IT Applications as a Didactic Tool in the Teaching of Math (Using of Spreadsheet to Programming)

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In this document, we proposed a methodology to teach financial mathematics using a spreadsheet and computer platforms as a didactic tool. We describe the traditional education process in a specific topic of mathematics, “debt restructuring and modeling with equivalent-equation” from the theoretical explanation to design a financial simulator programmed in a spreadsheet. After this, the result will be verified and validated by the designed software.

Keywords: ICT, Financial mathematics, Education-learning process, design financial tools

JEL Classification: C6, C63

Current situation

Nowadays, the teaching-learning process of mathematics has been positively influenced by the communication and information technologies, helping its evolution and growth. However, these technologies are design, administrated and executed by human beings, which means that the human hand is still above all. Before this, another question emerges, is it true that the use of information technologies have positively influenced the teaching-learning process of mathematics? Probably, the first answer could be ‘yes’,
and we actually believe that the use of new information technologies has significantly promoted the teaching-learning process. How to view this process as a first construct: (See figure 1)

![Figure 1: Teaching-learning through use of computer platforms](source: self-making)

The influential variables are: the process (teaching-learning), the didactic resources (the ICT), and the product (significant learning). In fact, we can notice that the model adjusts to the initial approach. Nevertheless, in the traditional teaching-learning process, the professor is the main element, therefore this variable should be considered in the model. Now, the model has to be reconsidered as a new construct: (See figure 2)

![Figure 2: Teaching-learning through use of computer platforms](source: self-making)

In traditional learning process the teachers was the main character, the root from which the knowledge is generated. For certain, the professor is the figure that has the experience and knowledge to guide the student. This is, from the explanation and activities that the teacher provides during classes, the students repeat the process and develop it. But, what happens
before this process? The student tends to push away from mathematics, so it is necessary to integrate new variables to the teaching-learning process in order to make it more attractive to the student.

These elements could be Excel spreadsheets (computer tools) in which it is possible to design series of calculations, which allows performing simulations with mathematical exercises (Garcia et al 2007, Nies: 2007).

The simulation and modeling in teaching-learning process

The simulation is considered to be hardware and software configuration in which, through some algorithms, it can be reproduce the behavior of a particular physical process or system. In this process, the real situations are substituted by artificial design, from which we can learn actions, skills, habits and/or competitions; and then transfer them to real life situations with the same effectiveness. In this activity, not only theoretical information is accumulated, it is brought to the practice.

The simulators constitute a procedure, in general to the concepts of creation and construction of knowledge. This is done to apply this new context in which, for some reason, the student can’t access the methodological context where knowledge is developed.

In this digital age, without a doubt, the potential in the use of computers and software for educational purposes is greatly recognize. Technological advances allow students, through computer simulation, face the learning situations that, for some physical and/or economical restrictions, could be difficult to experiment in a natural environment or in a laboratory. The computer simulation allows the construction of ideal scenarios, the manipulation of variables to observe its impact on certain phenomena or just to give an apprentice a teaching tool to replicate a theory learned. The influence of computer simulation for educational purposes has a broad spectrum, this, based on three main features:

a) Its motivational part, because it permits the representation of phenomena to study it capturing the attention and interest of the student;

b) Its facilitator to participate in the learning process, because the student interacts with him o her, helping the student to
comprehend through the discovery and understanding of the phenomena, system or simulated process;

c) And, finally the reinforcement part, this allows the student to apply the acquired knowledge, hence the generalization of it.

The simulation as a didactic strategy allows access to the construction of models in real situations that make easy the experimentation process. The use of simulation in the educational process, according to Abello, López and Sara (2003), allow training in real but controlled and secure environment; leaving out some difficult, expensive and hazardous aspects of a real life scenario that could be hard to reach.

And, with the benefit of repeating the experiment as many times possible, at a minimum cost.

The simulation in the educational process allows the alteration of time, with discretion, permitting the training in real time decision making that would carry on a certain action, without the waiting period. (See figure 3)

Simulation also makes possible the use of a scenario with a consistent hypothesis under certain conditions in which the real action or crisis eventually develops. Other benefits of simulation, according to quoted
authors, the use of images that create a graphic view about the situation in which they find themselves. If the expressed circumstances are given in a certain scenario, it is a good study to experiment the complex interactions that occur inside the system or organization that is under pressure.

With the same idea, simulation as a tool in the educational process makes it easy to create changes and alterations in the simulation model and observe the behavior of the users and its effects on these causes; it also helps to practice a forced procedure with new policies and rules of decisions. With this argument, we now discussed theoretical and empirical study.

