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CONSTRUCTING AN INTERACTIVE SANDSTONE PETROLOGY CD FOR UNDERGRADUATES: BRINGING A CLASSICAL SUBJECT INTO THE DIGITAL AGE

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Abstract

More than 80% geoscience departments in North America include coursework specific to sedimentary rocks, and almost all major geology departments have offerings that cover sedimentary petrology at the undergraduate level. Knowledge about the pore-scale properties of sedimentary rocks, a key element of sedimentary petrology, is fundamental to the management of water, oil, and gas resources. A clear national interest exists for maintaining a cohort of professionals who can effectively engage problems relating to the vital resources upon which economic and energy security depend. However, in the "curriculum squeeze" of the last two decades, petrographic instruction has been replaced in many curricula by other materials. Thus, it is imperative to find a way to retain petrographic instruction at the university level.

An interactive sandstone tutorial CD is being built through NSF DUE-CCLI funding (2003-2005) to provide undergraduates a 'virtual microscope' resource for efficient learning of sandstone petrography. It addresses the challenges of teaching highly visual materials by use of a large collection of interactive images. Students learn the components of a complex and heterogeneous natural system by repeated exposure to examples linked to conceptual information. More than 500 interactive images taken under plane- and cross-polarized light, reflective light, back-scattered electron, and cathodoluminescence are currently incorporated into the tutorial, supplemented by more than 100 quiz questions to check the progress of the user.

Assessment from six participating departments reveals that undergraduate students make significant gains in content attainment through use of the tutorial. Students also express strong approval of the tutorial and its approach. Complex expert knowledge about natural objects relevant to any field of natural science can be preserved and transmitted using interactive digital tools such as the sandstone tutorial.

1. The Challenges

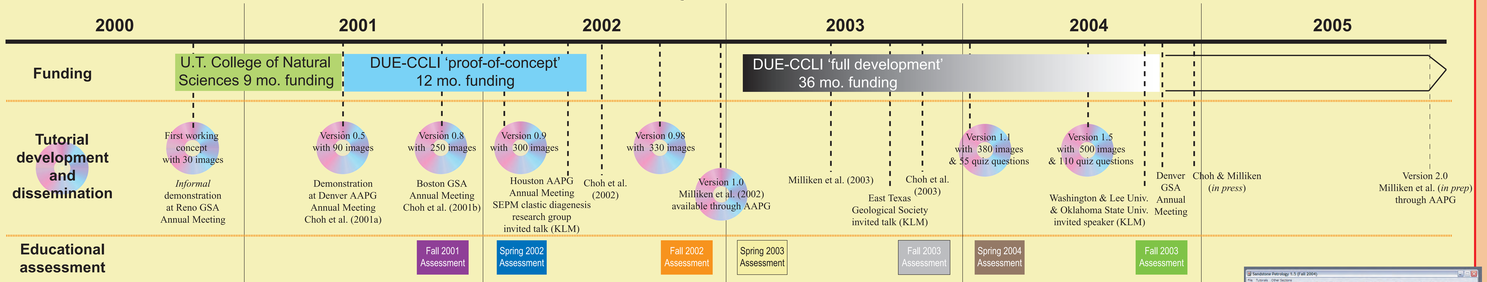
External challenge:

- Between 1989 through 2002, the number of "geo-" departments (geology, geological sciences, and geosciences) in the U.S. dropped by 16% and "earth science" departments decreased by 22% (Rossbacher and Rhodes 2004).
- During the same time period, 19 colleges and universities cancelled bachelor's degree programs in earth sciences (Rossbacher and Rhodes 2004).

Internal curriculum squeeze:

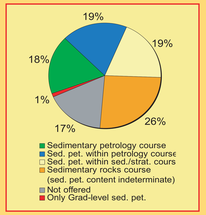
- Petrographic instruction is disappearing from the modern curriculum, due, in part, to the fact that it must compete for time within an increasingly diverse list of required courses (e.g., Fitz 2000).
- Experiences in the Department of Geological Sciences at the University of Texas at Austin exemplifies the challenges for retaining petrography in the curriculum. As a consequence of additional departmental requirements for undergraduates, including courses in geophysics and hydrogeology, the sedimentary rocks curriculum contracted in the mid-1980s.
- Today, sedimentary petrology instruction at UT Austin is subsumed under GEO416M "Sedimentary Rocks" and student receive 3 laboratory exercises in petrography of sandstone with 15 thin sections, and additional 2 exercises in carbonate petrography with 15 thin sections.
- A 'virtual microscope' resource addresses the need to keep the level of content attainment of the students equal to that in effect the prior to the curriculum squeeze.

