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SOLVING PROBLEMS USING THE WOLFRAM ALPHA PROGRAM

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Abstract:

This article describes the benefits and drawbacks of using Wolfram|Alpha as the platform for teaching calculus concepts in the lab setting. It is a result of our experiences designing and creating an entirely new set of labs using Wolfram|Alpha. We present the reasoning behind our transition from using a standard computer algebra system (CAS) to Wolfram|Alpha in our differential and integral calculus labs, together with the positive results from our experience. We also discuss the current limitations of Wolfram|Alpha, including a discussion on why we still use a CAS for our multivariate calculus labs.

Keywords: mathematics, calculus, Wolfram|Alpha, CAS, labs.

INTRODUCTION

Wolfram|Alpha is a free, browser-based web service, developed by Wolfram Research, which dynamically calculates results to natural language queries by applying algorithms to its extensive internal database of facts. Users submit queries or computation requests such as 'What is the half-life of Strontium-90?' or 'What's the derivative of x^x?' via a standard one-line text box. Wolfram|Alpha responds with data and computed results in textual, symbolic and graphical representations (Figure 1). While Wolfram|Alpha can be used for much more than calculus, this article will detail our view and experience of using it to teach calculus, and hereafter our views should be taken within that context. A more detailed discussion of its general uses can be found by reading the official Wolfram|Alpha blog and forum available through the official Wolfram|Alpha website [1].

MATERIALS AND METHODS

This article addresses our experience of using Wolfram|Alpha to replace an existing computer algebra system (CAS). In each of the courses in the Calculus sequence, students are required to attend a lab session 1 day per week on which they work through an assignment using a CAS. The lab assignments are meant to provide an extension of the material discussed in the class, and the use of a CAS allows for both visual and computational connections that are more difficult to achieve by hand. We have included our new Labs as a supplementary file, available online under the 'Supplementary Content' tab on the article web page or from the author on request. This type of lab experience has become common among Calculus courses at colleges and universities [9].

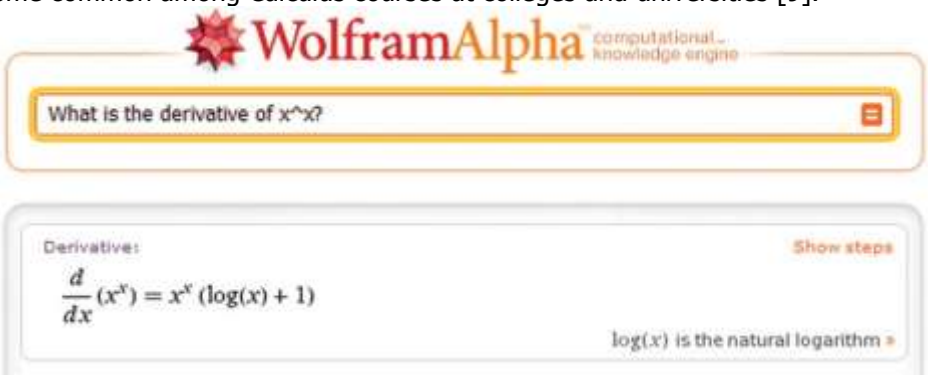

Figure 1. What is the derivative of x^x?

RESULTS AND DISCUSSION

Wolfram|Alpha also provides more information than a one word (or number) answer to the student's original question. Often students may not be sure how to request certain output or possibly do not know how to even ask the question. So the fact that Wolfram|Alpha will report all knowledge from its database in a variety of formats is an advantage for the student. One simple query can result in an equation, a graph, an exact answer and an approximate answer. Even more helpful for the student is the ability of Wolfram|Alpha to display the steps it used to arrive at a solution. The student then has an opportunity to view the process as well as the final answer. Sometimes

Wolfram|Alpha chooses a more rigorous process than one might expect due to its algorithmic nature of using Mathematica behind the scenes. However, most examples result in an explanation that is useful for the student (Figure 2). The 'Show Steps' feature of Wolfram|Alpha is one clear advantage that it has over Mathematica, especially since there are no plans to introduce this feature into Mathematica itself [11].

Moving away from a full CAS, implementing labs with graphing calculators may seem appropriate, as often times students are already familiar with the technology. While possible, we feel that using Wolfram|Alpha is far more practical, at least for labs. The output from Wolfram|Alpha, including graphs, is easily copied and pasted into a student's lab assignment which they turn in each week. For certain graphics and demonstrations, one can easily go back and forth between Wolfram|Alpha, MathWorld [12] and Wolfram Demonstration Project [13]. With Wolfram|Alpha, there is no need to make sure everyone has to buy the same calculator; indeed there is no cost for the student, though they may pay for the iPhone App [14], and with Wolfram|Alpha every student is using the latest version.

