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West Virginia + DERIVE = Mountain State Progress

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PREFACE

West Virginia is a mountainous state located in the mid-Atlantic region of the United States. The state was created in 1863, a product of America's civil war. West Virginia is usually known by its backwoods, Appalachian reputation, but the "times they are a changin!" You may have heard of the West Virginia University Mountineers and the Thunderin' Herd of Marshall University - well, these institutions of higher education are fed students by highland high schools like the one where I teach. Other colleges that are near TCHS are Davis and Elkins, Alderson and Broaddus, and West Virginia Wesleyan.

I am Thomas Klus and I am a Mountaineer who lives in Tucker County. On the map the western edge of Maryland points directly down to Tucker County High School, which is located about 14 miles from Lord Fairfax's stone, the corner point for the Maryland panhandle. Our county boasts the Monongahela National Forest and two major ski areas: Timberline and Canaan Valley Resorts. I teach and have taught mathematics classes at TCHS for twenty five years. I am the chairman of a department of three and we mathematically serve a student population of approximately 400, in grades 9-12. In Tucker County, West Virginia, we may be geographically isolated but we are technologically keeping pace.

My classroom is unique in that it was re-designed in 1990, from a previous band room, to accommodate a computer laboratory. It is a large room that is separated into two distinct areas. The typical classroom half and the networked computer lab half. Currently, I have 20 IBM PS2s Baseband networked with Novell, also I have one current technology computer. A mere 5 to 7 years ago the lab was FIRST rate. The lab now pales in comparison to the current technology but the math department still gets top use from the network. Our department has 20 TI81s and, just recently, obtained 24 TI82s with 8 CBL stations and assorted probes. We also have one TI92, which I refer to as the portable DERIVE machine. The site licensed software that is in use is: LANSCHOOL, Turbo Pascal, LOGO, Acrospin, Link82, Linkway and Linkway Live, Microsoft Works and, last but most surely not least, DERIVE version 2.51. We purchased are lab version in 1991 and DERIVE has been in use each year since. Its use has ranged from demonstrations in algebra I to problem solving in AP calculus.

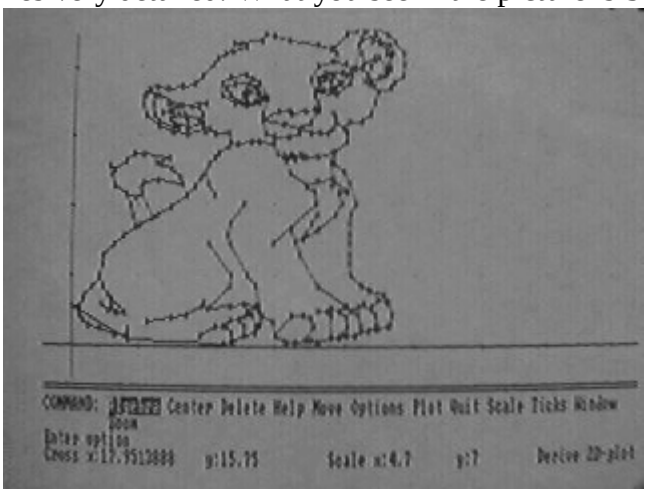
In the past years, I have taught the following courses: transitional math, algebra II, trigonometry, probability and statistics, AP calculus and AP computer science. In each of these classes I have tried to incorporate the use of DERIVE. The association that I relate is that DERIVE is a math processor, much like the various word processors. Just as word processors manipulate words and spelling and sometimes grammar, DERIVE can manipulate mathematical entities. The descriptions that follow are selected uses of DERIVE in my mountain state classroom.

Before detailed exploration with DERIVE begins each class is given an introductory lesson in the aspects of the program. Specifically; the help menu, the algebra page, the graph window and file manipulation. After much practice the students will turn in electronic DERIVE homework and test "papers".

Traditional teaching methods are used to deliver the West Virginia Instructional Goals and Objectives. DERIVE is used to supplement that instruction and is very dependent on the number of days that school is missed because of snow.

TRANSITIONAL MATHEMATICS -

This is a class for non-college bound students and usually the topics introduced are, at most, pre-algebra. But one exercise that the students seem to enjoy is the coordinate plane "Connect the Dots" use of DERIVE. The instructions are to find a picture that the student wishes to draw. They then trace or draw the picture into the first quadrant of a sheet of graph paper. The coordinates of the various intersections are found and written in a tabular form. The students are then DERIVE instructed as to how to create a matrix and then plot that matrix with the proper coordinate window with connected points. The results are sometimes very detailed. What you see in the picture is Simba - from the



Disney movie, drawn by my former student Arvita Pifer.

