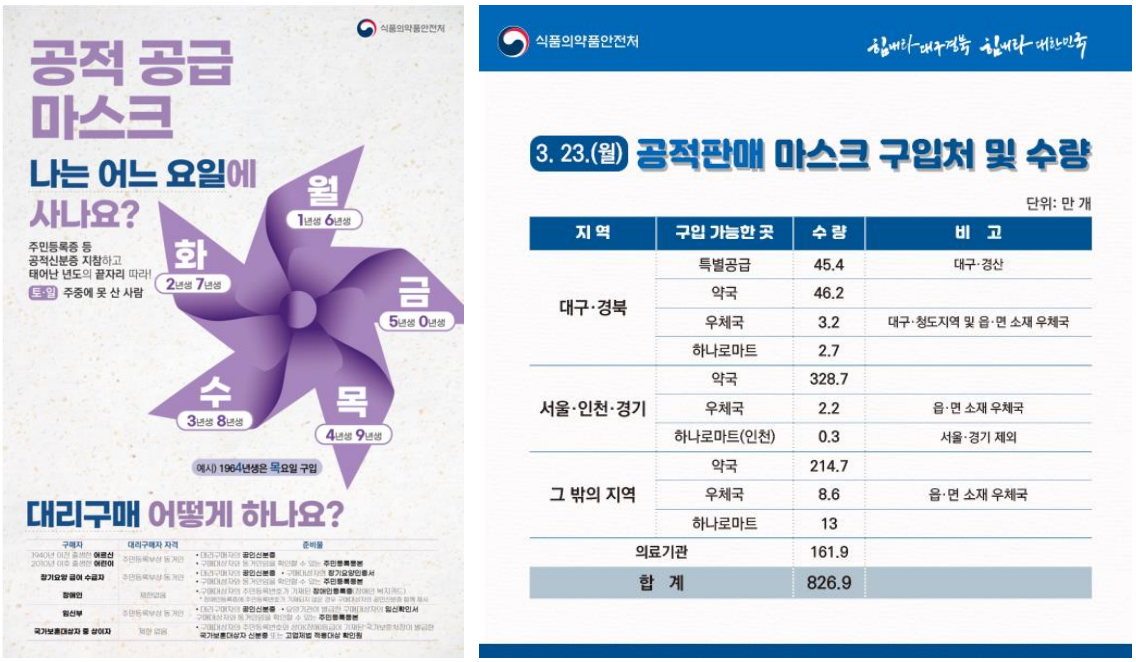

Figure 2. Regulations Implemented by the South Korean Government regarding Face Masks (Source: South Korean Government)

Contextual Dimension: A common way of approaching this situation in a mathematics class would be to draw connections to each mathematical domain using financial contexts. In statistics, for example, students can investigate how many masks have been distributed so far (as of March 23, 2020), which type of distribution center received the most masks, their total revenue, etc. In arithmetic and algebra, they can calculate the monthly cost of using one mask

a day. Students can also construct a function of the total cost according to the number of masks purchased between local stores and online marketplaces. In probability, it is possible to consider the expected price (expected value) that one would pay for a mask if they purchased it on a random day of the week.

All activities proposed above are individually potentially rich for a mathematics class. They all involve explicit mathematics content and practices that can foster students' ability in the formal discipline. However, they do not tackle explicitly the experiences lived in the current situation. This approach of dissecting a real-life event into domains of a discipline does not serve well the need to comprehend the disruption of life and the response from social actors such as the Korean government. Financial numeracy is a rather integrative concept that can account for the complexities experienced during the COVID-19 crisis. Based on this concept, multiple explorations can emerge. We propose here three open-ended questions that tackle the real-life event while making authentic connections to mathematics in an integrative manner.

Conceptual Dimension: To reach the conceptual dimension of financial numeracy, students can engage in mathematics to make predictions about the developments of the pandemic. For example, another integrative approach involves investigating what will happen to the price of masks sold in online markets if COVID-19 gets worse or gets better in Korea and around the world. In addition to collecting and representing data, students can mobilize a wide range of concepts to make such predictions. They can integrate regression techniques with geometry to check if prices depend on the distance from a production center or on the area of specific regions of the world.

