

USE OF COMPUTER ALGEBRA SYSTEMS IN TEACHING MATH AT SGU

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Abstract

We present our program to incorporate Computer Algebra Systems in teaching of Mathematics (College Math, Calculus, Linear Algebra & Geometry) at St. George's University (Grenada, West Indies). Modern Computer Algebra Systems (CAS), such as *Mathematica*, Maple, Maxima, etc. are very powerful, have good graphics facilities and can be used for teaching as well as research. We have selected Maxima as a base CAS to use.

Keywords: *CAS in Education, Maxima in Education.*

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1. INTRODUCTION

We present our program to incorporate Computer Algebra Systems in teaching of Mathematics (College Math, Calculus and Linear Algebra & Geometry) at School of Arts and Sciences, St. George's University, Grenada, West Indies.

There is a major problem in University teaching of Mathematics in Grenada and in the Caribbean in general (with the exception of Cuba where in spite of hard economical situation educational system still is rather strong) because students admitted to the University usually have very poor Mathematical skills, see e.g. [1–4]. The situation is slowly improving, but there is a need to enhance school teaching and to introduce new attitudes and technologies into teaching Math.

Authors also agree with the ideas presented in [5, 6], modern technology not only allows, but also puts a strong demand to changing the way of teaching Math. With modern computer systems (not only CAS, same is true for specialized statistical packages, etc.) one doesn't need losing time to practice computational skills by doing a lot of boring calculations. Time can be spent much more efficiently by concentrating on the understanding of basic ideas, leaving boring and bulky calculations for computer to do. It is important to remember that (unfortunately) very often users consider results obtained with the use of computer as the absolute truth and don't take it critically, so understanding the meaning and relevance of the results obtained with computer is very important.

Modern Computer Algebra Systems (CAS), such as *Mathematica*, Maple, Maxima, etc. are very powerful, have good graphics facilities and can be used for teaching as well as research. They are used in education for many years, good examples and discussions were (and still are) presented,

e.g. in the sessions on Computer Algebra in Education of the ACA (Applications of Computer Algebra) conference series, see <https://math.unm.edu/aca.html>. Unfortunately, *Mathematica* and Maple are commercial products. They are very powerful, convenient to use, but are rather expensive, even student's versions, so we have selected Maxima as a base CAS to use.

Maxima is a free computer algebra system, that is easy to install and use. It can be used on Windows computer as well as on iPad/iPhone or Android phone or tablet. Maxima for Windows has a convenient user-friendly GUI that allows even those who doesn't know how to use it easily start using it just by clicking the mouse and typing their expressions. Only basic knowledge of Maxima syntax is required. Maxima was and is used in Math and Engineering education for many years, see e.g. [7-9].

2. TEACHING BASIC MATH

In School of Arts and Sciences, all new students have a placement test on Math. Those who pass it, take mandatory College Mathematics, otherwise they have to take preparatory course Foundation Math. In this section, we consider using Maxima in teaching College Math, applications for more advanced courses we will briefly discuss in the next section.

In transforming the methodology of teaching College Math we have chosen evolutionary, not revolutionary way for many reasons, one important reason being the fact that many faculty involved have typical Caribbean Math education and are not ready for the introduction of new technologies and methods on full scale. So at the moment usage of Computer Algebra Systems (CAS) is recommended to faculty and students, not mandatory.

Most of home assignments students had to do certainly could be done by manual calculations, but one assignment involving multiplying matrices of higher dimensions, finding determinants and inverse matrix of the fourth order, solving linear systems with four unknowns certainly encouraged students to use CAS, though some students in the class (as well as most students in other sections where faculty didn't promote CAS) were doing it by hand.

To facilitate the learning process, we developed a Power Point presentation (guide) in order to assist persons with both the installation and the use of Maxima. The Power Point demonstrates how the teacher can use Maxima when preparing for the class and in the classroom; we also give examples of how students can use it when working on home assignments and solving complicated problems that are hard to deal with manually. Presentation is updated according to students' responses. Last term, data was collected in one section by one of the authors (S.H.) by way of questionnaires at the beginning and at the end of the semester. In the beginning of the semester, some students were not sure in the usefulness and necessity of using CAS in the course; argument was: "it may take a while to learn how to use that software and get familiar with it. I don't need added stress to the stress I already have in other subject areas." At the end of the semester most students had positive impression of using Maxima in the class with two exceptions: one student had found Maxima too complicated to use while there are more convenient systems online (these systems were not specified), while another student failed to install Maxima and was too shy to ask teacher for help. One recommendation from students was to make initially a good demonstration in the beginning of the semester, and may be devote a few classes to practice Maxima.

Students had mostly positive experience with Maxima, stating that

- "These systems really help in verifying your answers when one is in doubt."
- "It allows students to solve Mathematical Problem in a fast way. Students can also use it to check mathematical problems after manually working them out."
- "Maxima helps students in terms of doing math calculation in a more efficient way."

However, one student has pointed out that “on the other hand a student who relies on it may not fully understand the concepts.”

