International Engineering Journal For Research & Development

Vol.2
Issue 5

USE OF SCILAB IN LINEAR ALGEBRA

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Abstract

Our main aim is to reflect on key aspects related to the method, didactics and creative praxis in the teaching of linear algebra in higher education that if implemented, could contribute to a better learning in this area of mathematics so important for future engineers. In this sense, we propose some activities to develop with Scilab. After the implementation of the activities we gather information from students through an inquiry and we think we have achieved the proposed goals.

Keywords: creative educational process, higher education, mathematics education, linear algebra, Scilab, free and open source software

1 Introduction

Currently the area of mathematics education has come to play an increasingly important role in the teaching and learning of various math concepts, both at basic education level as higher education. According to, new paradigms related to the current higher education also lead the protagonists in this process (teachers, researchers and students) to think about how to act when faced with this challenge for that teaching, learning and research can take place in a more creative way, different from the formatted.

Some researchers studying the higher education, and, among others, alert us to the fact that nowadays there is more and more a requirement for teachers teaching in higher education to be not only skilled in the science component of teaching, but also be concerned with the training and learning of their students.

Nowadays a teacher of higher education has to look new challenges in the act of teaching, in order to contribute to a better personal and professional development of students. According to,

" ***it's not sufficient to teach what is known, it is also necessary to enable the student to question, reflect, transform and create, through an educational method that highlight the education that facilitates the learning as well as all learning that awakens the feeling favouring new creations*** **".**

Then it is necessary to adapt the methods of teaching and assessment to the different learning styles of students and their several interests, motivations, know-hows and potentials. It was thinking about the interests, motivations and current context in which students move in general (and of higher education in particular), that we propose the use of technology to address some topics of Linear Algebra.

In this paper we reflect on key aspects related to the method, didactics and creative praxis in the teaching of linear algebra in higher education that could contribute to a better learning in this area of mathematics so important for future engineers. In this sense, we propose some activities to develop with the *Scilab* and in the next section we will make a brief introduction to this software and present our proposal for its use. In the end of this paper, a section with some final remarks with some reflections about the use of this type of technology for teaching some topics in mathematics is considered.

Scilab in Linear Algebra

According to, Scilab, This computing environment can be downloaded in http://www.scilab.org and it is easy to install on any computer. Scilab is currently used in several industrial and educational environments around the world.

Some features of Scilab

Scilab, being an open source program, its use in education is, in our opinion, a viable and useful alternative for any educational project. Some key features of Scilab to highlight are that it is a program of free distribution, with source code available, with a simple and easy to learn language, having a system to aid the user (help) in several languages, including Portuguese. Also this tool offers resources for generating two-dimensional and three-dimensional graphics and animations.

From the point of view of the user, the latest version of Scilab is always available via Internet, the program can be used without any restriction and the results that are obtained with its use may be disclosed without problem.

In what concerns to Linear Algebra, Scilab implements various functions; for example, matrix manipulation, including transposition, addition and multiplication of matrices, calculation of the rank, the determinant, inverse and eigenvalues (if there exist) of a matrix, condensation of a matrix by Gauss elimination, allowing also to work with systems of linear equations, among other topics.

The use of a computational tool lets you quickly perform calculations that would be time consuming with paper and pencil and makes easy the exploration of some conjectures and properties related to certain entities of linear algebra. It is intended that students consolidate their learning, reflect on some common mistakes made with paper and pencil and increase their motivation, confidence and autonomy.

Our proposal

After introducing the basic concepts of matrices and the algebraic operations of addition, multiplication by a scalar and matrix multiplication, we suggest the presentation of Scilab to students. It will be enough to show one or two examples of each of the algebraic operations between arrays in order to familiarize themselves with the program.Scilab commands are fairly simple. To define a matrix of type 2 by 3 (2×3), i.e., with two rows and three columns, for example with entries, 1, 2, 3, 4, 5 and 6, it is sufficient to write on the line command of the program A = [1 2 3, 4 5 6] and press enter. Just separate entries by a space and the different lines by semicolons, (see Figure1).

