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EXAMPLES OF COURSE-BASED UNDERGRADUATE RESEARCH EXPERIENCES

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Introduction to Course-based Undergraduate Research Experiences (CUREs)

"*Course-based research give us, as professors, a way of translating the methods and insights of our own specialized scholarship into the introductory classroom. It allows us not only be the experts in the room but also help our students understand the mysterious journey we took to become experts. In turn, that helps students understand how they can become experts, how one learns to be confident in one's own research, assertions, and arguments*."

- Davidson, C. N. (2018)

Definition of CURE

Course-based Undergraduate Research Experiences (CUREs) have been in high demand in recent years in response to an increasing number of research that indicates how undergraduate students benefit from research opportunities and experiences (Dolan, 2019; Auchincloss et al.,2014; Hensel, 2018; Reisel et al., 2015). Hensel (2018) defines CURE as "the inclusion of research projects in the curriculum, and it expands research opportunities to all students" (p. 2). Hensel (2018) further specifies the following criteria for CURE in the first two years:

- Research is embedded into the course curriculum.
- All students engage in the research project.
- Students work collaboratively on the project.
- Research projects introduce students to the research methodology of the discipline.
- Outcomes of the research are unknown.
- Student outcomes of the research are communicated in some manner (Hensel, 2018, p.2).
- Incorporates student critical reflection (McRae, 2017)

Benefits of CURE

Embedding research into the course and curriculum opens a door for all students to engage in undergraduate research and promotes educational equity (Hensel, 2018). Unlike undergraduate research opportunities that often require an application or a network to find professors who are willing to involve undergraduates, entry into CURE only require undergraduates to enroll in the course (Auchincloss et al., 2014). Moreover, CUREs can be designed and integrated into first-year courses to expose the various elements of research and the "thrill of discovery" (Hensel, 2018, p.1) to all students early on (Auchincloss et al., 2014; Hensel, 2018). "Students will benefit from an early introduction to research by learning to think critically about existing knowledge, developing the ability to ask researchable questions, exploring possible solutions, and using evidence as they analyze the results of their work" (Hensel, 2018, p.2). Hensel (2018) also points out that CURE can provide many benefits for underrepresented students as well as students from first year to senior years, such as learning gains in content knowledge, improved analytical and technical skills, and increased confidence in conducting research (Auchincloss et al.,2014).

Developing CURE for the first two years

What would CURE look like for undergraduates in the first two years? Where do you get started with CURE in the first year? Hensel (2018) suggests beginning with examining aspects of the research process that are appropriate to integrate into first-year courses. Hensel (2018) elaborates on the following four common elements as examples of essential research and life skills:

- Observing: Encourage students to practice the ability to focus carefully and intensively – engage in acute observations.
- Questioning: Teach students how to develop analytical, reflective, and open-ended questions that ask “why, what if, and how” rather than “what”. Encourage students to challenge current assumptions and think about the hidden assumptions or bias in the question.
- Connecting: Share with students how faculty seek new experiences and make connections from those experiences. Encourage students to read outside their discipline to build an open and prepared mind.
- Use of evidence: Have students to conduct a literature review. Engage students in reading articles for their literature review and analyzing each source to determine its credibility. Engage students in discussions about the credibility of various articles by asking probing questions and encouraging students to question the evidentiary basis of information.

To conclude, incorporating CUREs into introductory courses will ensure every student has the same opportunity to engage with undergraduate research and hone their skills of observing, questioning, making connections, and using evidence (Hensel, 2018). The research skills that undergraduates develop through CUREs will enhance their learning experience throughout their university academic careers, as well as prepare them to address and solve problems or issues more effectively in their future careers (Hensel, 2018).

This handbook, a collection of examples for CURE, was created to spark ideas and inspiration for integrating CURE in the first-year large enrollment courses in Engineering.

Simple Project to Introduce Earth Science Research Methods

Keywords: earth science, small research assignment

Course Title: Environment Earth Science (Penn State University)

Student Description: 25 first-year non-science majors

Undergraduate Research: data collection and analysis, discussion of findings

Research Component: This project was developed when a student who was getting a custom wheelchair built approached the course instructor, asking if she could help her determine the slopes of the sidewalks. With this students' permission, the instructor asked her first year students to do this as a research project. They worked in small groups to measure characteristics of sidewalks using simple materials, such as sticks and strings. The focus of this project was experimental design and data collection, rather than analysis, which was done by the wheelchair manufacturer.