Systemic Dimension: To reach the systemic dimension of financial numeracy, students can explore the costs associated with producing one mask. Such a discussion entails more than just calculating production costs; it also includes exploring the reasons behind the recent spike in prices. Here, they can implement mathematical practices such as conjecturing and modelling in order to investigate the event. They can collect data and use it to represent, calculate and communicate their ideas, all the while developing a critical position towards the responses being implemented in their countries or among their communities.

Another line of questioning that can be used in mathematics classes to approach the current crisis in an integrative way refers to the difference in price between public spaces (pharmacies, post offices and community grocery stores) and online markets. Not only can students discuss the numerical differences and engage in mathematical practices associated with them (modelling, calculating, rounding, representing, etc.), but they also get the opportunity to discuss the sociopolitical implications of the actions of their government and individual vendors. What price is fair? How much would you be willing to pay for a mask? What happens to those who cannot afford to buy extra masks? Why do you think the regulations decided on two masks per person? These are all questions which students will be better equipped to discuss through financial numeracy investigations.

Learning Situation #2 – Danish and North American Supplies

This learning situation highlights the important role played by companies in responses to individual consumers' behavior. As the novel coronavirus spread around the world, individual consumers' reactions seemed similar in most countries. The practice of hoarding personal hygiene products became news and was subject to a lot of criticism by the media and by individuals in social media. Toilet papers, hand sanitizers, face masks and canned products are just a few examples of items purchased in large quantities by consumers afraid of the crisis created by the pandemic. In the United States, for example, an individual became news for stock piling hand sanitizers to resell them on Amazon. He traveled more than two kilometers across his state and cleared the shelves in local supermarkets for a total of more than 17,000 bottles that were stocked with the goal of driving prices up. Federal authorities are now prosecuting him for price gouging based on the state of Tennessee's laws[1].

In response to this situation, many small and large businesses implemented creative solutions to prevent the concentration of products in the hands of few customers. One common solution, illustrated by Figure 3, was to limit the number of items each customer was allowed to take in a single purchase. Costco, a North American wholesale chain, implemented this policy in many of its branches. Customers of this store need to be a member to purchase, so each member (associated with a card number) needs to register their card to purchase items, and that is how the limit of 2 paper goods could be implemented.

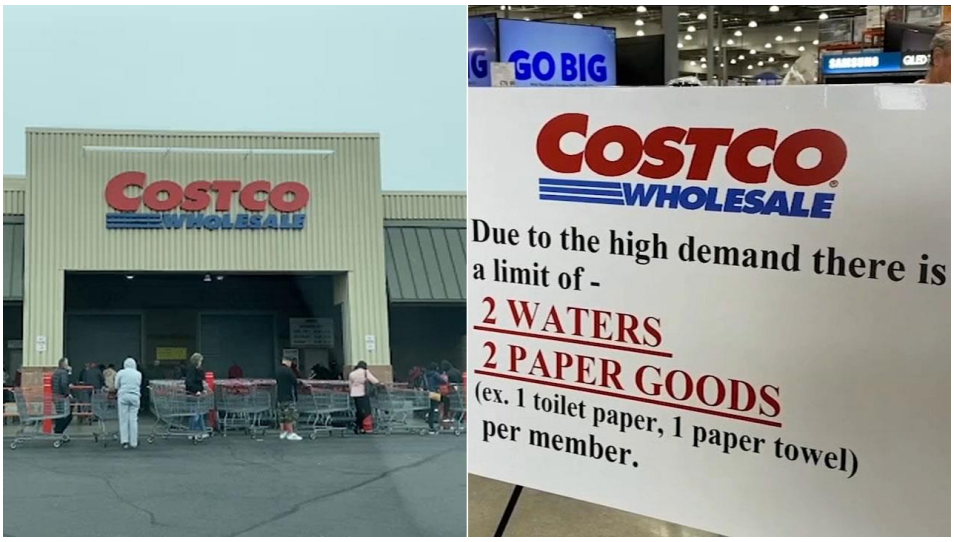

Figure 3. Response of A North American Wholesale to Consumers' Hoarding of Water and Toilet Paper (Source: Facebook)

Another solution to the hoarding situation was created by a Danish supermarket and went viral on social media. Figure 4 illustrates its solution. As we can see, instead of limiting the

[1] Source: Nicas, J. (2020). The Man With 17,700 Bottles of Hand Sanitizer Just Donated Them. Retrieved from: https://nyti.ms/33lqnqp

purchase of hand sanitizers by each customer (which would be difficult to implement as customers could simply return to the store multiple times), this supermarket charged a premium for each extra sanitizer purchased by the customer. In short, one bottle would cost 40 DKK (around $6 USD as of April 15, 2020), but upon buying more than that, customers would have to pay 50 times that price (1000 DKK, or $150 USD) per bottle.

