

# Student Guided Explorations/Assessments:

A series of guided explorations/assessments are being created to help students to gain a deeper understanding of the geometric nature of various concepts in multivariable calculus. Some of these explorations will also be used to help assess the effectiveness of the visualization tools and the explorations themselves at improving student understanding of various concepts. If you have ideas for future assessment topics and/or questions or functions to explore, please contact Paul Seeburger at [pseeburger@monroecc.edu](mailto:pseeburger@monroecc.edu).

So far, the following three explorations have been completed:

- **Dot Product Exploration**
- **Cross Product Exploration**
- **Velocity and Acceleration Exploration**

The following explorations are in the process of being created this semester:

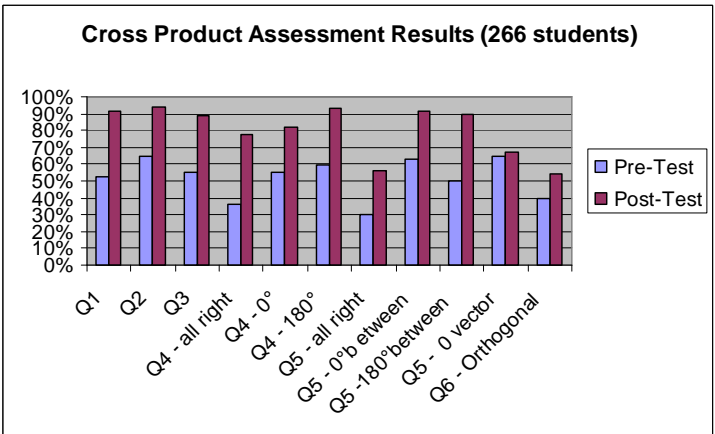
- **Lines and Planes in Space Exploration**
- **Contour Plots Exploration**
- **Lagrange Multipliers Exploration**

Each of these guided explorations have been created with SurveyMonkey to make it easier to collect student response data. Students are asked a short series of Pre-Test questions before they complete the body of the exploration. A link to the applet is provided in the survey which also supplies the script for the actual exploration in the CalcPlot3D applet. After the students complete the actual exploration using the applet, for which there is a second list of questions in SurveyMonkey to complete, they are asked a series of Post-Test questions which are very similar to (or sometimes the same as) the Pre-Test questions.

As you can see below, the results have been quite positive. For example, student success on the Cross Product Exploration went from roughly 60% or less on the Pre-Test questions to 90+% on six of the Post-Test items.

The screenshot shows a survey interface with the following questions:

- Which pair of vectors below will have the cross product with **largest** magnitude? (Options: a, b, c, d, e. I don't know.)
- Which pair of vectors below will have the cross product with **smallest** magnitude? (Options: a, b, c, d, e. I don't know.)
- Given two vectors of fixed length, and allowing the direction of one vector to vary, what angle between the two vectors will produce a cross product with **maximum** magnitude? (Select all that apply.) (Options: 90°, 45°, 0°, 180°, I don't know.)
- Given two vectors of fixed length, and allowing the direction of one vector to vary, what angle between the two vectors will produce a cross product with **minimum** magnitude? (Select all that apply.) (Options: 90°, 45°, 0°, 180°, I don't know.)
- What can cause the magnitude of the cross product to be **zero**? (Select all that apply.) (Options: The angle between the vectors is 90°, The angle between the vectors is 0°, One of the vectors is a unit vector, One of the vectors is the zero vector, The angle between the vectors is 180°, The angle between the vectors is 45°.)
- What is the geometric relationship between the cross product and the two vectors that form it?



Explore these exploration-assessments yourself by clicking on the **Workshop/Faculty** link on the left sidebar of the project website. These faculty links allow you to explore the assessments while keeping your results separate from student data.

### Invitation to Participate:

Please consider using these materials with your calculus classes! Also recommend them to anyone who might be interested in using them, including faculty in Mathematics, Physics, or Engineering.

If you would like to participate in class-testing the materials for this project and be involved in their continued assessment and improvement, or if you simply have some comments, questions, or suggestions concerning this project, please contact Paul Seeburger at [pseeburger@monroecc.edu](mailto:pseeburger@monroecc.edu).

To access these materials go to:  
<http://web.monroecc.edu/calcNSF>