Figure 2. Using the 'Show Steps' feature.

One example would be a question about the area under a curve. The lab assignment would ask the student to evaluate several definite integrals. Since Wolfram|Alpha displays both the numeric result and the graphical interpretation, the student is able to see connections in how the integral is set up and how the value of the integral changes based on the limits of integration (Figures 3 and 4). Once the student has an opportunity to observe examples, then the student will be required to make predictions about the result of other definite integrals. Questions can address concepts such as signed areas, symmetry and area or absolute value of areas.

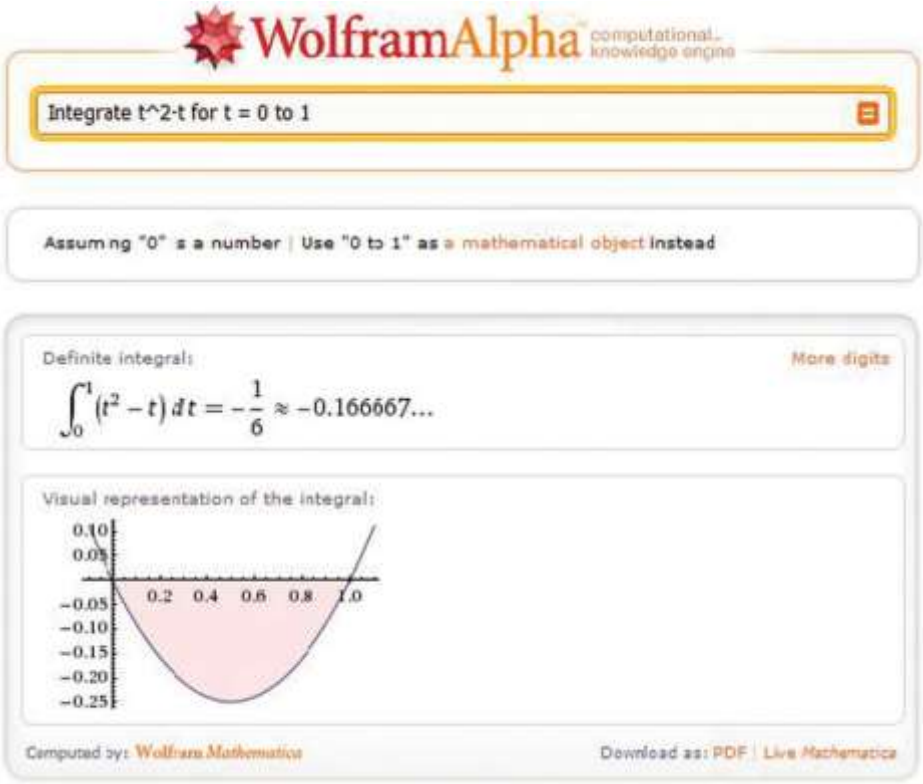

Figure 3. Integrate $t^2 - t$ for $t = 0$ to 1.

It should be noted that there are some concepts that Wolfram|Alpha cannot address directly such as approximation techniques for integration. Wolfram|Alpha will not return a numeric or graphical result from a request to approximate an integral using the trapezoid or Simpson's rule. However, for many of these common calculus concepts, the student can access the link to the Wolfram Demonstration Project [13] from the Wolfram|Alpha site or visit MathWorld [12], another Wolfram creation. In the case of approximation techniques, the student can go the MathWorld site, type 'Riemann Sum' in the search box and have access to a player that will allow them to input their function, the interval, number of subintervals and select the approximation method (Figure 5). In order to view the activities listed in the Wolfram Demonstration Project, the student is required to download (at no cost) a Mathematica Player. If the student is using their own computer, this is not a problem; however, if you are in university lab classroom, there may be some information technology (IT) issues with allowing students to download freely.