Theoretical framework

Goldenberg (2003) points out that, nowadays the trend that has major impact in education, is the one that is present in mathematics teaching and in the education process, with the use of information technologies (IT). Within this field, the use of computer spreadsheets has taken a major step forward in this topic.

The design of mathematical spreadsheet models began in 1979, when Dan Bricklin created “VisiCalc”, using an Apple II computer. This fourth generation software allowed to automatically development financial projections, by only manipulating a few values. Based on this, the management and business sector had been favored in time and costs, because now the financial decisions are based on financial simulation procedures to determine the best alternative.

The success of the spreadsheets is based on the experience of the professionals who manipulate this software, but besides that, they can know the true problems of the company, and solve them through the use of mathematics.

Moursund (2003) says that in real life exists a striking contrast in the field of education, this means, that the introduction of IT in the teaching-learning process at a basic and medium level, focuses more in what the tool can develop instead of what it can solve. He also noted, in the case of solving management problems, in the exact and social sciences and other fields, the spreadsheet provides a good environment for modeling these problems.
Lewis (2007) reveals the importance of using spreadsheets and the commitment that teachers must promote its use, because it could contribute significantly to the teaching-learning process, for example in mathematics. He strengthens his argument by saying that the spreadsheet is a powerful tool for learning and developing student skills that enables them to:

a) Organize data (sort, categorize, generalize, compare and highlight the key elements),
b) Perform different types of graphical interpretation and analysis,
c) Use graphics to reinforce the concept of percentages,
d) Use specific visual elements with a view to exploring abstract mathematical concepts (visual and spatial intelligence),
e) Discover patterns,
f) Understand basic math concepts such as counting, addition and subtraction,
g) Stimulate mental abilities by using logical formulas for conditional answer: "if ... Then " and finally ----
h) Solving problems and using formulas to manipulate numbers, exploring how and which formulas can be used in a certain problem and how to change the variables that affect the outcome “(Lewis Op. Cit).

In figure 4, we can see all that has been described, but it also shows the process of logical functions generated by the use of spreadsheets; this could encourage the design of planning session with IT applications. Mainly, this is the most important event between the traditional way of teaching and the migration to the use of spreadsheets in the teaching of mathematics (See figure 4)

The excel platform as a learning tool and the methodological development of the topic

The use of IT and its benefits starting with the planning of sessions in an specific mathematical topic. Before this, it is programmed in an excel spreadsheet, other than the fact that this makes it easier to explain a mathematical topic, but also it also is going to constitute the design of a simulator that helps as a tool (as a product for the session). This event pretends to prove that mathematics, one of the sciences most rejected by students, in the teaching-learning process, the use of the TI could be an influential element in acceptance of mathematics by the student.
Developing a theme

How we visualize a mathematical problem in a traditional way: Equivalent equation model (Traditional session). Valuation of debt: When we have more than one debt

Now, with compound interest formula (including capitalizations)

\[ V_{D_o} = \frac{D_{o1}}{(1 + \frac{i_1 t_1}{365})^m} \]  

Valuation of debt: When we have more than one debt

\[ V_{D_o} = \sum \frac{D_{o1}}{(1 + \frac{i_1 t_1}{365})^m} + \ldots \ldots \ldots \frac{D_{on}}{(1 + \frac{i_n t_n}{365})^m} \]  

Following the generalization model, it’s necessary to display a timeline for establishing moments: prior to the focal date (PDF), the focal date (FD), and subsequent to the focal date (SFD).

Timeline Value of the Original Scheme: \( V_{D_o} \)
The elements for determining the value of the new scheme: VD are: the interest rates or discount in the renegotiation of the pacts i1... in the time t1...tn, the obligation before the focal date Siaf (from 1 to n), in the focal date Sff and the obligations after the focal date Sipf (from 1 to n).

The new scheme, from the renegotiation with “Y” equal payments on different dates, both prior to the focal date, in the focal date and after the focal date, they can be seen in a timeline:

Timeline Value of the New Scheme: $V_{D_n}$

The expression of the mathematical model of the New Debt, with the accurate Simple Interest, is as follows:

$$V_{D_n} = \sum_{b=0}^{off} S_{iaf} \left(1 + \frac{t_{ib}}{365}\right) + ... + S_{iaf} \left(1 + \frac{t_{in}}{365}\right) + S_{i1f} + \sum_{a=0}^{off} \frac{S_{iaf}}{(1 + \frac{t_{ia}}{365})} + ... + \frac{S_{iaf}}{(1 + \frac{t_{in}}{365})}$$  \hspace{1cm} (4)