You will notice that the picture requires numerous matrices to be plotted. The students learn very quickly that if you do more than you wish to do again , make a copy to file. Other characters matrix DERIVE drawn include Tweety, Scooby Doo and various seasonal celebrations; Halloween, Thanksgiving and Christmas. This DERIVE activity is usually preceded by using the TI82s as Etch-A-Sketches. One of the key points that carries over between all my classes is that when you graph with DERIVE you must make, "MOVE, CENTER, SCALE" decisions. These decisions are mathematical considerations that make their drawings more pleasing.

This class also DERIVE investigates the computation of real numbers so that the student can realize the "new" symbols required to use the software to provide the computational answer. Students also Factor natural numbers to check their mental answers. What really

seems to impress the students is the simplification of fractional expressions. They know that certain calculators can do that but now a computer does it.

ALGEBRA II -

This is the class where it all starts. DERIVE is sequentially introduced to supplement the classroom textbook material. Students are first exposed to the various aspects of the software. The grade level of the class is primarily 9th and 10th graders.
The main aspects that are DERIVEd are:1) evaluation of expressions, 2) supplementing the solution of equations, 3) graphing equations, and 4) function notation and manipulation.

With the evaluation of expressions the students are taught to directly evaluate the Authored expression. This then progresses to the use of Manage and Substitute to evaluate the Authored expressions. Graphing equations used to be a really big deal until the TI+ graphing revolution. We still investigate graphs but it is just an introductory learning experience to use the graphing with Move, Center, and Scale.

Function notation is heavily investigated using DERIVE. The total use of f(x) manipulation is pursued. Function declaration and evaluation is reinforced by the use of DERIVE. Composition of functions is given great attention since the students usually have trouble mentally forming f(g(x)) and are, positively reinforced, by using DERIVE to check their composition. All of this is great but the use in algebra II that I see most useful is the use of DERIVE as a "supplement" to solving equations.

Although the students, early on, discover that there is a Solve command. I do not permit them to utilize it at will. We solve equations in a non-traditional manner using DERIVE to relieve our burden of arithmetic. Take, for example, the linear, split variable equation 3x-5 = -2x+4 where we wish to solve for x. The following example is algebra I but it serves to show how I use the DERIVE notation.

#1:= 3x-5 = -2x+4	author		
#2:= #1+2x	simplify	==>	[3x-5 = -2x+4] + 2x
#3:= 5x-5 = 4	author		
#4:= #3+5	simplify	==>	[5x-5 = 4] +5
#5:= 5x = 9 and continues.			

I now insist that the students give up the traditional method of indicating the solution steps, " by doing it to both sides" and have them write the enclosing brackets and just one number to be operated on both sides of the equation.

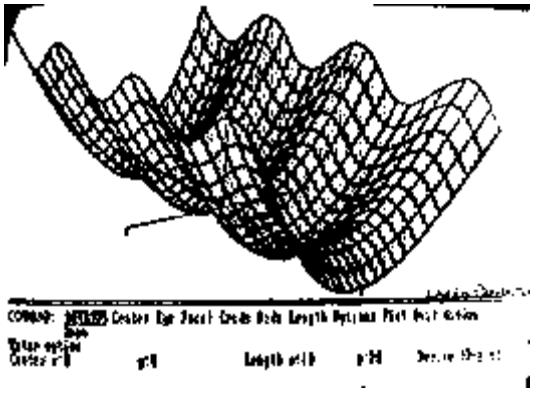
I am a firm opponent of factoring to a solution for a quadratic equation. A student does not need to mentally factor or, for that matter, DERIVE factor to find a solution. If they use the above notation and DERIVE to assist them, then "completing the square" solutions take on a whole new meaning.

TRIGONOMETRY -

This class is when DERIVE takes on an element of necessity just as much as using the TI+ calculators. Initially, in the course students use TI+ technology to compute the basic right triangle trig. functions. Then we learn how to do the same computations using DERIVE's trig, functions. Later in the year, vectors and matrices - to draw the vector planes are investigated. Force resolution and navigation problems are solved using DERIVE to compute the law of sines and law of cosines. The determination of a stable system of forces is investigated during a DERIVE lab. This lab led to a student science fair project that will be described later.

The sinusoidal nature of the equation $y = A \sin(Bx + C) + D$ is computationally and graphically investigated by the students. Polar coordinates and graphs of polar equations on DERIVE lead to "what if" graphing by the students. A polar equation is investigated by selecting and varying a specific parameter to see the changes in the nature of the polar graph. Much like the classic rectangular linear equation slope and y-intercept variations. This "what if " polar DERIVE lab is run concurrently with the use of TI+ graphing calculators.