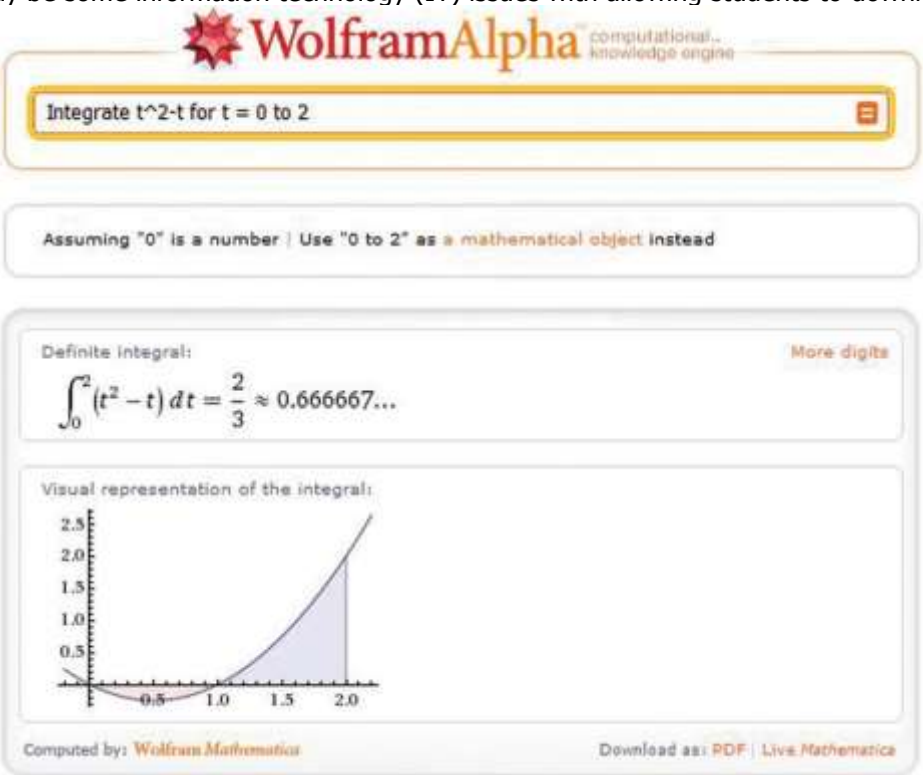

Figure 4. Integrate $t^2 - t$ for $t = 0$ to 2.

Each lab assignment required a written component in which the student would summarize or analyse results instead of simply collecting source code, which often occurs when a full CAS is used. Most students chose to use Microsoft Word although they were given the option to use any word processing program. This worked well. The output from Wolfram|Alpha can be easily copied and pasted into the word processing document as an image. Also, the copyable plain text option for Wolfram|Alpha output allowed for multistep problems and investigating different examples of the same concept. The student did not have to type the input over again.

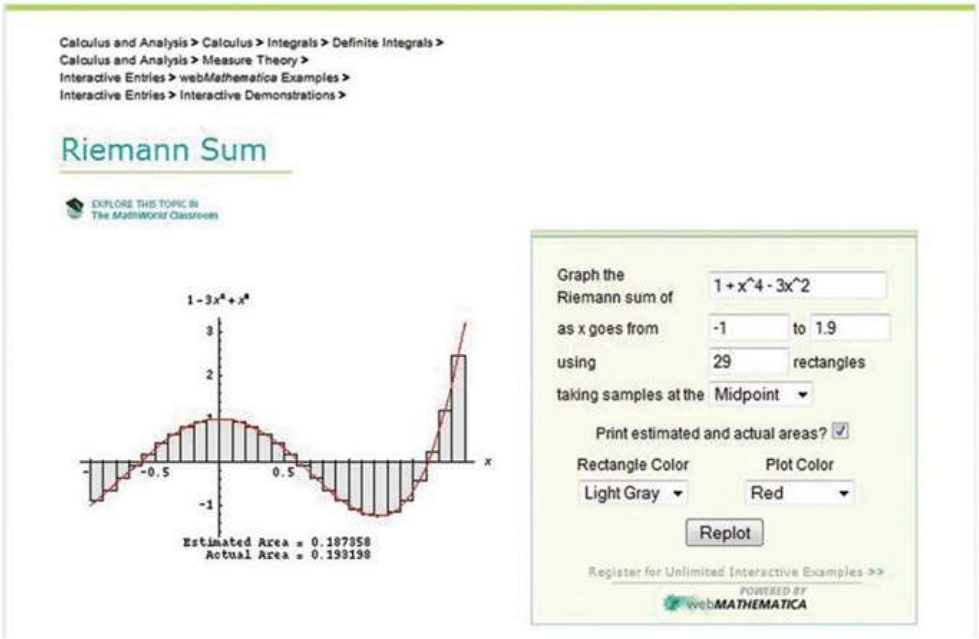

Figure 5. Riemann Sum activity from MathWorld.