It is replaced: $S_{iaf}$ and $S_{i1f}$ by X

$$V_{D_n} = \sum_{b=0}^{off} X_{iaf} \left(1 + \frac{t_{ib}}{365}\right) + ... + X_{iaf} \left(1 + \frac{t_{in}}{365}\right) + X_{i1f} + \sum_{a=0}^{off} \frac{X_{iaf}}{(1 + \frac{t_{ia}}{365})} + ... + \frac{X_{iaf}}{(1 + \frac{t_{in}}{365})}$$ \hspace{1cm} (5)
It is replaced: \(X_{aff} \cdot X_{ff} \cdot X_{pff}\) by the unity (1) to obtain the coefficients

\[
V_{D_n} = \sum_{0=0}^{aff} 1_{aff} \left(1 + \frac{it_1}{365}\right) + \ldots \cdot 1_{n} \left(1 + \frac{i_{n}t_{n}}{365}\right) + 1_{ff} + \sum_{0=n}^{pff} \frac{1_{pff}}{(1 + \frac{i_{pff}t_{pff}}{365})} + \ldots \cdot \frac{1_{n_{pff}}}{(1 + \frac{i_{n_{pff}}t_{n_{pff}}}{365})} \quad (6)
\]

To reduce the expression of the mathematical model, we substitute the expression \((1+it/365)\) of the accumulation factor by “Fa” resulting in the next expression

\[
V_{D_n} = \sum_{0=0}^{aff} 1_{aff} (Fa) + \ldots \cdot 1_{n} (Fa) + 1_{ff} + \sum_{0=n}^{pff} \frac{1_{pff}}{(Fa)} + \ldots \cdot \frac{1_{n_{pff}}}{(Fa)} \quad (7)
\]

If we identified the payments coefficients: before the focal date, within the focal date and after the focal date like: Caff, Cff, Cpff

We obtained the next expression:

\[
V_{D_n} = Y \left( \sum_{0=n}^{aff} C_{aff} + C_{ff} + \sum_{0=n}^{pff} C_{pff} \right) \quad (8)
\]

Replacing, now we get the model expression that allows us to obtain the amount of each payment:

\[
Y = \frac{V_{D_n}}{\sum_{0=n}^{aff} C_{aff} + C_{ff} + \sum_{0=n}^{pff} C_{pff}} \quad (9)
\]

Where:

\(Y =\) Value of each payment,

\(V_{D} =\) Value of the new debt previously valued,

\(\Sigma C_{aff} =\) Sum of the payments coefficients in the prior focal date,

\(C_{ff} =\) Payments coefficients in the focal date.

\(\Sigma C_{pff} =\) Sum of the payments coefficients after the focal date.

The expression of the mathematical model of the New Debt, with Compounded Interests accurate, is as follow:
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\[ V_{D_n} = \sum_{0=0}^{n} a_{1af} \left( 1 + \frac{i_t}{365} \right)^m + \sum_{1=0}^{n} a_{1fa} \left( 1 + \frac{i_f}{365} \right)^m + \sum_{n=0}^{pff} a_{naf} \frac{S_{1af}}{(1 + \frac{i_t}{365})^m} + \sum_{n=0}^{pff} a_{nff} \frac{S_{nff}}{(1 + \frac{i_f}{365})^m} \]  \hspace{1cm} (10)

To substitute: \( S_{1af} \), \( S_{ff} \) and \( S_{1pff} \) by \( X \)

\[ V_{D_n} = \sum_{0=0}^{n} X_{1af} \left( 1 + \frac{i_t}{365} \right)^m + \sum_{1=0}^{n} X_{1fa} \left( 1 + \frac{i_f}{365} \right)^m + X_{1pff} + \sum_{n=0}^{pff} X_{1af} \frac{S_{1af}}{(1 + \frac{i_t}{365})^m} + \sum_{n=0}^{pff} X_{1pff} \frac{S_{pff}}{(1 + \frac{i_f}{365})^m} \]  \hspace{1cm} (11)

Again, we substituted: \( X_{1af} \), \( X_{ff} \) and \( X_{1pff} \) by the unity (1) to obtain the coefficients

\[ V_{D_n} = \sum_{0=0}^{n} 1_{af} \left( 1 + \frac{i_t}{365} \right)^m + \sum_{1=0}^{n} 1_{fa} \left( 1 + \frac{i_f}{365} \right)^m + 1_{pff} + \sum_{n=0}^{pff} 1_{af} \frac{1_{af}}{(1 + \frac{i_t}{365})^m} + \sum_{n=0}^{pff} 1_{pff} \frac{1_{pff}}{(1 + \frac{i_f}{365})^m} \]  \hspace{1cm} (12)

