A Course-Based Research Experience (CURE) Model for Scientific Ocean Drilling-Related Undergraduate Research

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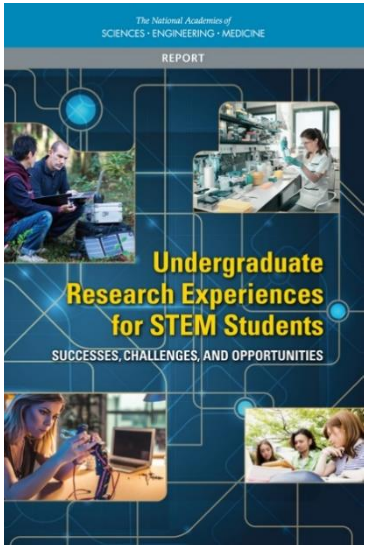
What the Research Tells Us about CUREs:

Undergraduate Research Experiences (UREs): engage students in research practice:

- Generate original results
- [Situate research in context of prior (published) work]
- Relevant problems of interest
- Collaborate/work in teams
- Iterative process
- Develop technical skills
- Reflective practice
- Communicate results
- Mentorship and student ownership



List modified from National Academies of Sciences, Engineering, & Medicine. (2017). *Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities*.

UREs

Apprentice Model

1+ student(s) work with an individual/small group of established scientists on a research problem, typically outside of the classroom.

CURE Model

A cohort of students in a research project [with established scientist(s)] as part of a formal academic experience.

What the Research Tells Us about CUREs:

Corwin et al., 2015. Modeling Course-Based Undergraduate Research Experiences: An Agenda for Future Research and Evaluation, CBE—Life Sciences Education.

Table 1. Support for CURE outcomes based on a review of relevant CURE literature[a]

	Outcome	CURE References
Probable	Increased content knowledge	Lopatto et al. 2008; Shaffer *et al.*, 2010, 2014; Siritunga *et al.*, 2011; Brownell *et al.*, 2012; Rowland *et al.*, 2012; Jordan *et al.*, 2014; Kloser *et al.*, 2013
	Increased analytical skills	Shaffer *et al.*, 2010, 2014; Siritunga *et al.*, 2011; Bascom-Slack *et al.*, 2012; Brownell *et al.*, 2012; Hanauer *et al.*, 2012; Alkaher and Dolan, 2014; Jordan *et al.*, 2014
	Increased self-efficacy	Drew and Triplett, 2008; Lopatto *et al.*, 2008; Shaffer *et al.*, 2010, 2014; Siritunga *et al.*, 2011; Kloser *et al.*, 2013; Jordan *et al.*, 2014
	External validation from a science community	Hatfull *et al.*, 2006; Lopatto *et al.*, 2008; Caruso *et al.*, 2009; Shaffer *et al.*, 2010, 2014; Jordan *et al.*, 2014
	Persistence in science	Drew and Triplett, 2008; Harrison *et al.*, 2011; Hanauer *et al.*, 2012; Bascom-Slack *et al.*, 2012; Brownell *et al.*, 2012; Jordan *et al.*, 2014; Shaffer *et al.*, 2014
	Increased technical skills	Drew and Triplett, 2008; Shaffer *et al.*, 2010; Jordan *et al.*, 2014; Rowland *et al.*, 2012
	Career clarification	Drew and Triplett, 2008; Harrison *et al.*, 2011; Shaffer *et al.*, 2014
Possible	Increased project ownership	Shaffer *et al.*, 2010; Hanauer *et al.*, 2012; Alkaher and Dolan, 2014
	Increased communication skills	Lopatto *et al.*, 2008; Jordan *et al.*, 2014; Shaffer *et al.*, 2014
	Increased motivation in science	Shaffer *et al.*, 2010, 2014; Alkaher and Dolan, 2014
	Increased collaboration skills	Shaffer *et al.*, 2010, 2014
	Increased tolerance for obstacles	Jordan *et al.*, 2014; Shaffer *et al.*, 2014
	Increased sense of belonging to a larger community	Jordan *et al.*, 2014; Shaffer *et al.*, 2014
	Enhanced science identity	Hanauer *et al.*, 2012; Alkaher and Dolan, 2014
	Increased positive interaction with peers	Shaffer *et al.*, 2010; Alkaher and Dolan, 2014
Proposed	Increased access to faculty interaction	Alkaher and Dolan, 2014
	Increased access to mentoring functions	Hanauer *et al.*, 2012
	Enhanced understanding of the nature of science	Russell and Weaver, 2011
	Development of self-authorship	Alkaher and Dolan, 2014

CURE COURSE DESIGN OVERVIEW

JMU Geol 406: Paleoceanography & Paleoclimatology
(upper level undergraduate elective, 1 semester course, 3 credits)

Post-Course Outcomes

COURSE FRAMEWORK → SITES & TOPICS → ANALYTICAL METHODS → COURSE RESEARCH DELIVERABLES

Learning about Paleoceanography & Paleoclimatology by doing it: *"....you will investigate the methodologies and data used to reconstruct Earth's climate history. Emphasis will be placed on the marine sediment records of the Cenozoic. This course will involve research, inquiry-based workbook exercises, and lectures; together these will challenge you to work at multiple levels of learning (see figure)."*