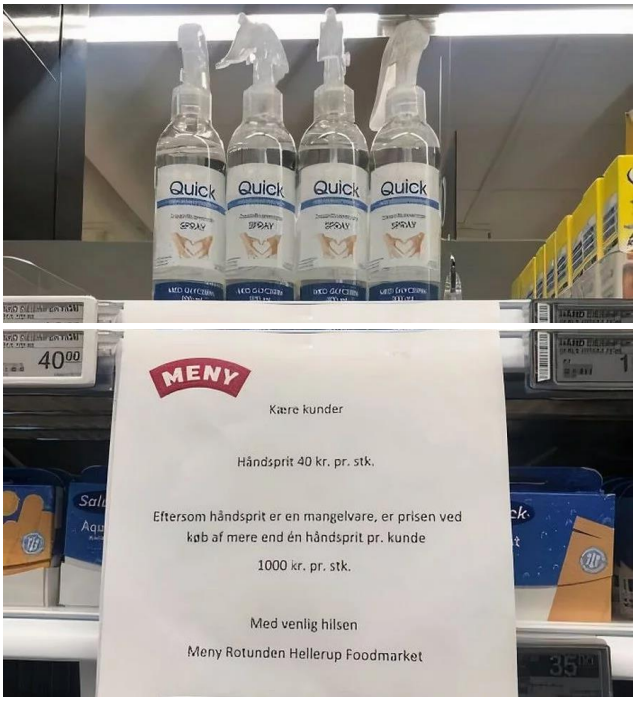

Figure 4. Response of a Danish Supermarket to Consumers' Hoarding of Hand Sanitizers (Source: Facebook)

Contextual Dimension: Apart from the specifics of the current pandemic, our experience shows that these types of situations are quite common in mathematics classes. Teachers often use consumption contexts to teach about proportions, percentage, equations, inequalities, etc. The context of discounts and taxes are particularly common among early secondary mathematics teachers. Some arithmetic and algebraic questions include: what is the increase (numerical and percentual) in price for hand sanitizer from the first to the second bottle purchased? How about from the second to the third? What kind of function best describes the total price of hand sanitizers purchased?

In probability and statistics, these situations can also generate productive questions. For instance, they can explore issues of combinatorics: assuming paper goods in the store include toilet paper, paper towel, napkins, facial tissues, how many different combinations of products one customer can make?

Conceptual Dimension: Although the approaches above can illustrate the applications of mathematics in real life, they do not portray this complex situation (such as the implications of the COVID-19 pandemic) in authentic ways. Instead of promoting discussions about the

situation, they tend to use the quantitative information to work on mathematical reasoning without leveraging mathematics as a way to better understand the crisis and take action. An approach rooted in the conceptual dimension could improve students' experience during these trying times by discussing the implications of these stores' decisions. From the point of view of the store manager, for example, students can predict how long stocks will last under the new rules for consumption (as opposed to normal operation). In doing so, they can engage with financial concepts related to resource management and sales strategies. From the point of view of the consumers, students can explore how to best use the products in the context of scarcity. Not only do they need to understand budgeting, but also how to use products in the most efficient ways. These ideas are all related to financial numeracy as we conceptualize in this article.

Systemic Dimension: A systemic approach to financial numeracy in the context of consumption of essential products involves discussing their accessibility during the COVID-19 pandemic. Mathematics educators can, for example, tackle the following question: why is it important to ensure equitable access to personal hygiene products? Answers to this question can touch on different epistemologies: social justice, epidemiology, public health, etc. In addition to that, students can explore the impacts of hoarding and price gauging on the spread of COVID-19: what happens if these products cost too much, and some people cannot afford to buy them? How does that influence the rate of infection? Who would be most affected in such a scenario? What other solutions can we envision to prevent hoarding and price gauging?