Associated Learning Outcomes:

- Use scientific techniques to solve a problem or answer a question
- Work collaboratively with peers to develop content knowledge and communication skills

Assessment:

- Students submitted a report describing the findings of their experiments. As this project required more work than the average lab, it is worth twice as much as their other laboratory assignments. However, this was still a small portion of the overall course grade.
- The instructor developed the rubric based on conversations with the student who was planning to use the information in the reports for her wheelchair design. Students were graded on whether they included key information clearly and consistently.

Findings/Recommendations:

- Despite being a very simple project and not generating brand new data, it was still very impactful for students.
- Even though the students taking this course were non-majors, they still were very engaged with the project. Students were enthusiastic about using research to help a peer.

Source:

Guertin, L. (2015). Are you looking for a CURE? (Course-based Undergraduate Research Experience). Retrieved from https://blogs.agu.org/geoedtrek/2015/07/15/are-you-looking-for-a-cure-course-based-undergraduate-research-experience/

Keep It Simple

A well-designed, short-term research project can be just as impactful as a larger one, and may be less intimidating to first year students. This example outlines a project that was not time consuming, expensive, or complicated, but still applied course concepts in an interesting, engaging way.

Industrial Engineering In-Class Research Experiences

Keywords: engineering, lecture-based, small research assignment

Course Title: Applied Ergonomics and Work Design (Iowa State University)

Student Description: 40 second-year industrial engineering majors

Undergraduate Research: data collection and analysis, discussion of findings

No Laboratory Necessary

Data collection can take place in regular classrooms, as long as the equipment is safe to use and transportable. The example here required commercially available tools and vibration sensors, which were easy to bring into the lecture classroom.

Research Component: The course had several in-class research activities integrated throughout the semester. While most classes were traditional lectures, several classes in each unit were dedicated to working on research assignments. During each activity, students worked in teams to develop a hypothesis, collect data, and come to a conclusion about a given problem. For example, one of the course topics is Tools and Tool Selection. In this research assignment, students had to assess a variety of power drills to determine the safest and most effective one for construction workers. They collected data by attaching vibration sensors and electrodes to students drilling into small pieces of wood in different positions. They compared the impact of each tool on the user to determine the one with the least potential for harm. This activity was authentic to the work of the discipline.

Associated Learning Outcomes:
- Collaboratively collect data using appropriate methods
- Differentiate between viable and nonviable data
- Discuss and justify the analysis and conclusion of research with peers
- Design future research based on experimental findings

Assessment:
- Students submitted a report for each research experience. The reports described the experience, outlined the data and findings, and suggested future steps for the project. There are many styles of rubrics that can be used to guide students on their reports.
- Students also completed a traditional final exam for the course.

Findings/Recommendations:
- This course integrated research into lecture time rather than in labs. Students could see the close connections between the content they learned and the activities they did.
- The research activities were inspired by actual projects done in the department of industrial engineering. This allowed them to be relevant and authentic to the discipline, and meant the instructors did not have to design interesting, authentic experiments from scratch.
- Using several small research projects allowed students to see a wider variety of topics in the discipline than they would if they just had a single, larger project.

Source:

Potter, L., Stone, R., Fyock, A., & Popejoy-Sheriff, D.F. (2018). Implementing a Course-based Undergraduate Research Experience (CURE) into an IE Curriculum. *2018 ASEE Annual Conference & Exposition.* https://peer.asee.org/30617

Engineering Research and the Design Process

Keywords: engineering, laboratory-based, smaller research assignments

Course Title: Special Topics in Mechanical Engineering (Texas Tech University)

Student Description: 40 upper-year engineering students

Undergraduate Research: guided inquiry project, research design, data collection and analysis

Research Component: A textbook containing Michael Faraday's lectures *The Chemical History of a Candle* guided the course. Students read a lecture each week and discussed it as a group in class. Then they completed an experiment based on the lecture topics. For example, in one lecture, Faraday explained and demonstrated how combustion reactions generate hydrogen gas, which reacts with oxygen in the air to produce water. In their experiments, students had to generate hydrogen gas from a chemical reaction and condense it with oxygen to form water. They modified different conditions of their experiment to determine how the rate of hydrogen gas production changed and how they could maximize it.

After each hands-on experiment, students had to design and outline a new experiment based on their findings. These experiments were not physically executed, but considered theoretically for their effectiveness. This integrates the design-mindset that is key to engineering.

Associated Learning Outcomes:
- Use scientific skills that compliment engineering design practices
- Apply prior knowledge to solve problems

Assessment:
- Students were assessed on the experiments they designed for each topic. They had to expand on the concepts in the lab they completed, and include how the topic of study could improve an existing technology or be used in practical engineering.

