

MODELING IN THE REAL WORLD: TEACHING STUDENTS COST ESTIMATION METHODOLOGIES

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ABSTRACT Modeling can give ideas about mathematics at an early age through easy introductory examples, stimulating students to learn applied mathematics sooner than it is common in most of schools through a wide variety of computer-aided teaching methods and approaches. Modeling in the real world is possible to apply in the curriculum of secondary level; this article discusses how to teach mathematics students an introduction of ABC (activity based cost) methodology and how to make links to algebra and arithmetic concepts. The ABC is a methodology for supporting decision on strategic and operational planning of companies and a way to estimate their activity related costs and performance. After an introduction to this methodology and a pedagogical argumentation favoring the usage of modeling in secondary school classes, this article suggests how to use financial spreadsheet software like the ones that are common in most personal computers nowadays to develop simple investigations that can potentially bring significant insights to students.

KEYWORDS Modeling - Simulation - Cost Estimation - Mathematical Education - ABC

INTRODUCTION

"It is not just the role that mathematics, science, and technology play in the changing economy and workplace that matters. Mathematics and science have become so pervasive in daily life that we tend to overlook them. Literacy in these areas affects the ability to understand weather and stock reports, develop a personal financial plan, or understand a doctor's advice. Taking advantage of mathematical and scientific information does not generally require an expert's grasp of those disciplines. But it does require a distinctive approach to analyzing information. We all have to be able to make accurate observations, develop conjectures, and test hypotheses — in short, we have to be familiar with a scientific approach". (NCMST, 2000)

The scientific approach can be developed through modeling and simulation. Nowadays, the existence of computers allows educators to teach many subjects in a way not possible in the past, with several pedagogical advantages (MISKULIN, 1999).

Particularly, modeling can give ideas about mathematics at an early age through easy introductory examples, stimulating students to learn applied mathematics sooner than it is common in most of schools through a wide variety of computer-aided teaching methods and approaches. Also, modeling exercises allow students to customize their learning (AMORIM, 2001), which turns the learning experience more efficient.

Modeling in the real world is possible to apply in the curriculum of secondary level (AMORIM and MACHADO, 2001); this article discusses how to teach Mathematics students an introduction of ABC (activity-based costing) methodology in a simple but efficient way. The ABC methodology is a well-know way to estimate activity costs and performance and orient managers to improvement opportunities.

After an introduction to this methodology and a pedagogical argumentation favoring the usage of modeling in secondary school classes, this article suggests how to use financial spreadsheet software like the ones that are common in most personal computers nowadays to develop simple investigations that can potentially bring significant insights to the students. The intent is to show how ABC can help students to apply Mathematics to understand their surrounding environment while applying concepts of fractions, variation taxes, matrices, etc.

THE ABC METHODOLOGY

Both in Brazil and globally there are many obstacles to the Internet use for education and training; in the specific case of education, some of the issues are: shortage of computers, modems and Internet connection in classrooms; insufficient teacher training; funding; school budget covering Internet time; lack of interest of administrators; and lack of appropriate content. In what concerns content, this work intends to contribute offering a possible approach to teach the ABC methodology to primary and secondary levels.

The trend to globalize markets (clients, suppliers, legislation, etc.) and business entities makes more pressure to companies to re-organize the way they make their business to offer better products and services concerning quality and costs. Traditional management practices are not suitable any longer in this global environment.

The ABC methodology emerged to support companies with cost and performance management practices more oriented to products, services and clients. The ABC methodology orients the company to find opportunities to improve its processes. Attempting to figure the costs of the actual activities that are necessary to produce a specific product or to deliver a specific service this non-traditional accounting method focuses on "cost drivers" that can guide allocations. The usage of this methodology allows the manager to minimize unnecessary non-value added costs distinguishing them from necessary value-added costs. That's why nowadays companies integrate ABC into critical management systems and use it to make day-to-day decisions.

With the purpose of teaching ABC, KAPLAN (1998) shows an application appropriate to the management level. The intent in this work is to show how ABC can help students to apply mathematics to understand their surrounding environment while applying concepts of fractions, variation taxes and matrices.

