Using computing software in Calculus I: Replacing coding with dynamic visualizations.

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Background

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- DFW rates consistently around 45% (20% withdrawal rate)
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- Many students repeat the course many times

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- Visualize aspects of calculus concepts
- Perform mathematical computations faster/more accurately/ work with more complicated problems than by hand.

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Research on CAS in the classroom focuses on the role of dynamic imagery, mixed results on student outcomes:

- Melin-Conejeros (1992): use of CAS in calculus 1 was related to decreased exam scores.
- Park, Travers, 1996; Tiwari, 1999: CAS use increases exam scores.
- Consensus that computer simulations promote discussion; more effective than static images at developing computation skills. (Aldahmash, Abraham, 2009; Keller et al., 2007; Nichols et al., 1996; Steinberg, 2000; Szabo, Pookhay, 1996).

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4. We express the equation using *Mathematica* replacing s and x by $s(t)$ and $x(t)$ because they are functions of t.

```
Clear[eq, s, x, t]
eq = (s[t]^2 == x[t]^2 + 3^2)
```

5. We differentiate both sides of the equation with respect to time t.

```
Clear[derivativeeq]
derivativeeq = D[eq, t]
```

6. We solve the resulting equation for $s'[t]$ because we want $s'[t]$ when $x = 8$. We perform this operation with the *Mathematica*

```
srate = Solve[derivativeeq, s'[t]]
```

7. We calculate the numerical value of $s(t)$ when $x(t) = 8$ using the equation that we found in Step 3 above. Note that the values $x(t) = 8$ at a particular instant of time. In order to compute $s'(t)$ we only need $s(t)$ at this particular instant of time.

```
Solve[s^2 == 9 + 8^2, s]
```

8. We find the answer $s'[t]$ by substituting the values $x'(t) = -400$, $x(t) = 8$, and $s(t) = \sqrt{73}$.

```
theanswer = srate /. {x'[t] → -400, x[t] → 8, s[t] → Sqrt[73]}
N[theanswer]
```

Hence, the plane is approaching (note the minus sign in front) the radar antenna at the speed of 374.532 kilometers per hour when the plan

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  - Is a Calculus I course the best place for programming?
  - Why are labs so unpopular?
- Opted to reimagine the labs using SageMath online instead.

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Chose SageMath due to the ease of embedding into webpages (wordpress) and syntax that we felt was more natural for students.

Example of one of our SageMath labs

Lab 5: Extreme Values

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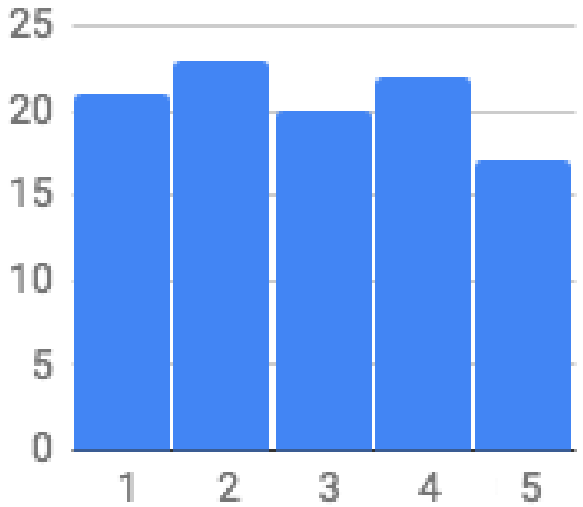

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  - Students who were repeating calculus and had completed both Mathematica and SageMath labs strongly preferred SageMath.
  - *I enjoyed using sage labs much more. Mathematica was a bit confusing and annoying.*
  - *Sage is easier in terms of computation. In Mathematica I was so focused on the syntax. With Sage it is easier to type it in.*
  - *I learned more about the actual topic in SageMath. The wording is easier to understand.*

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- Calculus II (?!)

Thank you!