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An Effective Use of Maxima in Teaching and Learning Mathematics: An Overview

Dr. Kailas S. Borase

Department of Mathematics, RNC Arts, JDB Commerce and NSC Science College, Nasik Road - 422 101, India

Abstract: ***Nowadays, mathematical software rather free software is found their effectiveness and rapid use while tackling the complex types of problems in Mathematics. Much mathematical software is used to make tremendous improvements in all fields of Mathematics, viz. Axiom, GAP, Cadabra, GeoGbra, Octave SageMath, Scilab etc. In this research paper, it is overviewing of the same for free software 'Maxima', a Computer Algebra System (CAS) which is written on common lisp as effectiveness in teaching and learning Mathematics at undergraduate courses to demonstrate the relevance of traditional teaching and teaching under use of Maxima software.***

1. Introduction

The main intend of this research paper is to give introductory pleasing in utilization of Maxima with successive in understanding while applying to a particular concept in Mathematics. Author has included an overview of Maxima for practical's curriculum implemented by S. P. University of Pune since academic year 2019 - 2020 at undergraduate level students with the aim in its preamble of syllabi is to give the students a sufficient knowledge of fundamental principles with clear perception of mathematical ideas and tools and know how to use them by modeling, solving and interpreting. In addition, reflection of mathematical tools in various fields of Science and Technology, enhancing students overall development and enable the students to attract for the courses where Mathematics being offered as a main core.

2. Role of Maxima in Teaching - Learning Mathematics

What can be role of Maxima in teaching and learning Mathematics? Can Maxima be powerful tool in teaching and learning Mathematics? Obvious answer comes yes! Because it's user friendly design of technology. This research paper attending the methods in which use of Maxima in teaching and learning Mathematics becomes a powerful aids as a part of technology based education system. Naturally, every course of action there is a reaction and hence the advantages and disadvantages of using Maxima in teaching - learning process of Mathematics also discussed in this research paper.

Maxima can play a role of teaching aid in Mathematics which may include assisting beginner enhance reading power, understanding skills, sketching, strengthening a skill, or conception. Maxima may be applied for tasks with different Mathematics concepts, including constructions of several problems and their proofs. Whatsoever, the uses of Maxima in Mathematics, the center should be arranged thinking with the aim prominence on excessive curiosity, logical reasoning and commitment in valuable mathematical tasks.

3. Advantages and Disadvantages of Using Maxima

The main advantages of using Maxima is that now it runs on Android mobile devices or tablets and can be used offline where ever you need to do so. The installation of the application requires total of 150 MB only as the storage. One can perform many mathematical operations such as integral, differentiation, matrix operations, rational numbers; use of constants pi, e etc. and numerical use of trigonometric functions.

Maxima also cover the following area of Mathematics:

- Algebraic operations with polynomials and their demonstration using graphical approach
- Functions and their graphs
- 2D, 3D plots, contour plots
- Computations of limits of functions, special functions, integral equations
- Number theory, linear algebra, group theory

The main disadvantage of using Maxima is the minimum requirement of Android OS is Kitkat Andriod 4.4 APP level 19 and above. The fear of addiction of mobile phones or computers to Mathematics loving community and which can hamper the thinking process of learners and may lead to eye vision problems. The considerable impediment of using Maxima is still it is not possible at rural places, where internets like things are yet not approached.

4. Benefits from Advantages and Overcomes on Disadvantages of Using Maxima

4.1 Benefits from Advantages of Using Maxima

Following may be measure benefits from advantages of using Maxima software.

- One of most challenging benefit of using Maxima is that learners are able to develop commands at their own, consequently endeavor the interest in Mathematics study.
- One of the benefits of using Maxima to solve mathematical problems is the quickness of producing correct answers
- It can be an interesting tool for teaching purposes in Mathematics
- Free availability of Maxima software to every learner to

access
- For reuse of developing commands on mobile like devices is the tactile for copying pervious commands.