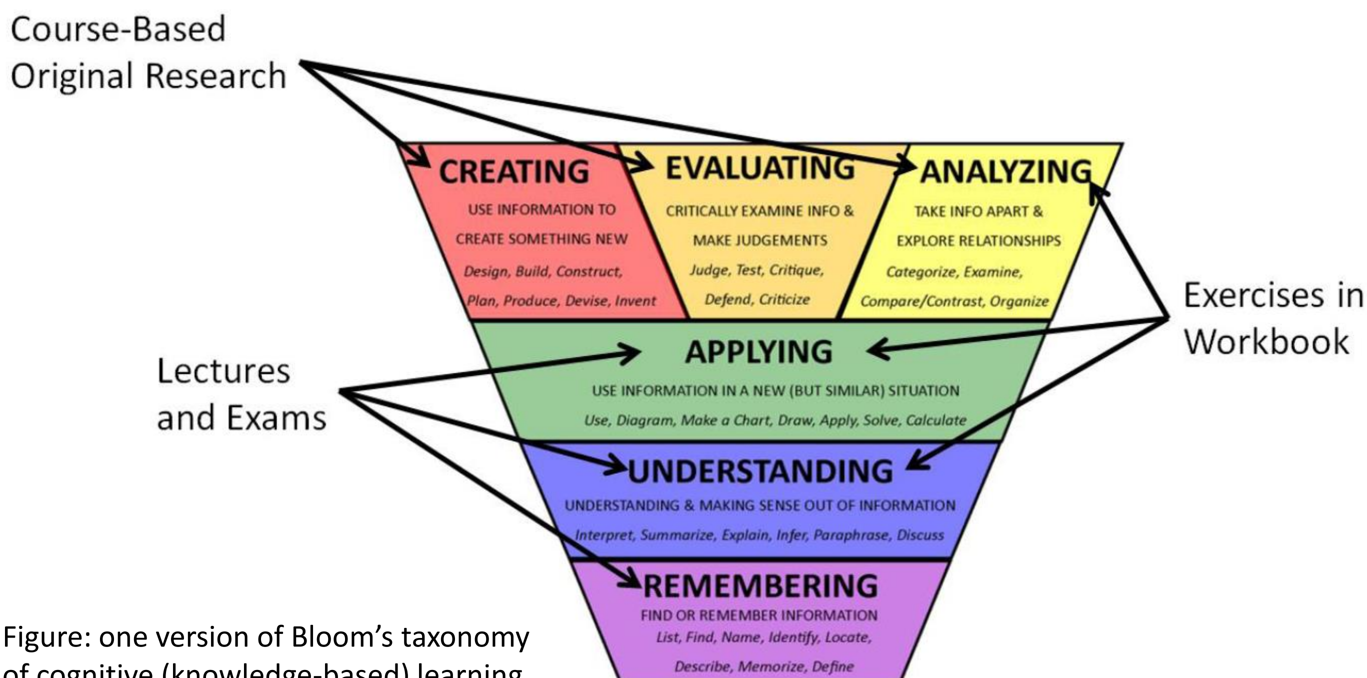


Figure: one version of Bloom's taxonomy of cognitive (knowledge-based) learning

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Sites & Topics: Core sections & discrete samples from sediment records of Last Glacial Maximum → Holocene;

- 'Orphaned' cores from Gulf of Mexico USGS sites MD02-2535, 2555, 2560
- STEMSEAS North Pacific Site 1 & 2
- Discrete samples from North Pacific ODP Site 887
- Discrete samples from Chilean Margin ODP Site 1234

Analytical Methods: Subset of samples per student; use a multi-proxy approach to gain hands-on experiences to characterize sediments and address student-generated research question(s):

- smear slides
- grain size
- XRD clay mineralogy
- coarse-fraction point counting;
- planktic/benthic ratios
- XRF elemental analysis
- sample prep for (external) carbon-dating

Benchmark assignments for each research step; used for:

- quality control
- individual accountability,
- sharing of data/findings

Individual AGU-style abstract & poster synthesizing all course data (from all students), addressing research question(s)

CURE COURSE DESIGN OVERVIEW

- Taught 7 times: 63 students total
- 7 to 14 students/class

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- **Students presented their CURE findings at professional meetings:**
  - 94% of students co-authored/presented one or more **GSA/AGU posters** of their CUREs.
- **Launched follow-on individual undergrad research projects involving scientific ocean drilling samples or data:**
  - 29% of students in course did at least 1 additional semester of independent research.
  - Includes 3 Honors Theses (these are 1.5 year projects)
- **Provided a foundation for graduate school:**
  - 100% of the follow-on research students who applied for graduate school got into one or more of their preferred programs with funding.
  - 2 have since sailed as IODP scientists
- **Provided scientific and transdisciplinary workforce skills, and increased student confidence**
  - Government jobs: Several have done USGS internships/jobs
  - Consulting/industry jobs: "*they offered me the job because of my experience with cores*"

Observed Challenges & Benefits of CUREs

Challenges:

- Much more time-intensive for faculty than teaching a “regular” course.
- Trade offs: course-embedded research means less “general material” covered.
- Increased risk that analytical equipment breaks.

Benefits:

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