Learning Situation #3 – Brazilian Informal Workers

This learning situation highlights the important role played by the Government in responses to individual consumers' needs. Brazil, just like most countries, is facing the economic impacts of social distancing measures taken with the goal of slowing down the spread of the novel coronavirus. In addition to suffering political and economic crises over the past four years, the GDP (gross domestic product, a measure of all the goods and services produced in a country), for example, is expected to shrink by 5.9% in 2020. Consequently, many workers have already lost their jobs and many others have forcibly taken licenses without pay. Among those, informal workers are especially vulnerable to income loss.

In Brazil, there are two forms of employment. The first one, formal employment, refers to workers who have an official job contract as per national labor laws. Such laws were first established in the late 1950s in order to regulate the tax system and the contributions collected by the state and entail multiple benefits to workers: mandatory 30-day vacations, 13th salary paid at the end of the year, contribution to the national pension plan, a security fund which is paid if workers lose their job, 30% fine on the sum of the security fund paid by the company in case of job loss for no reasonable cause, etc. The second form of employment, informal, refers to workers who do not have official contracts. In 2019, it represented around 41% of the job market in Brazil, with some states accounting for more than 50%[2]. Their employment status is

[2] Source: Garcia, D. (2019). Informalidade supera 50% em 11 estados do país, diz IBGE. Retrieved from: https://folha.com/12cov5s0

much more precarious as they do not contribute to the tax system and do not enjoy any of the benefits described in the labor laws. In other words, these workers are not covered by any system in the case of job loss. Also, contrary to some arguments, their income is significantly lower (43%[3]) when compared to formal workers (Filho, Mendes, & Almeida, 2004).

In order to support these workers and avoid economic catastrophe in the country, the Ministry of the Economy announced measures to provide financial assistance in these exceptional circumstances. Its initial proposal was to create an emergency benefit of R$ 200 (around $ 38 USD as of April 15, 2020) per month to every informal worker who had lost their job due to the COVID-19 crisis. This proposal was met with significant backlash in media outlets, which led opposition parties to intervene and vote for an increase in the amount of the financial support. After several debates and votes, it was decided that the benefit would total R$ 600 (around $ 115 USD) a month per person for up to three months, limited to two people per household (Figure 5 shows the mobile application used to apply for the benefit). This aid is supposed to support workers that are not covered by unemployment insurance or pension plans. To be eligible, they need to be registered in the Unified Registration system (for low-income families) and have reported an equivalent income per capita lower than half of the minimum wage (or a total household income lower than three minimum wages). Additionally, they cannot be collecting other forms of social assistance (such as the Bolsa Familia program).

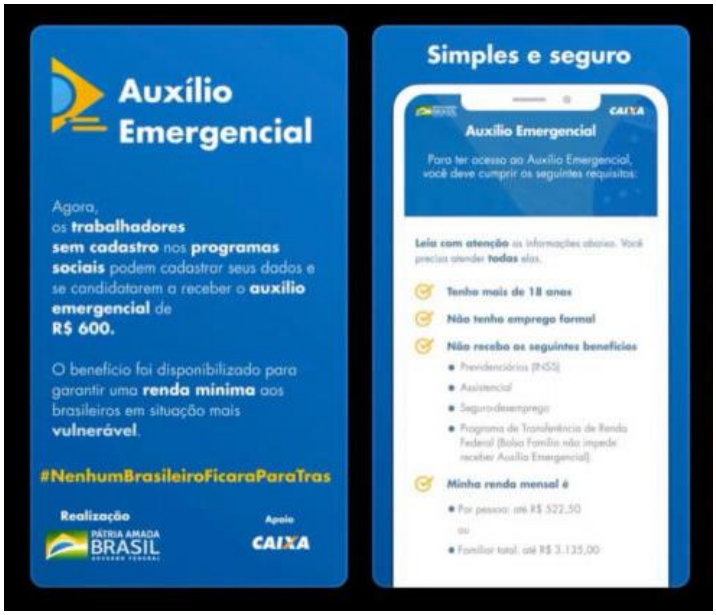

Figure 5. Mobile Application used to Apply for the Emergency Benefit Created by the Brazilian Ministry of the Economy

