An Expanded Framework for Course-based Undergraduate Research Experiences in General Education Courses

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Course Based Undergraduate Research Experiences

Course-based undergraduate research experiences (CUREs) positively impact retention, graduation, equity, science identity, and science literacy. In comparison to out-of-class undergraduate research experiences, they provide important additional *institutional* benefits: 1) they are able to engage larger student populations who are not self-selected or pre-selected based on their perceptions of research self-efficacy; 2) they are better equipped to serve working students who cannot afford to engage outside of the classroom; and 3) they do not require the development of large co-curricular research infrastructures. However, the *student* benefits of CUREs (for instance increased science literacy and improved retention/graduation rates) are usually linked in to full and authentic research experiences, where students complete all stages of research.

The Council on Undergraduate Research defines undergraduate research as "A mentored investigation or creative inquiry conducted by undergraduates that seeks to make a scholarly or artistic contribution to knowledge" (Council on Undergraduate Research, 2022).

CUREs are defined as "learning experiences where whole classes of students address a research question or problem with unknown outcomes or solutions that are of interest to external stakeholders" (Dolan, 2016). CUREs have been linked to increased content mastery and improved scientific literacy, as well as to increased retention, degree persistence and graduation rates (Rodenbusch, Hernandez, Simmons & Dolan, 2016; Dolan, 2016; Brownell et al, 2015). CUREs and other undergraduate research experiences are considered to be especially useful for women and underrepresented minority students (Gregerman, Lerner, von Hippel, Jonides & Nagda, 1998; Carpi, Ronan, Falconer & Lents, 2017; Bangera & Brownell, 2014; Chang, Sharkness, Hurtado & Newman, 2014). CUREs are backed by an extensive literature, national alliances, reports, professional associations and instructional/administrative resource websites.

CUREs are most often *defined* through the use of dimensions that must be present for the course to be considered a CURE (see Table 1). In addition to these dimensions, CUREs are sometimes *described* by the instructional mechanisms, activities and/or research practices used in implementation. Examples include "asking questions, building and evaluating models, proposing hypotheses, designing studies,

selecting methods, using the tools of science, gathering and analyzing data, identifying meaningful variation, navigating the messiness of real-world data, developing and critiquing interpretations and arguments and communicating findings (Auchincloss et al, 2014)." An example of a CURE might include a class project where students collectively identify a real-world problem, conduct a preliminary literature review, design a research study, collect data, analyze data, and publish or present their findings. CUREs are most commonly utilized in labs courses, upper division courses, and courses with low enrollments.

Table 1. Five Dimensions that Make a Learning Experience a CURE
(Auchincloss et al, 2014)

DIMENSION	DESCRIPTION
Scientific practices	Uses generally accepted scientific practices to answer research questions
Discovery	Generates new knowledge, insights or understanding (focuses on questions where the answers are unknown).
Broadly relevant or important work	Findings are meaningful and important beyond the classroom
Collaboration	Involves teams of researchers working together
Iteration	Builds upon previous research and current knowledge

Expanding the CURE Framework for Lower Division General Education Courses

While the CURE framework has been widely defined and described in the literature, an emerging body of research describes the importance of course-based research experiences that do not meet the standards or definition of traditional CUREs. These experiences are sometimes called Pre CUREs or undergraduate research pathways. Pre CUREs are defined as learning about research outside of a full research setting.

In the literature, Pre CUREs are sometimes described as "modular" implementations (Horsch, St. John & Christensen, 2012). Pre CUREs teach students concepts such as iteration, thinking critically about research, and learning about research methods and experimental design (Mahatmya et al, 2017). These courses provide more tangible connections between lectures and lab or real world applications (Horsch, St. John & Christensen, 2012), contribute to the development of student confidence, and encourage students to participate in research experiences (Mahatmya et al, 2017). Preparatory research experiences also improve pathways to undergraduate research for traditionally underrepresented students (Hurtado, Cabrera, Lin, Arellano & Espinosa, 2009). This is especially true for students who cite lack of research preparedness as the primary barrier to their participation (Mahatmya et al, 2017). Though Pre CUREs are gaining in popularity, and have been linked to improved retention rates (Horsch, St. John & Christensen, 2012), there have been few large-scale multi-disciplinary implementations of Pre CUREs designed to compare outcomes to traditional CUREs.

The UNM Academic Affairs General Education Faculty Fellows further characterized and defined the Pre CURE model to create an expanded CURE framework (ECURE) designed specifically for general education courses.

This expanded framework categorizes Pre CURE into two levels of student immersion in research: preparatory instruction (PREP), and partial research engagement (PARTIAL). When combined with the traditional full CURE model (FULL), this framework can be implemented more extensively through the general education core, including in large lecture sections. This framework is called "ECURE", for Expanding Course-Based Undergraduate Research Experiences.

