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A student's modeling of a business problem: a case representative of students' struggle to see meaning in mathematics

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Abstract

This article analyses the modeling approach used by one student in a business problem. It is argued that if we use previous frameworks we are not able to classify the students' approach to modeling as purely theoretical or empirical. Instead the student used a theoretical approach when constructing a real model, but abandoned it when she had to create a mathematical model. Reasons for this shift seem to be: greater familiarity with real-world concepts than with mathematical concepts; lack of appreciation of how mathematics could help understand or solve the problem; and discredit in the usefulness of mathematics for solving real problems.

1. Introduction

The problem discussed in this article was brought to class by an undergraduate business student working at a distributor branch of the Coca-Cola company in Brazil. The student was working towards her final monograph and chose to propose and write out a solution to the problem she perceived, which will be described subsequently. Following the description of the problem and of the student's modeling process, I will raise some concerns about the need to help students carry out the validation of the models they construct.

The company in question distributed products to be sold by supermarkets and convenience stores. As a part of its sales strategies, it installed, free of charge, vending machines where the products could be displayed at the distributing locations. The distributors with a larger number of sales would get the best machines and the greatest number of equipments.

The company's managers assumed the distribution of vending machines was an efficient strategy, i.e., that it increased the number of sales by the distributors. However, they could not say precisely to what degree that was happening.

It would obviously be of great interest to the company if the distributor who received a vending machine had a number of sales compatible with the costs generated to install and maintain it. It has happened before that some distributors that had a vending machine installed did not achieve a great number of sales, and the company had to remove the machine and relocate it, incurring more costs.

Is the criteria used to make decisions about which distributors should be provided with a vending machine a valid one? The student's hypothesis was that other factors could be more decisive than the amount of sales in determining how effective the installation of a vending machine would be in increasing the sales of a distributor. For example, a convenience store that is just starting into business may not have a great number of sales yet, but there is a positive perspective in relation to its potential for sales. On the other hand, a store might have a great number of sales at the present, but could also have reached a saturation point, or could have display equipment from other companies, or still, could be located in a neighborhood without much potential for growth.

2. Considerations about the student's modeling style

The fact that the student herself raised the problem to be modeled brought many benefits to the process: there was greater involvement of the student in the comprehension of the problem, she had a lot of background information about the variables at play in the situation, and she had many hypotheses about how they were related, since she worked at the company studied.

Below is a list of the variables the student chose to include in her model and some of the hypotheses she made about them.

a. location of the equipment: if the equipment is not placed where it could easily be seen by costumers, its effect on the sales volume should be lower.
b. location of the establishment: if the establishment is located in a wealthy neighborhood, the products will have a greater number of sales. The competition of low-quality, low-priced products is higher in neighborhoods of low economic status.
c. sales volume before the installation of the equipment: variable considered before and which seems to impact in some way the potential of machines benefiting the distributor's sales power.
d. sales volume after the installation of the equipment: knowledge of the effects that the display had in previous cases should be used to determine the other parameters.
e. adequacy of display pattern of products inside the equipment: the products should be displayed in ways that promote sales. For example, products usually bought by children should be in lower shelves.
f. size: in small establishments, low-quality, low-priced products represent greater competition to Coca-Cola products. The student chose to use a classification of the size of the establishment as an indicator of the amount of competition affecting the products.

The company had data about each of the variables above on its database. Qualitative variables had values attributed to them according to the way the company categorized their data. Other variables, such as the selling price practiced by the distributor or the existence of similar equipment in the neighborhood of the establishment were discarded by the student for the difficulties they would present in being measured, showing a conscious process of the negotiation between desirability and possibility that always goes on in the building of a model.

The point that raised concerns to me was that the high degree of involvement, confidence, and care in the treatment of the problem that the student showed when dealing with "real world" variables were not observed when she started building a mathematical model.

The way in which the student proceeded was parallel to the observations of Maull and Berry (2001) in their study of the modeling style of four groups of mathematics undergraduate students. Maull and Berry observed that the majority of students who participated in their study opted for linear models without questioning their appropriateness. Besides, they did not revise their models, taking a linear trajectory instead of a cyclic one.

In the same way my student, after data collection, used a computer program to make a linear regression with which she tried to explain the independent variable "sales volume after the installation of the equipment" by the dependent variables (described in the previous section). Using the significance tests performed by the program, she concluded that the variable "sales volume before the installation of the equipment" was the most significant in the explanation of the independent variable, and that "adequacy of exposition pattern of products inside the equipment" and "size" were not statistically significant in the model.

It is interesting to notice that, in the case of my student, this attitude, typical of what Lawson and Tabor (2001) call the empirical approach, only occurred when mathematics entered the scene. Earlier the student was adopting a theoretical approach, searching for explanations for the real processes involved in the problem.

Many questions could have been raised after the first modeling attempt to the problem: Is a linear model the most appropriate? In what ways would the equation help in the distribution of equipment? Can it be used to make predictions of the sales volume after the installation of the equipment, since it combined variables that would be measured after the installation of the equipment with others that can only be measured after the installation? Did we not expect that "sales volume before the installation of the equipment" would be highly predictive of "sales volume after the installation of the equipment"? Does this fact not affect the gauging of the contribution of other variables by the model? How can the knowledge of the statistical significance of other variables to the prediction of "sales volume after the installation of the equipment" be of use to the company?

These questions could have been discussed in terms of real-world concepts with which the student was well familiar. That is, even without expecting the student to utilize more advanced mathematical tools we should have expected her to relate what she chose to do mathematically to the situation she was trying to understand. However, the closing of the modeling cycle, i.e., the return to the real situation to validate the model, was not done. It seemed that the student did not see connections between the mathematical model she created and the real problem she brought to the classroom. Or rather, it seemed that the connection between the problem and the authentic search for solutions was lost somewhere during the process of modeling.

3. How strongly do students believe in their models and their potential for understanding real life phenomena?

The difference between my student's style of modeling and that observed among groups of students by Maull and Berry is that the latter adopted an empirical approach to the problem from the start, while my student first adopted a theoretical approach, defining the variables to be incorporated in the model and hypothesizing about their role in the problem, but abandoned it when she had to use mathematics in her model.

One reason for this shift is obviously the greater familiarity the student had with the real-world concepts involved in the problem than with the mathematical concepts used in the model. However, another issue seems implicit: the student did not have an appreciation of how mathematics could help to understand or solve the problem. If she did not perceive the model as useful to understand the real situation, it seems natural not to be willing to go back to the real situation to analyze the efficacy of the model.

Having students fall short of completing the modeling cycle points towards a discredit in the usefulness of mathematics to solve real problems, an attitude opposite to that we would desire to see in business school graduates or any mathematically literate person.

4. Conclusions

Students may need more guidance toward gaining confidence in the modeling approach as an effective way of using mathematics in the real world. This calls for increased attention to the validation phase of modeling, an important part of the process which students not always see a need to and which is at the core of making a link between mathematics and reality.

References

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