An Inquiry-Oriented, Application-First Approach to Linear Algebra

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The IMAGEMath project combines inquiry based learning with an application-inspired approach. Students first learn about an application, and then, in an inquiry framework they develop the mathematics necessary to investigate the application. A novel feature of this approach is that the applied problem inspires the mathematics, rather than the applied problem being presented after the relevant mathematics has been learned. In this poster, we give an overview of the IMAGEMath modules that use image and data applications (radiography, tomography and heat diffusion) to inspire linear algebra topics. We present results from implementing the modules on a small scale at a few institutions, including student and faculty feedback. We also provide information for faculty interested in using IMAGEMath materials.

Keywords: Linear Algebra, Inquiry-based Learning, Technology, Applications

The IMAGEMath Project (www.imagemath.org), funded by a collaborative NSF IUSE grant (DUE-1503929, DUE-1642095, DUE-1503870, and DUE-1503856), consists of a suite of classroom modules that use data applications to inspire mathematical concepts in upper-division math classes. In this poster, we focus on the two IMAGEMath modules designed for linear algebra. The two data applications (brain scan tomography and diffusion welding) motivate most topics taught in a standard linear algebra course. These modules use inquiry-based learning strategies and group work to guide students to forge mathematical tools.

In brain scan tomography, students' main goal is to reconstruct a 3D view of a brain based on 2D radiographic data. In the process, they discover and work with vector spaces, span, linear independence, linear transformations (and properties such as injectivity and surjectivity), inverse transformations, and pseudo inverse transformations like SVD.

In the diffusion welding setting, students must predict how long it will take for a diffusion-welded rod to cool to a safe temperature. The heat diffuses out the ends of the rod as the weld sites cool, causing the temperature profile to change over time. Along the way, students develop the ideas of eigenvectors, diagonalizability, and long-term behavior.

Active learning and inquiry based learning techniques were studied by Kogan & Laursen (2014), and inquiry methods found to be at least as effective as traditional methods for all students and more effective for some groups of students. Additionally, the incorporation of applications has consistently been recommended as a good practice for linear algebra courses (see (Carlson, Johnson, Lay, & Porter, 1993) and (Zorn, 2015)). While the IMAGEMath project incorporates both of these, the application-inspired approach at its core differs markedly from other application-integrating approaches that illustrate the use of learned tools on real problems. IMAGEMath modules begin by introducing a cutting edge research problem. The solution path inspires the development of mathematical concepts.

We administered pre- and post- content and attitudinal surveys. Content results were positive. Results of the attitudinal surveys were statistically inconclusive. In this poster we also present student and faculty comments. In the future, we hope to study on a larger scale the efficacy of the linear algebra IMAGEMath materials. In addition, should this prove to be a fruitful approach, our vision is to create a community of undergraduate faculty interested in module development using other applications, targeting linear algebra or other courses.

References

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