Project Timeline



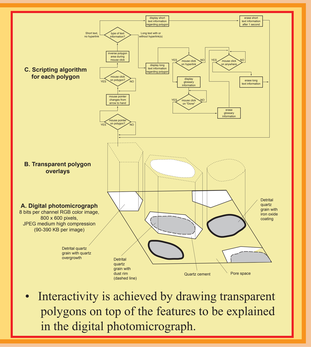
2. The Audience

- The sandstone petrology tutorial is designed for use in laboratory courses such as 'general geology', 'petrology', 'sedimentology', 'stratigraphy', and 'sedimentary petrology'.
- Random examination of 344 geoscience department web sites among 500 geoscience departments in North America (http://www.usd.edu/esci/geodepts.html) shows that 82% of these departments include coursework specific to sedimentary rocks.
- Knowledge about the pore-scale properties of sedimentary rocks is fundamental to management of vital resources such as water, gas, and oil. An understanding of porosity evolution is particularly relevant as companies drill deeper and explore unconventional rock types in the search for these resources.
- A clear national interest exists for maintaining a cohort of professionals who can effectively engage problems relating to the vital resources upon which economic and energy security depend.

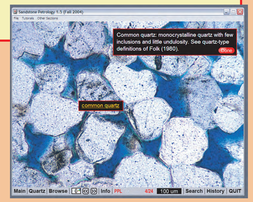


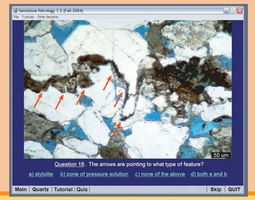
3. The Tutorial

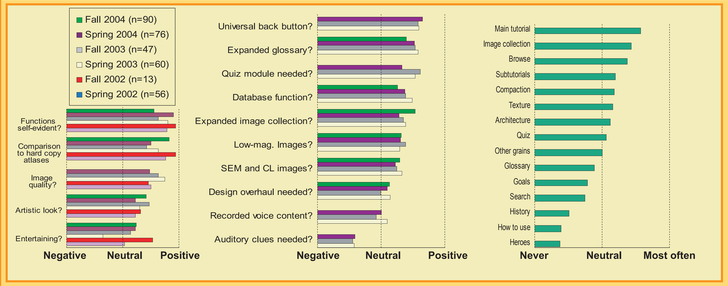
- The tutorial addresses the challenges of teaching highly visual materials by use of a large date base of interactive images.
- Students learn the components of a complex and heterogeneous natural system by repeated exposure to examples that are linked to identifying and conceptual information.
- The tutorial could be used as a sequential tutorial, an image browser, and a sandstone image database
- The tutorial is currently at version 1.52, with over 500 interactive images and 100 quiz questions
- More than 700 copies distributed to undergraduate students for evaluation and in class use.
- Over 500 copies of version 1.0 sold through AAPG (as of summer 2004)



- Interactivity is achieved by drawing transparent polygons on top of the features to be explained in the digital photomicrograph.







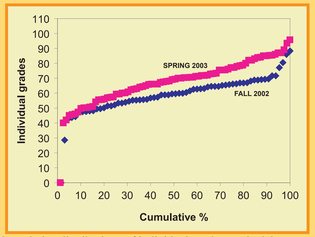
Student attitude toward the tutorial (Spring 2002 - Fall 2004)

Features student wanted more from the tutorial (Spring 2003 - Fall 2004)

Normalized student usage pattern of the tutorial (Fall 2004)

4. The Assessment

- Strong student approval of the digital sandstone tutorial
- The functional aspects of the tutorial worked well for the undergraduates
- The students report a high level of tutorial use
- Apparent improvement in student attainment (Fall 2001 semester w/o the tutorial vs. Spring 2002 semester w/ the use of the tutorial)
- Development of the tutorial reflecting student feedback (1st generation quiz module in Spring 2004 semester, 2nd generation quiz module in Fall 2004 semester, 3rd generation quiz module construction in progress based on Fall 2004 feedback)



Cumulative distributions of individual grades on the laboratory examination in siliciclastic petrography in fall 2001 and spring 2002 semesters of GEO 416m at UT Austin (after Milliken et al. 2003).

5. The Future

Toward version 2.0 of the sandstone tutorial:

- More complete coverage of lithic and non-QFL components are under way.
- Mudrock section is being built with a greater diversity of petrographic images such as BSE (backscattered-electron) and CL (cathodoluminescence).
- Quiz module is undergoing revisions based on the student inputs

Educational assessment shows:

- The tutorial works well for undergraduate geoscience students, who are demonstrated to make significant gains in content attainment through use of the tutorial. Students express strong approval of the tutorial.
- The educational approach of the tutorial can be applied to similar fields in geosciences as well as any field of natural science that utilizes highly visual data.

And thus ultimately:

- The sandstone tutorial may form a single component of a much larger digital library of petrographic images encompassing carbonate petrology, igneous petrology, metamorphic petrology, and paleontology.

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