To reduce the expression of the mathematical model, we substitute the expression \((1+it/365)^m\) with the accumulation factor for \((Fa)^m\) resulting in the next expression:

\[ V_{D_n} = \sum_{0=0}^{n} 1_{af} (Fa)^m + \sum_{1=0}^{n} 1_{af} (Fa)^m + 1_{pff} + \sum_{n=0}^{pff} 1_{af} \frac{1_{af}}{(Fa)^m} + \sum_{n=0}^{pff} 1_{pff} \frac{1_{pff}}{(Fa)^m} \]  \hspace{1cm} (13)

Again, if we identified the payments coefficients, before the focal date, in the focal date and after the focal date like: \( C_{aff}, C_{ff}, C_{pff} \)

We obtain the following expression:

\[ V_{D_n} = Y \left( \sum_{0=0}^{n} C_{aff} + C_{ff} + \sum_{0=0}^{pff} C_{pff} \right) \]  \hspace{1cm} (14)

Through substitution, we obtain the model expression that allows us to get the amount of each payment.
\[
Y = \frac{V_{D_n}}{\sum_{n=0}^{aff} C_{aff} + C_{ff} + \sum_{n=pff}^{C_{pff}}} \quad (15)
\]

Where:
\( Y \) = Value of each payment,
\( V_D \) = Value of the new debt previously valued,
\( \sum C_{aff} \) = Sum of the payments coefficients in the prior focal date,
\( C_{ff} \) = Payments coefficients in the focal date.
\( \sum C_{pff} \) = Sum of the payments coefficients after the focal date.

### Programming in excel spreadsheet

After explaining and practicing each subject of Financial Mathematics, the following step is now for the student to design their own group of formulas for this subject, in this case being equivalent equations with simple and compound interest. The cover is designed and inserted in the spreadsheets for any formula that we will use.

### Process of Teaching-Learning

Step 1: The modalities are established (See sequence images)
Step 2: Programming the Excel spreadsheet for any formula (For example)

=IF(D7="i",(1*POWER(1+(K13*(D7/12)),D7)),0)+IF(F7="i",(1*POWER(1+(K13*(F7/12)),F7)),0)+IF(H7="i",(1*POWER(1+(K13*(H7/12)),H7)),0)+IF(J7="i",(1*POWER(1+(K13*(J7/12)),J7)),0)+IF(L7="i",(1*POWER(1+(K13*(L7/12)),L7)),0)+K19+IF(D11="i",(1/POWER(1+(D11/12)),D7)),0)+IF(F11="i",(1/POWER(1+(F11/12)),F7)),0)+IF(H11="i",(1/POWER(1+(H11/12)),H7)),0)+IF(J11="i",(1/POWER(1+(J11/12)),J7)),0)+IF(L11="i",(1/POWER(1+(L11/12)),L7)),0)+

Design tool (excel)

See sequence images
Discussion
The use of ICT for teaching mathematics has become a new trend. This is, through computing platforms have opened new ways in education, specifically in teaching mathematics. Some studies have given us evidence, to say that the population nowadays is getting better results, both in understanding and the skills of developing mathematical functions, with the use of the spreadsheets and computer technologies itself, all of that compared with the student that carries out the teaching-learning process in the traditional system\(^1\).

The uses of ICT have helped the manipulation of variables in mathematical information or data that is used for development of some formula or mathematical model. The graphic representation, the modeling and other qualities of this application, is what ICT offers for developing the exercises. Just as we know, a few practical mathematical cases turn to be very difficult or complex to solve in a traditional way, using only paper and pencil.

In the same way, it is necessary to break paradigms and old customs in the teaching-learning process; it has been recommended that the teacher designs his session plan with the use of computer technologies, being the specific case, the introduction of spreadsheets.

The bases of the proposed model (Figure 1 and 2) show variables: the teaching-learning process, the tool (the use of the ICT, specifically the spreadsheet) and the product (significant learning). In both cases the student is the subject, but the b) model integrated the teacher as an important variable.

In the final one, the character through which migration occurs from traditional education system of mathematics, towards the teaching-learning process based in the use of ICT, specifically the use of Excel spreadsheets.

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\(^1\) SRI International, “A Review of Research on Computer-Based Tools (Spreadsheets, Graphing, Data Analysis, and Probability Tools), with an Annotated Bibliography”

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