One of the final uses of DERIVE in trig., if there is time left at the end of the year, is to introduce three dimensional coordinates and the graphs of the equations. The students, it seems, have not been exposed to 3-d graphs of equations prior to this time and they seem to take great interest in creating the "best" 3-d graph with DERIVE. This interest prompted me to have a contest to see which students could produce "nice" and colorful



three dimensional graphics. The picture below was prepared by Laura Carpenter.

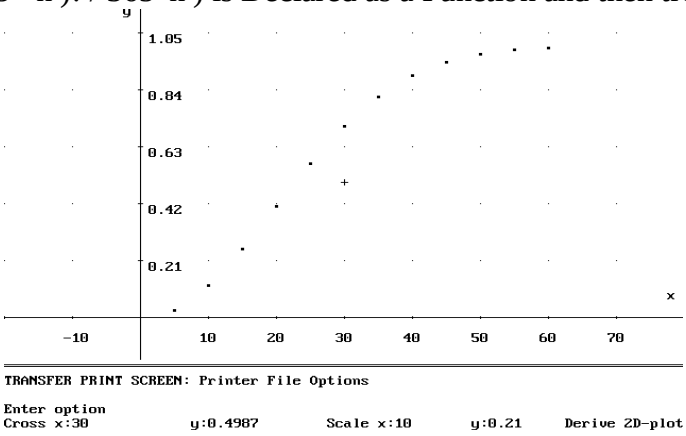
PROBABILITY and STATISTICS -

In this class I use DERIVE to duplicate the examples in the textbook. As each lesson progresses the students are directed to go to DERIVE and show on the computer screen the examples that are shown in the text. Early in the course, scatter plots are plotted from matrices. Then the FIT command is used with TI+ technology to find regression models for data. This is then followed by the use of DERIVE's basic statistical functions.

During the year we have occasion to discuss finances and the students use the PMT function to duplicate a TI+ worksheet. Also, at this time, we use the piecewise functions, especially the greatest integer function, to model the West Virginia Sales Tax Tables. DERIVE is used somewhat with the major emphasis on programming the TI82s to reproduce the tax on the sale of an item from the charts distributed by the tax office of the state of West Virginia.

Probability functions are investigated extensively, especially FACTORIAL, COMB, PERM., and RANDOM. The students investigate Monte Carlo Method Models and work with probability distributions. One simulation that is investigated is the checkout line model. It is from a worksheet from the NCTM. That model and the overbooking model that airlines use are investigated with DERIVE and the RANDOM function. With the Binomial Probability distribution the students Define a function, then fill a Matrix, then Approximate the matrix, then finally Plot the distribution. They then answer questions posed to them concerning the nature of their work and the interpretations of the distribution.

A classic probability problem using combinations and distributions that we investigate is the *BIRTHDAY* problem. The students find it interesting and the TI82s find it hard to do. The formula is developed from a duplication worksheet from the NCTM. The formula 1 - (365! / (365 - n)! / 365^n) is Declared as a Function and then treated in the same



fashion as other distributions and finally plotted. The students then investigate the graph of the distribution after it is plotted. I find it curious that I had never seen the curve of this problem in any text or reference. I first visualized the birthday probability distribution below only after I used DERIVE to investigate the problem.

AP COMPUTER SCIENCE -

In this class, time is very limited but I try to use DERIVE to support my explanation of number bases to the students. We will use DERIVEs Radix function to enter and record the changing numerals when base 10 is changed to the bases: binary, duodecimal and hex.

AP CALCULUS -

This is when the DERIVE climax occurs. For example, this is the first time the students are exposed to DERIVE's utility files. It is a shame that sometimes due to snow day time constraints, test material and calculator usage must take precedence over the use of DERIVE. But just as my students take a class to help them use the family automobile, I insist that they learn my DE'RIVERs Ed. material.

I think we all share an amazement of the beauty of calculus and most of us hate the labor of algebra. Did any of us work for 20 minutes on a "calc." problem only then after another 5 minutes checking it realize that, "I forgot to twice the product!" This question may be outside the realm of this topic, but why do we try to teach mathematics to the college bound high school population as if all the students were all going to be math majors? I, like probably many others, think that word processors have allowed me a literary freedom. Is it not time to allow an algebraic freedom? Algebra is the HEAVY burden of the calculus.