The ABC considers that every product or service of a company is performed by a sequence of activities. In this level, it is where the company resources (energy, raw material, personnel, machine, etc.) are consumed. This sequence of activities can be very long and describe how the company utilizes its available resources. For instance, in a fast-food shop, it comprises since the activities related to storage of the ingredients (hamburgers, soft drinks, potatoes, etc.) until the food delivery to the customers. In a factory, it would comprise different activities but still related to the goods produced by this company.

This products and services affect in some way the activities related to them. Similarly, these activities affect the use and consuming of resources. These relations are identified and quantified by the methodology and they are called cost drivers. These activities can have different objectives: products, services and clients. They are called cost objectives.

There are two types of cost drivers: the resource driver and the activity driver. The resource driver models the causal relation between the resource and the activity. And the activity driver models the causal relation between the activity and the products and services. This driver estimation is a critical phase of the ABC methodology and is implemented in two steps.

So, considering the example of fast-food shop, the manager knows how much of hamburgers, bread, etc the shop spends every period (week, month or year). And the manager knows also how many sandwiches A and B were made. So, the manager has the total cost of these ingredients spent in this period and wants to estimate the unit cost of the sandwich A and B. Each kind of sandwich has a sequence of activities that produce it. Each

activity of this sequence consumes some time and resources. A specific activity, frying hamburgers for example, consumes some energy, personnel and meat (it is a simplified view). It is necessary to estimate how much of these resources are consumed to fry one hamburger. These causal relations are the resource drivers. Of course, the energy is used for many activities directly related to sandwiches or not. It can be a complex calculation to estimate how much a machine to fry hamburgers consumes of energy and therefore it is important that this information is given for free.

The students know, for instance, a KW/h costs U\$ 0,50 and to fry one hamburger, the machine consumes 500 W/h. Then the students can estimate how much costs to fry one hamburger. But the hamburger is not the whole sandwich. It is necessary to calculate the costs related to mayonnaise, bread, tomatoes, etc. Then, once the students know how the activities affect the resources (resource drivers), it is time to estimate how the activities affect the production of sandwiches (activity drivers).

CASE STUDIES AND TUTORIALS

An interesting case study that shows how ABC assigns costs accurately to two products, which are similar hotdogs produced by a fictitious hotdog shop called HD is part of a tutorial developed at Campinas State University Laboratory of Research on Computer Aided Mathematical Education (LAPEMMEC - <http://www.cempem.fae.unicamp.br/lapemmec>). The first kind of hotdog has the following components: bread, sausage, mayonnaise, ketchup, and mustard. The second one has additionally a second sausage, potato cream, special tomato sauce and onions. The total working time of the shop is 6 hours. At first, the activities being performed by organizational resources are identified. After, resource costs are assigned to the activities. Then, all the products, services, and customers of the shop are identified. At last, activity costs are assigned to these outputs via activity cost drivers. This tutorial on ABC intends to include the HD hotdog shop case study. The purpose is to use this tutorial in a Campinas city school during the second term of 2001 to test the methodology suggested here.

At the Internet, a huge quantity of papers and tutorials related to the ABC methodology can be found. For example, the following site from the IMSE Department at The University of Texas at Arlington, which is mainly related to industrial engineering, has a comprehensive list of papers: <http://www.uta.edu/ie/abc.htm>.

CFO Europe is a monthly magazine published by The Economist Group. At the site <http://www.cfoeurope.com/199810f.html>, for example, Robert Kaplan, the Harvard Business School professor credited with being the founding father of activity-based costing (ABC), suggests that "*ABC has stagnated over the last five to seven years*". With ABC, however, every cost is traced to a customer, service or supplier. The site <http://www.cfoeurope.com/200104g.html>, in turn, suggests that ABC helps companies to understand what makes money and what doesn't.

An interesting tutorial from the Department of the Navy Acquisition Reform Office can be found at <http://www.acq-ref.navy.mil/wcp/abc2.html>. It suggests, for instance, that ABC provides visibility to information that was previously hidden in a traditional accounting system.

At the site <http://www.pitt.edu/~roztock/abc/abctutor/>, a tutorial called "Introduction to Activity Based Costing - Internet ABC Online Presentation" from Narcyz Roztock at the University of Pittsburgh offers many illustrations on how to apply the ABC

to real situations. At <http://www.pitt.edu/~roztock/abc/abcrefer.htm> a list of references is offered.