4.2 Overcomes on Disadvantages of Using Maxima

Overcomes on disadvantages of using Maxima in teaching and learning Mathematics can observed as the remedies for further future work.
Following may be measure of overcomes on disadvantages of using Maxima software.
- To develop Maxima as an interesting tool in teaching Mathematics
- To investigate those cognitive free software which are assumed to be involved in the effect and usefulness for teaching and learning Mathematics
- To investigate the role of correct free software approach for the teaching and learning mathematics
- To develop proper sequential commands that will lead to the most accuracy of the topic involved
- To overcome on learners misconceptions on use of Maxima software awareness shall be the task

5. Principal Task of the Research Paper

The principal task of this research article is to see usefulness between traditional teaching methods such as chalk - board teaching and experimental methods such as Maxima based understanding of concept of Mathematics under consideration and correlate between them. The main idea of developing 'syntax' for the given concept, it has been developed as what we did at the time of 'chalk - board' teaching in regular classroom of undergraduate courses. For this following undergraduate topics in Mathematics have been chosen.

5.1 Analytical Geometry

Ex: 1 Obtain the equation of the sphere through the four points (1, 1, 1); (−1, 0, 2); (0, 3, −1) and (2, 1, −3). To obtain this, most of times Bayer's method or else which is to be remember by the learner. As equation of sphere $x^2 + y^2 + z^2 + 2ux + 2vy + 2wz + d = 0$ leads to following four equations that convey to solve system of four equations in four unknowns which shall solved using determinant of order 5, which is itself tedious and complex, but using Maxima as following sequential commands we can have the desired results as better.

```
(%i1) EXPN:(x^2+y^2+z^2+2*u*x+2*v*y+2*w*z+d=0);
```
$$z^2+2\,w\,z+y^2+2\,v\,y+x^2+2\,u\,x+d=0$$

Here, 'EXPN', we mean 'expansion', 'expression' or 'equation' as the case may be. Next, we let all these points on the required sphere as we did the same while studying in regular teaching classes and obtain four equations in u, v, w and d using command 'subst' mean 'substitute in' as below:

```
(%i2) A:[x=1,y=1,z=1];
```
$$[x=1,y=1,z=1]$$
```
(%i3) E1:subst(A,EXPN);
```
$$2\,w+2\,v+2\,u+d+3=0$$
```
(%i4) B:[x=-1,y=0,z=2];
```
$$[x=-1,y=0,z=2]$$
```
(%i5) E2:subst(B,EXPN);
```
$$4\,w-2\,u+d+5=0$$
```
(%i6) C:[x=0,y=3,z=-1];
```
$$[x=0,y=3,z=-1]$$
```
(%i7) E3:subst(C,EXPN);
```
$$-2\,w+6\,v+d+10=0$$
```
(%i8) D:[x=2,y=1,z=-3];
```
$$[x=2,y=1,z=-3]$$
```
(%i9) E4:subst(D,EXPN);
```
$$-6\,w+2\,v+4\,u+d+14=0$$

It is obvious, on solving four equations in four unknowns we have to be values of u, v, w and d. So, it is assigned 'RV' stand for 'required values' and using 'solve' command to solve the equations.

```
(%i10) RV:solve([E1,E2,E3,E4],[u,v,w,d]);
```
$$[[u=\frac{11}{10},v=\frac{9}{20},w=\frac{33}{20},d=-\frac{47}{5}]]$$

Now, required equation of sphere can be using 'RS', it stands for 'required sphere' as below:

```
(%i11) RS:subst(RV,EXPN);
```
$$z^2+\frac{33\,z}{10}+y^2+\frac{9\,y}{10}+x^2+\frac{11\,x}{5}-\frac{47}{5}=0$$

Still it is not done unless we simplify the denominator using 'ratnumer'.

```
(%i12) ratnumer(RS);
```
$$10\,z^2+33\,z+10\,y^2+9\,y+10\,x^2+22\,x-94=0$$

In this way, the output from (%o12) suggest to accept as the required equation of sphere because it contains coefficients of variables of square terms are all equal and containing no product terms of variables. Thus, output from (%o12) found to be correct answer subject to following verification is being sustained.