ECURE defines undergraduate research to students as "investigating a question or problem where no one (including your instructor or other researchers) is certain what the answer will be or should be. Participation with research can be individual (where you independently investigate the question or problem), or social (where you collaborate with others, possibly including instructors and peers within your school or major)."

In the ECURE Framework, PREP is defined as teaching students how research is conducted (including explaining the connection of foundational skills to research processes), but *without* actual engagement in research. PREP can be taught in either lecture or active learning environments. Examples include teaching students to differentiate between correlation and causation, exploring the value of peer-based literature compared to Wikipedia, or using MS Excel to determine significance.

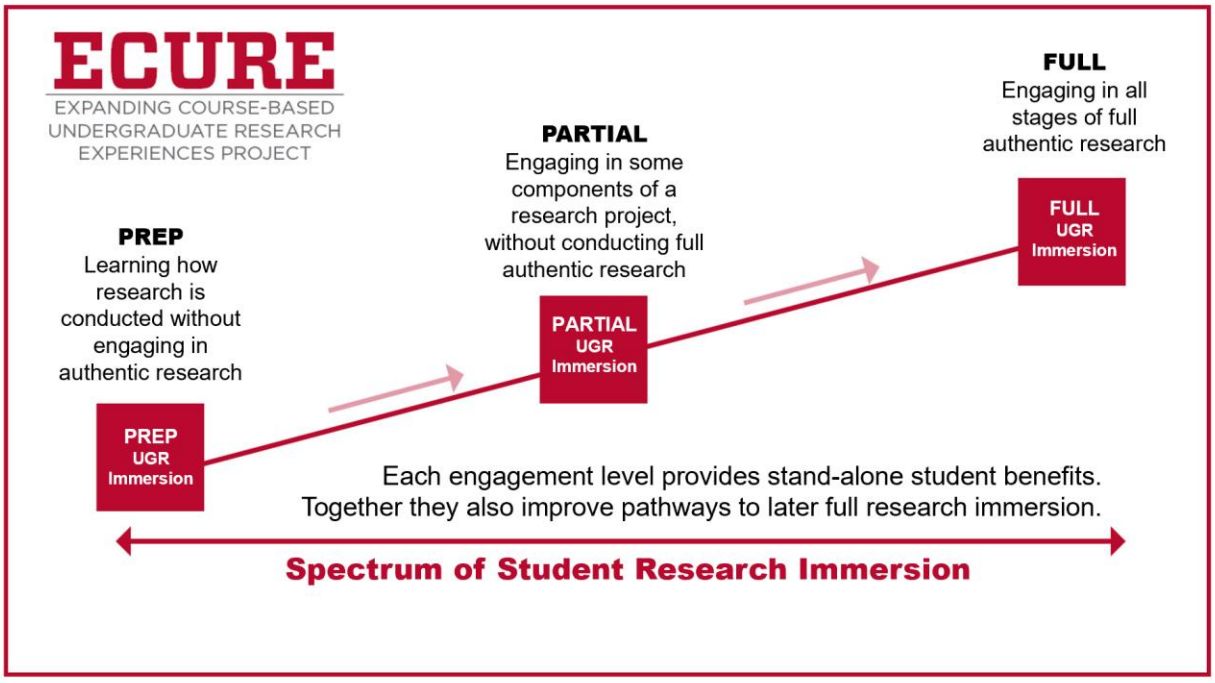
PARTIAL is defined as engaging students in selected components of research, *without* engaging in all of the essential elements of full CUREs. An example of PARTIAL might include a class where students are provided a research problem by the instructor (rather than identifying one themselves), are provided a summary of existing knowledge (rather than conducting their own lit reviews), are provided with a research method (rather than selecting their own), are required to collect & analyze data individually, and report their findings to the instructor in a research journal (rather than sharing with research peers). ECURE operationalizes the PARTIAL definition as engaging students in at least one of the essential CURE element and multiple research stages, within a context in which students ask or answer questions to which the answers are unknown. This definition differentiates PARTIAL experiences from cookbook experiments.

FULL is defined as students engaging in a full and authentic research project that involves all five essential CURE elements.

Several key institutional benefit of the ECURE framework include:

- providing a gradual onramp for instructors to begin incorporating undergrad research experiences into courses and/or disciplines where they are hesitant due to lack of classroom support resources, rigid content requirements and large class sizes.
- providing a fallback option for instructors who aim for FULL implementations but find themselves needing to scale back at the last minute.
- scaffolding the delivery of undergraduate research pedagogy to students, with no prior exposure to research concepts or professions, building student understanding and confidence gradually

Figure 1. ECURE Framework



For more information regarding the ECURE Framework, including implementation presentations by UNM instructors and the first cohort report, please see: https://urad.unm.edu/faculty-staff/ecure.html

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