I use DERIVE in my calculus class, at the very least, for the following topics. We will do the traditional methods and then compare and contrast with the "modern" DERIVE" methods. The first student amazed usage comes with Implicit Differentiation, and in particular, IMP_TANGENT and IMP_PERPENDICULAR. We also use the software for: MAX./min., related rates, trapezoidal rule, area(s), volume of solid of revolution. Some specific applications follow.

During the integration theory presentation, I show the students the LEFT_RIEMANN function. One of the questions I pose is, "How many rectangles will you need to arrive at an approximate answer for the area, within 10% of the calculated answer?" I then think to myself two thoughts. 1) Try that without DERIVE - not! 2) Why might that knowledge be valuable?

Further along the integration theory we use INT_DATA to see the trapezoidal rule applied to the calculation of a local acreage. We use a topographical map of an area called the Fernow Experimental Forest and setup the data. That data is matrixed and then integrated. The District rangers office is then called and the students are impressed that the calculated measurement is always within 5 % of the actual land survey.

Toward the end of the year, if time permits, we focus on one of my favorite curves y=x^2. We do an investigation sheet using DERIVE to answer some of the following questions. Find the x value that limits the area under the curve to the value of 1? Find the volume of the solid of revolution about the x axis from 1 to 3? Find the area of the region "triangulated" by y = sin x, y = cos x, and y = x^2? Find the perimeter of the previous region? These questions that would require a ton of time to do are investigated routinely by my class. I take great pride when the students start asking their own what if questions. For example, one student asked and then investigated, "What percent of decrease do we see for the areas under the following curves y = x^2, x^3, x^4, etc.?". I believe when a

student or a teacher has more time to ask and try to answer these types of questions true learning takes place.

One dramatic example of the time saving element with DERIVE is the answer to the following simple calculus question. WHAT IS THE LENGTH OF THE CURVE Y = X^2 FROM 0 to 1? I do not ever remember considering this question in college. In researching I soon discovered why. The inclusion of the x^2 into the length integral provides for some *real fun times* in evaluating the integral and computing the distance. It took me, a masters of mathematics degree holder, twenty five minutes - consulting a table and using a calculator to arrive at an answer. When I turned to DERIVE I had the same answer in 3 and 1/2 minutes. Gee, I wonder if I would try to answer the question, "What would increasing the x interval from 0 to 2 do to the answer? **No way, not another 20 minutes!**

The problem is such a testament to my philosophy that I rewrote the whole, by hand, solution on a poster. The poster hangs in my classroom and states in bold print what is written in the previous paragraph. But below the poster I have printed the DERIVE screen showing 5 lines and 3.5 minutes for solution.

I firmly believe that this problem shows the advantage of Computer Algebraic Systems. Let's learn the beauty of the application of algebra and not be burdened with the baggage of algebra. Is factoring a skill needed in the 21st century? Do we still need to know how to use a two-man crosscut saw to fell a rain forest? When was the last time you did the long division algorithm instead of using a calculator?

CONCLUSION

I would like to share a success story of one of my former students, Vickie Bennet. She came to me and wanted an idea for a science fair project and asked if I had any suggestions. I suggested predicting the force that would create a stable state in a system of forces. This equilibrium project would have the judges place weights on a "tilt" board and then Vickie would predict and place the weight that would return the board to level. In her project she used DERIVE and TI-81 program. She gave me the project when she graduated and I bring it out on special occasions. Vickie's project was exceptional and went on to win the WV Regional Science Fair. Her use of DERIVE and the TI-81 program allowed her to have the "REAL" time prediction she needed to impress the judges. It was a dramatic use of the software DERIVE.

I have taught math for 25 years and I am glad DERIVE has been a part of my career for the last 5 plus years. I am amazed that more have not boarded the C.A.S. train. At the West Virginia Council of Teachers of Mathematics state meeting, not one session in the last 4 years has dealt with the use of DERIVE. I promise I shall propose a session at the next state meeting concerning the high school classroom use of DERIVE. Technology has begun to lead West Virginia "out of the woods" and DERIVE needs to be part of technology use in West Virginia.

I thank you for this opportunity to present my views concerning DERIVE. It should be noted that DERIVE has served the graduates of Tucker County High School well. One of our graduates attended M.I.T. and has a career as a N.A.S.A. engineer.

We have had one graduate of the U.S. Air Force Academy, one graduate and two current students at West Point, and a current Midshipmen at the Naval Academy and two current students at the U.S. Coast Guard Academy. Our high school may be on a mountain top in rural West Virginia but our education system is right on with the turn of the twenty- first century.