Wolfram|Alpha is becoming more useful in the multivariable context as time progresses. The main use of any CAS for multivariate calculus is for visualization. Three-dimensional graphing is somewhat limited in Wolfram|Alpha at this point in time; however, there has been some progress in 3-D graphing recently that will increase the usefulness of Wolfram|Alpha. In MathWorld, there are useful demonstrations of arc length, curvature and partial derivatives. Also, directional derivatives have a very helpful demonstration in MathWorld. However, it is still difficult to graph space curves and quadric (quadratic) surfaces. Also, parametric representations of surfaces are used extensively in vector calculus. These are very difficult to graph in Wolfram|Alpha.

Unlike Calculus One and Two, in Calculus of Several Variables, the students cannot simply type in intuitively obvious commands to graph surfaces or space curves. These are the types of graphs that are necessary to illustrate the concepts in this third semester calculus course. Some common surfaces can be observed, such as quadratic surfaces. However, the students need to make connections between the different representations of these surfaces: algebraic (both in parametric form and in a form where the parameter has been eliminated), numerical and graphical. The first computer assignment in third semester calculus is one in which the students are to explore the effects of changing different parameters for quadratic surfaces. However, the student cannot input different forms of the equation for quadratic surfaces and see how the shape, position and orientation of the surfaces changes.

There are some excellent illustrations for some multivariable calculus concepts in the MathWorld Demonstration Project, for example, the Frenet Frame and Curvature of a space curve. However, again, these examples lack the freedom to change equations and parameters to demonstrate specific examples selected by the instructor or student.

CONCLUSION

We conclude that using Wolfram|Alpha as the computation engine for beginning calculus labs is not only possible but also offers advantages over standard CASs. These advantages include platform independence, natural language processing, being always up-to-date, the show details feature and cost (for both students and institutions). Our experience of converting our CAS-based labs over to Wolfram|Alpha was, in general, a good one. We do note, however, that Wolfram|Alpha is not as powerful as a standard CAS. These limitations make it currently difficult to replace a standard CAS with Wolfram|Alpha for classes beyond Calculus Two.

REFERENCES

1. Wolfram|Alpha. Retrieved March 3, 2010. Available at http://www.wolframalpha.com/.
2. J.R. Young, A calculating web site could ignite a new campus 'Math War,' Chron. High. Educ. (June 12, 2019). Retrieved March 3, 2010. Available at http://chronicle.com/article/ A-Calculating-Web-Site-Coul/47316/.

3. G. Karaali and B. Yoshiwara, A different pencil too good to be ignored. MAA Focus Oct/ Nov 2019 (2019). Retrieved March 3, 2020. Available at http://www.maa.org/pubs/ octnov09pg15.pdf.
4. D.M. Bressoud, Wolfram|Alpha Launchings. MAA Online (August 2009). Retrieved March 3, 2010. Available at http://www.maa.org/columns/launchings/ launchings_08_09.html.
5. M. Andersen, Wolfram|Alpha: recalculating teaching and learning (October 23, 2009). Retrieved March 3, 2010. Available at http://teachingcollegemath.com/?p=1727.
6. C. Bialik, Sum help: new search engine for mathletes, Wall Street J. (June 17, 2009). Retrieved March 3, 2010. Available at http://online.wsj.com/article/ SB124516890985419379.html#printMode.
7. R. Talbert, Wolfram|Alpha for calculus students (September 3, 2009). Retrieved March 3, 2010. Available at http://blog.wolframalpha.com/2009/09/03/wolframalpha-for-calculus- students/.
8. Walpha Wiki. Retrieved March 3, 2010. Available at http://walphawiki.wikidot.com/.
9. D. Tall, D.A. Smith, and C. Piez, Technology and calculus, in Research on Technology and the Teaching and Learning of Mathematics: Volume 1: Research Syntheses, M.K. Heid and
10. G.W. Blume, eds., Information Age Publishing Inc., Charlotte, NC, Summer, 2008, pp. 207–258. ISBN 978-1-931576-19-2.
11. B. Terris, Rebooted computer labs offer savings for campuses and ambiance for students (December 6, 2009). Retrieved March 3, 2010. Available at http://chronicle.com/article/ Computer-Labs-Get-Rebooted-as/49323/.
12. S. Wolfram, Live Q&A with Stephen Wolfram (September 17, 2009). 21:30 mins Retrieved March 3, 2010. Available at http://www.wolfram.com/broadcast/ qa20090917/.
13. MathWorld. Retrieved March 3, 2010. Available at http://mathworld.wolfram.com/.
14. Wolfram Demonstration Project. Retrieved March 3, 2010. Available at http:// demonstrations.wolfram.com/.