Findings/Recommendations:
- The authors note that while this was a small class, most of the experiments required very inexpensive equipment and could easily be scaled up for larger groups of students.
- Students completed a survey at the end of the course and reported an increased appreciation and understanding of the research process in engineering.

Include Design Components

After each research experiment, students had to design a new experiment based on the topic and methods used. They also have to think about how the knowledge gained from their experiments could be used to improve or develop new technologies. This keeps the content relevant, despite being based on lectures from 1848.

Source:

Pantoya, M., Hughes, P.C., & Hughes, J.S. (2015). A case study in active learning: teaching undergraduate research in an engineering classroom setting. *Engineering Education, 8*(2), 54-64. doi.org/10.11120/ened.2013.00014

Independent Laboratory Project in First Year Physics

Scaffold the Project
Early laboratory activities had a lot of guidance and support, as students were new to the research process. As they built their skills, they had more independence, until they get to create their own project.

Keywords: physics, laboratory-based, smaller research assignments, large research project

Course: Accelerated Beginning Physics: Mechanics (Stanford University)

Student Description: 41 first-year science majors

Undergraduate Research: guided inquiry project, research question and project design

Research Component: The course instructor modified the laboratory component of the course from traditional methods (observing or proving a known concept) to a student-driven research project. In their projects, students generated a research question on a given topic, determined the type of apparatus needed to test it, collected data, analyzed it, and gave one another feedback on whether they answered the question.

The first few lab exercises were smaller to students thinking about each component of the research process before putting them together in a large project. For example, in the first laboratory session, they were given a simple question about gravity and were asked to design an experiment to test it using items in the room. They shared their designs and discussed whether they would have enough evidence to answer the question if they did these experiments. This got them thinking about what makes an effective experiment.

Associated Learning Outcomes:

- Recognize research as an iterative, ongoing, and collaborative process
- Participate in the design, experimentation, and communication of small research projects
- Give and receive constructive peer feedback

Assessment:

- This course was graded as Pass/Fail, so the instructor's focus was on giving quality feedback for each lab component, rather than determining a grade for performance.
- Students also gave and received peer feedback in small groups throughout the semester.

Findings/Recommendations:

- Students need time to build content knowledge and laboratory skills, so fewer experiments were done in this class compared to other physics courses (2-3 experiments per semester compared to 10-12 experiments per semester).
- Some lecture content was not covered in the laboratories. However, the instructor felt that the research experience was more valuable for students than doing extra experiments that may not reinforce their learning.
- The instructor recommends focusing on ensuring the lab activities align with the course objectives, so student and instructor time is used effectively.

Source:

Castillo, A. (2015). How to create physicists. Retrieved from https://teachingcommons.stanford.edu/teaching-talk/how-create-physicists

Authentic Computer Science Research Projects

Keywords: computer science, larger research project

Course: Autonomous Intelligent Robotics (University of Texas at Austin)

Student Description: 30 first-year computer science majors

Undergraduate Research: question and experimental design, data collection and analysis

Research Component: As students explored research in Artificial Intelligence and Autonomous Robotics, they researched and implemented a new feature onto an existing robot. Alone or in small groups, they had to select a feature to add to the robot and search the literature for research about how that feature was being implemented and tested in practice. They wrote a program to add that feature to the robot, and designed experiments to test it. They often required several iterations of the code before it functioned properly and then had to design new experiments for the new code. Students presented their research to their peers and submitted a final report, including their background research, code, experimental design, and results.

Associated Learning Outcomes:

- Read and critically assess original research
- Collaborate effectively with peers
- Devise solutions and/or approaches to open-ended problems
- Write about and present solutions and/or approaches from the course

Use Literature

A key part of the research process that this course introduced is reading and analyzing literature. For their final report and presentation, students had to put their project into the context of current research in robotics and artificial intelligence.

Assessment:

- The assessments in the course were broken down as follows:
  - **Class Participation (10%)**
  - **Reading Responses (10%)**
  - **Preliminary Assignments- project proposal and drafts (60%)**
  - **Final Project (20%)**

Findings and Recommendations:

- Most projects required programming skills above what is taught in first-year computer science classes. Students embraced the challenge and had a robust skill set by the end of the course.
- Students were expected to participate in discussions and updates about their research project throughout the course. This mimicked the environment and process of graduate school, and gave students an opportunity to experience it before deciding if they would like to pursue it.

Source:

Sinapov, J. (2016). CS378: Autonomous Intelligent Robotics (FRI). Retrieved from http://www.cs.utexas.edu/~jsinapov/teaching/cs378/

Building Research Skills in First Year Mathematics

Presentation Options

There are many different platforms for presenting research, such as posters, powerpoints, or infographics. Giving students a choice of presentation method allows them to be creative and use their strengths.