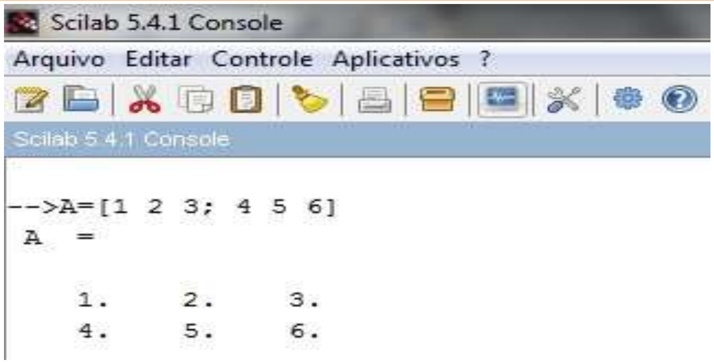

Figure 1: A window with the introduction of a matrix A of type 2 × 3.

Using Scilab, all main controls related to matrices are quite simple and intuitive. For example, the commands A', rank(A), inv(A), det(A) and spec(A) compute for a matrix A, respectively, the transposed, the rank, the inverse, the determinant and the eigenvalues (if there exist), (see Figure2).

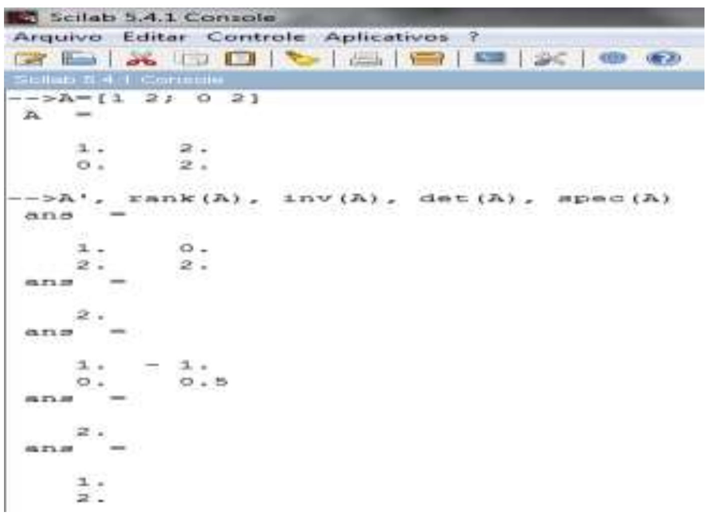

Figure2: A window illustrating the use of the commands the commands A', rank (A), inv(A), det(A) and spec(A).

Several examples of the use of these commands can be found. Also in order to calculate the product of A by B (AB) we write A * B. These commands can be easily provided to students in the presentation of the program. From this point, the student has a tool to check the calculations made by themselves, with paper and pencil, and explore some conjectures and properties related to algebraic operations with matrices or other contents.

As a proposal we suggest the following:

Consider the matrices

$$A=\begin{bmatrix}1&5&2\\3&4&6\end{bmatrix},B=\begin{bmatrix}0&4&1\\3&2&5\end{bmatrix},C=\begin{bmatrix}1&0&-1&5\\4&3&2&1\\8&-2&6&-3\end{bmatrix}$$

$$D=\begin{bmatrix}2&3\\1&0\\-1&5\end{bmatrix},E=\begin{bmatrix}1&0&-1\\3&2&4\\-2&5&3\end{bmatrix},F=\begin{bmatrix}0&2&1\\-1&3&5\\-3&4&-2\end{bmatrix}\quad G=\begin{bmatrix}1&2&-1\end{bmatrix},H=\begin{bmatrix}3\\0\\-2\end{bmatrix}$$

Compute, using Scilab:

A + B b) AB c) A + C d) AC e) CA f) AD
g) DA h) EF i) FE j) A2 k) E2 l) E7

Conclusions: Notice that the matrix product is not commutative, unlike the product of real numbers. It may be possible to multiply a matrix X by a matrix Y, but not be possible the opposite (see d) and e)) and, even if possible, the product obtained can give rise to different types of matrices (see f) and g)). In case the result is of the same type, usually, does not match (see items h) and i)). In general, for A = [aij], its square A2 ≠ [a2] and such operation is possible only if A is a square matrix (see j) ij
and k)).
Consider the matrices

$$A=\begin{bmatrix}1&0\\3&4\end{bmatrix},B=\begin{bmatrix}1&5\\-1&0\end{bmatrix},C=\begin{bmatrix}2&0\\-1&1\end{bmatrix},D=\begin{bmatrix}1&1\\1&1\end{bmatrix},E=\begin{bmatrix}1&-1\\-1&1\end{bmatrix}$$

$$F=\begin{bmatrix}3&1\end{bmatrix},G=\begin{bmatrix}2\\-1\end{bmatrix}$$

Compute using paper and pencil:

a) AB b) BA c) AC d) CA e) DE f) E2 g) FG h) GF

Now, confirm the results obtained, using Scilab.