Contextual Dimension: Based on our experience as mathematics educators, this situation (and those like that) can be sensitive to discuss in mathematics classes given how close it relates

[3] Source: Garcia, A. (2018). Carteira assinada rende salário 76% maior a trabalhador brasileiro. Retrieved from: http://r7.com/4Zad

to students' personal lives and experiences with low income and social inequality. The contextual dimension of financial numeracy can provide some guidance for teachers who which to introduce some aspects of the context to their classes. They can use, for instance, word problems that describe one aspect of the situation (budget, salary, unemployment rates, national GDP, etc.) without exploring it in its entirety. Such an approach can also be useful to demonstrate some applications of mathematics; its focus is work on specific mathematical concepts related to proportions, percentage, equations, data organization and mathematical representations. For instance, mathematics educators can use this sort of context in arithmetic and algebra to calculate the percentage decrease in income that a family might experience with the emergency benefit. In statistics and probability, students can design a survey to be implemented in their community to investigate how many people were affected by the crisis and how many were able to receive the benefit.

Conceptual Dimension: In order to think about this situation and develop critical stances toward the economic impacts of the COVID-19 pandemic, the conceptual dimension seems to be an important guide for mathematics educators to coherently propose questions that integrate mathematical content in meaningful ways. Here, we highlight a line of questioning that can be used which relates to the individual implications of the emergency benefit. Mathematic educators can develop rich tasks that involve the usage of the emergency benefit in a family budget. A series of questions can generate student engagement with financial numeracy in authentic ways: How much can you afford with this sum of money? What would your budget look like? What strategies would you use to support your life as a single person? What about a couple or a family? What is the impact of an extra family member to the budget?

Systemic Dimension: This line of questioning looks at the sociopolitical implications of the emergency benefit. Because the situation described above stems from a policy decision, mathematics educators can engage in discussions that tackle the rationale and impacts of such a policy. Some examples of questions that can generate financial numeracy discussions include: How do you think policy makers decided on that sum of money? How many people are expected to receive the emergency benefit? What are the impacts of providing the benefit? How long can the government keep providing the benefit?

Upon discussing these sorts of questions, students can engage in financial numeracy through mathematical practices such as calculating, estimating, making predictions, modelling real-life situations, solving problems, communicating mathematical ideas, etc. In that sense, financial numeracy becomes more than just arithmetic in the context of finance; it involves all domains of mathematics (in this case, statistics seems to be especially important) and different mathematical competencies. Financial numeracy then can be envisioned as an integrative concept that can emphasize the ability to mobilize mathematical ideas to make sense of real-life situations involving money.

Discussing the economic or financial aspect of an ongoing crisis such as the COVID-19 pandemic, is important for us and for people all around the world. Despite working in a privileged context (Canada), we, the authors, have an experience living and working in other socioeconomic systems. The first author was born and grew up in Brazil and had the opportunity

to work and study in South Korea and China. The second author grew up in a minority context in Canada (the French-speaking province of Quebec) and currently works in French-speaking African countries. We do not claim expertise of those countries, but we are aware of the different implications of the current pandemic for people living in different areas of the world. We are very concerned about the social and financial consequences of this crisis on the communities who live there. In this regard, we believe mathematics education research should embrace financial numeracy and reflect on our practices and how they can provide support to students in different contexts.

In each of the learning situations that we presented in this article, the three dimensions of financial numeracy (contextual, conceptual, and systemic) can be mobilized in class to promote the development of such a concept. The systemic dimension seems to be the richest in terms of promoting an authentic and a critical understanding of the current crisis and envisioning possibilities for the problems faced by different societies. Yet, we do not wish to undermine the potential of the contextual and conceptual dimensions in mathematics classrooms. As we mentioned before, the contextual seems to be more common in current classrooms for it promotes contexts that apply mathematics. This dimension can act as a starting point to the teaching and learning of financial numeracy.