Verification of the Solution:
It is to verify the equation of required sphere attends all four points on it as following 'syntax' says.

```
(%i13) VerifyAll:[subst(A,RS),subst(B,RS),subst(C,RS),subst(D,RS)];
(%o13) [0=0,0=0,0=0,0=0]
```

Above skills of developments of 'syntax' is accordingly traditional teaching method for which no need to remember other out of scope of syllabi viz. above Bayer's method.

Ex.6 Find the centre and equation of the sphere passing through the points (3, 0, 2), (−1, 1, 1), (2, −5, 4) and having centre on the plane $2x + 3y + 4z = 6$. Assume the sphere accordingly as below:

```
(%i1) EXPN:(x^2+y^2+z^2+2*u*x+2*v*y+2*w*z+d=0);
(%o1) z^2+2 w z+y^2+2 v y+x^2+2 u x+d=0
```

Whose centre is $(-u, -v, -w)$ and let lies on the given plane

```
(%i2) Centre:[x=-u,y=-v,z=-w];
(%o2) [x=-u,y=-v,z=-w]
(%i3) EXPN1:(2*x+3*y+4*z=6);
(%o3) 4 z+3 y+2 x=6
(%i4) E1:subst(Centre,EXPN1);
(%o4) -4 w-3 v-2 u=6
(%i5) A:[x=3,y=0,z=2];
(%o5) [x=3,y=0,z=2]
(%i6) E2:subst(A,EXPN);
(%o6) 4 w+6 u+d+13=0
(%i7) B:[x=-1,y=1,z=1];
(%o7) [x=-1,y=1,z=1]
(%i8) E3:subst(B,EXPN);
(%o8) 2 w+2 v-2 u+d+3=0
(%i9) C:[x=2,y=-5,z=4];
(%o9) [x=2,y=-5,z=4]
(%i10) E4:subst(C,EXPN);
(%o10) 8 w-10 v+4 u+d+45=0
(%i11) RV:solve([E1,E2,E3,E4],[u,v,w,d]);
(%o11) [[u=0,v=2,w=-3,d=-1]]
(%i12) RS1:subst(RV,EXPN);
(%o12) z^2-6 z+y^2+4 y+x^2-1=0
(%i13) RCentre:subst(RV,Centre);
(%o13) [x=0,y=-2,z=3]
```

Verification of the Solution:

```
(%i14) VarifyAll:[subst(A,RS1),subst(B,RS1),subst(C,RS1)];
(%o14) [0=0,0=0,0=0]
```

Ex.3 Find the equation of the tangent plane to the sphere $x2 + y2 + z2 + 4x - 5y - 3z - 3 = 0$ at a point (1, 2, −1) on it

```
(%i1) EXPN:(x*x[1]+y*y[1]+z*z[1]+u*(x+x[1])+v*(y+y[1])+w*(z+z[1])+d=0);
(%o1) w(z+z_1)+z_1 z+v(y+y_1)+y_1 y+u(x+x_1)+x_1 x+d=0
```

We assign equation of a required as usual

On comparing with the general equation of sphere we may have $u = 2$, $v = (-5/2)$, $w = (-3/2)$, $d = -3$, and let it pass through given point $x1 = 1$, $y1 = 2$ and $z1 = -1$

```
(%i2) R:subst([u=2,v=(-5/2),w=(-3/2),d=-3,x1=1,y1=2,z1=-1],EXPN);
(%o2) -z-3(z-1)/2-5(y+2)/2+2 y+2(x+1)+x-3=0
```

It shall be noted that same development various command may applied for rest of Mathematics.

6. Conclusions

As it has been demonstrated in this research paper to grow sequential commands in Maxima software might be found effective in teaching Mathematics to other areas of Mathematics too which may then lead to better understanding of these topics under considerations. In this way, the Author intends to show the necessity and benefits of use of free software in teaching Mathematics as the importance of an attitude to derive innovative practices in teaching - learning process of Mathematics by means of free mathematical software such as Axiom, GAP, Cadabra, GeoGbra, Octave SageMath, Scilab etc. This is the aspirant of Mathematics teacher worldwide.

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