3. TEACHING ADVANCED MATH COURSES

Our first experience of using Maxima in teaching basic Calculus we described earlier [10]. In "advanced" Math courses (Calculus and Linear Algebra & Geometry) students were strictly recommended to use Maxima or another CAS while taking the course. In the beginning, students were hesitant to learn new system. There also was a short period of making standard mistakes related to misinterpretation of the results (taking multiplicity of the eigenvalue as another eigenvalue, etc.), or elementary mistakes and misprints due to poor knowledge of Maxima syntax, but as time progress most students started to use Maxima or other CAS actively. At the end of the courses, general opinion of students was that using CAS was helpful and useful. Some students stressed that using CAS helped to deal with problems that were looking hard and/or complicated while other have found Maxima very convenient to check results obtained by hand. On the final exam on Calculus I all students were using CAS.

Using CAS in the class allowed to concentrate more on understanding the ideas, leaving technicalities aside. Certainly, during the course students had to do a number of exercises, in the beginning solving simple problems by hand and controlling results with CAS, later it was students' choice to use CAS, or continue in a traditional way. But when assignments become more involved, all students started to use CAS in most cases.

4. CONCLUSIONS

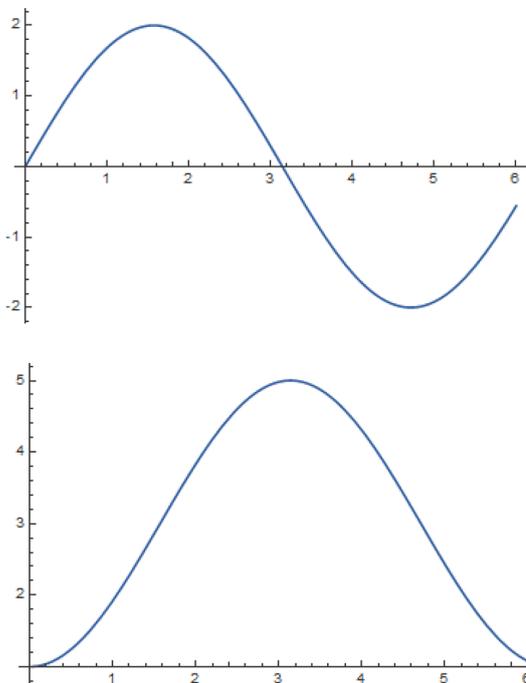


Figure 1. Plots of the function $f(x)$ and its derivative $f'(x)$ are shown. What plot shows the function, what plot shows its derivative?

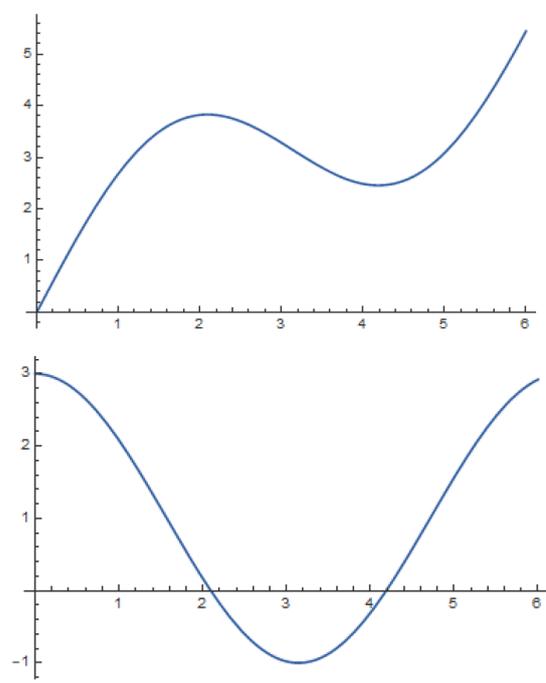


Figure 2. Plots of the function $f(x)$ and its antiderivative $F(x)$ are shown. What plot shows the function, what plot shows its antiderivative?

We believe that Maxima will play a useful and important role in the teaching and learning of Mathematics at SGU. Students can use CAS to deal with problems that are hard to solve in mind or by hand, they can quickly check correctness of solutions, experiment with different modifications of the original problem (parameter changes, etc.) Easy way to check results of manual calculations with CAS increases students' confidence in the case solutions are correct and helps to find the error if there is disagreement between results of manual solution and the one obtained by computer.

As was mentioned earlier, using CAS reduces time loss on practicing manual calculations leaving more time to discuss ideas and deal with "theoretical" problems like examples shown in Figures 1, 2. Authors had seen similar example in Roger Penrose book [11], liked the idea and wanted to use it in the class; the problem always was the lack of time to deal with exercises like this. Now with extensive use of Maxima, enough time was finally saved giving the opportunity to discuss and deal with problems of this kind.

Faculty can use CAS in preparing for the classes and in the class to demonstrate what happens when we change some parameters in the system, etc. Teachers can also use CAS to create multiple choice questions, and so on.

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Использование систем компьютерной алгебры в преподавании математики в университете Сент-Джорджеса

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Аннотация

Мы представляем нашу программу по внедрению систем компьютерной алгебры в преподавание математики (Элементарная математика, Математический анализ, Линейная алгебра и геометрия) в Университете Сент-Джорджеса (Гренада, Вест-Индия). Современные системы компьютерной алгебры (СКА), такие как *Математика*, Мейпл, Максима и т. д., очень мощные, обладают хорошими графическими возможностями и могут использоваться как для обучения, так и для исследований. Мы выбрали систему Максима в качестве базовой СКА для использования.

Ключевые слова: *CAS в образовании, Максима в образовании.*

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