Mathematics classes should put real-life situations at the center of the learning process, and therefore moving towards the conceptual and systemic dimensions is important. Using these situations as mere contexts for teaching formal mathematics concepts seems to be insufficient to address the challenges posed by the current pandemic and its economic implications. For many people, particularly those who learned mathematics in a decontextualized way, mathematics does not seem to provide any useful tools or methods to unpack the crisis and figure out solutions to its problems. If mathematics educators and researchers want to go further in the epistemology of numeracy and promote it in authentic ways, we need to go further in the financial aspect as well.

The educational value of our framework of financial numeracy resides on the model itself. We understand that teachers might feel overwhelmed by the idea of incorporating financial elements to their mathematics teaching. Most of them might not have received any training in this regard, which makes it challenging to implement financial numeracy without professional support. In this sense, our conceptual model seems to provide a useful framework onto which they can draw to start this journey. Small changes, such as asking follow-up questions in mathematics word problems, can be helpful to explore the potential of financial numeracy in class without overloading the necessary preparation in each class.

Furthermore, another reason why teachers might feel overwhelmed particularly with the systemic dimension relates to the answers for open-ended questions. Based on our experience as mathematics teacher educators, having the "right answer" is usually regarded as important for teachers. They feel more comfortable with asking questions and teaching concepts when they already know the results/answers. However, the teaching of financial numeracy goes beyond numerical results of financial calculations, especially because they touch on different epistemologies (values, beliefs, politics, ethics, etc.). In that sense, we urge mathematics

teachers to embrace the unknown and explore financial situations with their students. This is already a common practice in natural and social sciences. The benefit of this approach can be higher engagement among students and more authenticity in the answers to open-ended questions.

The analytical framework model of financial numeracy that we shared here is also interesting for researchers. In addition to providing a theoretical lens through which they can analyze the teaching of mathematics in financial contexts, this framework helps us highlight the importance of numeracy for financial decisions, an idea commonly mentioned by financial education scholars (Skagerlund et al., 2018; Jayaraman, Jambunathan, & Counselman, 2018) which has not yet been properly theorized.

The decisions that we described in the three learning situations were contextually constructed in different regions in the world. These decisions were made by Governments (Brazil and South Korea), companies (North America and Denmark) and by individuals (North America, Denmark, and South Korea). Sometimes, these decisions were more economically driven, but all levels are somewhat responsible and involve numeracy competencies. Those situations highlighted and bolded the daily tensions between individual and collective interests. In our opinion, citizenship is the key to face off those tensions. At this end, financial numeracy supports the participation of citizenship in a democratic way by showing empathy about the community. It does not revolve only around personal finances, but rather how to make decisions that promote the well-being of individuals and communities. We hope the examples shared in this article highlight the importance of discussing financial matters in complex and deep discussions.

Conclusion

In a time of pandemic, governments of different countries implemented their own strategies to address health and financial issues. Social distance was spread out, so that financial issues arose. We provided three examples coming from four different areas of the world to provide some diversity and to show the importance of financial numeracy.

It has become increasingly more complex to understand and make sense of social phenomena. The rise of complex technologies, the emergence of a climate crisis, the financialization of essential items into commodities (such as housing) all pose challenges that require the teaching of mathematics to be responsive and adaptive. We cannot remain in separate boxes while expecting students to integrate knowledge by themselves. COVID-19 has imposed enormous challenges to societies around the globe in terms of public health, food security and supply chains. It has also exposed the precarity under which many individuals have been working and providing for themselves and their families. In order to have students understand their own societies and envision solutions, teachers must address mathematics and it emerges in real life, and financial situations are at the forefront of numeracy in the capitalist world. Consequently, financial numeracy becomes an essential part of what it means to do

mathematics in everyday life. It has a special role to play in the curriculum and should be addressed as such in mathematics classes.

Particularly in a time of crisis, mathematics education must address immediate needs of society as well as contribute to overcoming social challenges. While we write this paper, the COVID-19 health crisis unfolds by the hour. The economic outcomes of this situation are yet to be faced by countries around the world. Predictions vary widely, with some predicting faster recoveries while others predicting recession followed by depression in already slow economies such as Brazil, Canada, and South Korea. We hope that financial numeracy brings innovative and positive solutions on how to produce and manage our limited resources in a way that protects the Earth.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been covered completely by the authors.

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