Conclusions: Sometimes XY = YX. In this case we say that the matrices X and Y commute (see c) and d)). It is possible that the product of two non-zero matrices be a null matrix (see e)). It is possible that the square of a matrix be a null matrix (see f)). FG is a matrix with only one entry, while GF has a different type.

To investigate using Scilab:

Compute (A + B)2, A2 + 2AB + B2 and A2 + AB + BA + B2. Consider now C
instead of B and make again the calculations. Why (A + B)2 G A2 + 2AB + B2?
Think also what happens in cases
(A — B)2/A2 — 2AB + B2, (A + B)(A — B)/A2 — B2 and(AB)2/A2B2.
Are identical pairs? Why not?
Does the product of a row matrix by any matrix result in a row? And changing the order of the matrices? And if it is a column matrix?

At the end of performing these exercises the student may conclude that, although the sum of matrices of the same type is possible, the product is not always, and that the matrix product is not commutative, unlike the product of real numbers. In cases where the addition (or multiplication) of matrices is not possible, the program displays an error message such as "Inconsistent addition" (or "Inconsistent multiplication"). (See Figure 3)

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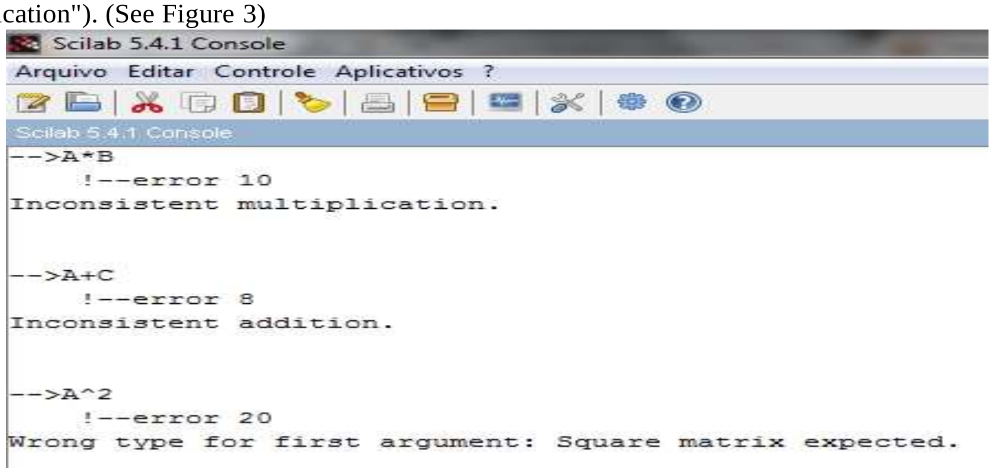

Figure 3: A window illustrating impossible algebraic operations with matrices.

It is important that students realize that it may be possible to multiply a matrix A by a matrix B, but not be possible the opposite and that even being possible, the product obtained can give rise to different types of matrices. In case the result is of the same type, usually, does not match. It may then be provided to the student an example in which the matrix product AB is equal to the product BA and mention that, in this case, we say that the matrices commute. It

is also important that the student realize that, in general, for a matrix A = [aij], A2 ≠ [a2] and such operation is possible only if A is a square matrix. Consider A2 = [a2ij] is a very common mistake done by students, despite the insistence of the difference that can be presented in class. Also with this activity, the student can verify that the notable cases and other valid properties for real numbers are not valid when, instead of real numbers, we consider matrices.
It will be important to guide the student to the fact that these properties do not arise in the case of matrices because matrix multiplication does not have the commutative property.

Final remarks

New technologies applied to higher education not only open a new way of teaching and learning, but also allow us (teachers, researchers and students) to adapt to the needs that the new society presents.

In our opinion, it would be quite time consuming, students perform those calculations needed to draw the conclusions that we intend with the realization of this proposal without the use of Scilab or another computational tool.

The potential of technology is huge and its application in everyday life and future profession of our students is notorious. It is our duty contributes to the preparation of this challenge, hoping that this work will be the beginning of this contribution.

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