SUGGESTED USAGE IN CLASSROOMS

The first attitude would be to suggest students to visit part of the sites mentioned in this work. After, the teacher could turn to an exercise of modeling a hotdog shop, for example. Right after, changes in the model should be considered in order to verify how to improve the situation. It is a fact that ABC can turn to be a very complex problem to solve. On the other hand, a teacher can easily show the basic principles while avoiding unnecessary complexity on the model.

The use of software like spreadsheets should be stimulated as a way to teach matrices and other mathematical concepts while developing cost models. VORSIM (<http://www.vorsim.com/>), for instance, is a Windows-based tool for the construction and management of economic and other mathematical models in the Microsoft Excel (<http://www.microsoft.com/office/excel/>), a spreadsheet for Windows. One of its documented, working models is DWAG; this model is a partial equilibrium world agricultural trade model which projects world agricultural trade, production, and consumption from a base year of 1997 to 2010. It can be suggested to students to visit sites like this in order to give them a feeling of how developed the field of modeling is and how software can be used to solve real and complex problems.

Numerous books on Microsoft Excel spreadsheet for Windows and economic and mathematical simulation models are available and could be used to better prepare classes and activities for students. An ABC cost model for the Microsoft Excel can be viewed at <http://srl.marc.gatech.edu/education/Recycle/ABC.html>. This model was developed at Georgia Institute of Technology (Systems Realization Laboratory - George W. Woodruff School of Mechanical Engineering).

The use of new techniques like TCO (Total Cost of Ownership) is also of interest; these techniques can be used as motivation to students since a simplified approach is possible, in general. The TCO technique, for instance, intends to measure all the expenses associated with technology beyond its initial budgeted and direct costs of hardware and software (SUSTAR, 2001), something fundamental, for example, for a long-range planning of an educational IT infrastructure.

FINAL CONSIDERATIONS

"Modeling and simulation are inseparable procedures which include the complex activities associated with the construction of models representing real processes, and experimentation with the models to obtain data on the behavior of the system being modeled" (KOSKOSSIDIS and BRENNAN, 1984).

Taking complex tasks and breaking them down into highly specified actions that can be performed by low skill workers is normally called deskilling. KINCHELOE (1991) suggests that teachers should fight deskilling; teachers shouldn't be just consumers of knowledge but also producers. In the same sense, students should also be prepared to be both consumers and producers of knowledge. A systems thinking can be developed through modeling and simulation and can help students to better understand the phenomena of their everyday lives while learning more about mathematics. A systems thinking can be of a fundamental importance for the ones interested in knowledge production.

A wide variety of teaching methods and approaches (BASSANEZI, 1994) should be encouraged as a way to stimulate students to learn science and mathematics (NCMST, 2000). The approach of teaching the ABC methodology to primary and secondary levels suggested in this work has not been tested yet but at the university level the training on similar methodologies is a common part of the curriculum. Anyway, some authors suggest that mathematical modeling can be taught at any educational level as a way to enhance mathematical learning (BIEMBENGUT and HEIN, 2000).

It is well known that both modeling and simulation in general represent one of the primary methodologies in the treatment of projects that are interdisciplinary in their nature. Also, modeling and simulation are directly or indirectly included in all modern methods of analysis and design. Teaching the ABC methodology to the secondary level and maybe even to the primary one can be a way to incorporate the nature of systems to the traditional curricula. In this way, students would have extensive personal experience in working with systems that are close to the reality they experience in their daily lives.

The globalization of business and savage competition in most industries leads to increasing cost pressures, which affects even education; in most countries, economic, social, and technological drivers are transforming education and turning human capital the chief source of economical value.

Emphasizing applications of scientific knowledge and skills is possible especially with the usage of computer-based education. The understanding of the connections between daily-life and technology should be exploited while relating mathematics and science to the needs and interests of the pupils. Further work could consider the adaptation of other engineering methodologies to the reality of both secondary and primary level students in order to create a set of instructional contents to be shared by teachers in their aim to enhance the teaching of mathematical disciplines. In order to keep their classes updated, teachers must drastically change the way they access and provide information to their students.

The intent in this work was to show how ABC methodology can potentially help students to apply mathematics to understand their surrounding environment while applying concepts of algebra and arithmetic.

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NOTE The addresses of the Internet sites mentioned in this work were accessed in May of 2001.