Keywords: mathematics, laboratory-based, smaller research assignments, larger research project

Course: Mathematical Experimentation (Ithaca College)

Student Description: First-year mathematics majors

Undergraduate Research: inquiry assignments, question and experimental design

Research Component: Students completed a small research exercise each week in a three-hour laboratory session. For example, one lab began with a class discussion on the Pythagorean Theorem. Students then had to use the software *Mathematica* to generate a list of Pythagorean triples and to identify patterns. As the labs progressed, students were given fewer guiding questions.

In the final weeks of the semester, students designed their own mathematical research project. They had to select a topic, develop questions, and plan how to answer them. The instructors helped ensure that the questions are deep enough to foster good research while still being reasonable for finishing in the remaining three lab sessions. Students synthesized their findings of this project in a short presentation to the instructor. They must submit a draft before the final project is due.

Associated Learning Outcomes:

- Explore mathematical phenomena experimentally
- Detect patterns and provide mathematical explanations
- Design and implement mathematical algorithms with computer algebra systems

Assessment:

- Students submitted a report after each laboratory, and the instructor provided feedback, both on their mathematic content and communication.
- After receiving feedback, students submitted an edited version of the report. While this was a lot of work for the instructors, it allowed students to develop scientific writing skills early in their academic careers, which benefits them in upper year classes.

Findings/Recommendations:

- Research is very different to the types of math assignments students are used to doing. Traditionally "strong" students in mathematics found the research and writing components frustrating. Lots of instructor and peer support was necessary at the start of the semester, as students were far outside their comfort zones.
- Mathematics majors took this class alongside their introductory calculus class. This concurrent instruction was meant to help them have a deeper appreciation for where concepts come from.

Source:

Brown, D. (2013). Experimental mathematics for the first year student. *Problems, Resources, and Issues in Mathematics Undergraduate Studies, 24*(4), 281-293. doi.org/10.1080/10511970.2013.870264

Experimental Design in Biology Inquiry Project

Research for Large Classes
A balance of open-endedness and structure is essential when creating research for a large class. In this example, each group had a unique project, but the instructor did not need to provide different materials and equipment to each one.

Keywords: biology, laboratory-based, larger research project

Course: Introductory General Biology (Davidson County College)

Student Description: 180 first-year biology majors

Undergraduate Research: guided inquiry, experimental design

Research Component: The focus of the laboratory sessions (taught alongside standard introductory biology lectures) was an inquiry project investigating whether essential oils can control pests such as the cowpea weevil. Early in the semester, students submitted two annotated references for relevant, peer-reviewed research on the topic. All the references were added to a class bibliography that was used throughout the project. During labs, students selected a research question that fit within the inquiry topic and designed experiments to answer it. For example, students have chosen to compare the weevils' reactions to varying doses of the same essential oil, different types of essential oils, and plain vs mixed essential oils. Students analyzed their data and reported their findings in a final poster.

This project differed from a traditional laboratory experiment because students selected their own research project and generated new, previously unknown data. Students also did not follow a prescribed methodology and had to determine how to use the available tools in the lab to answer their question.

Associated Learning Outcomes:
- Define a research question
- Analyze and interpret data
- Plan and carry out scientific investigations
- Develop literature review and library search skills

Assessment:
- Students were graded on their submission of annotated sources, laboratory notebook, and a scientific poster that they presented at the end of the semester.
- This detailed poster rubric helped to guide students, as many were making an academic-style poster for the first time. The Taylor Institute is regularly used for digital poster presentations.

Findings/Recommendations:
- The instructor of this course noted that students often had differing results due to the choice in the research question and design. Some did not get any useful data at all, but still had a successful learning experience, since that is often what happens in scientific research.
- Some students had to modify and repeat their experiments to get results. Groups had disagreements and lack of consensus over their results, but this is also a part of the learning process.

Source:
Felts, J.W. (2019). From an inquiry-guided project to a CURE in general biology: testing repellent effects of essential oils and a parasitoid wasp against *Callosobruchus maculatus.* Retrieved from https://serc.carleton.edu/curenet/institutes/hampton/examples/199371.html

Applying Geology Content at Home

Keywords: geology, homework-based, smaller research assignment

Course: Intro to Geology: Geohazards (Pomona College)

Student Description: First Year, non-geology majors

Undergraduate Research: discovery project, data collection and analysis

Research Component: Students applied their course knowledge about different types of natural disasters and damage mitigation strategies in an independent research project. They had to analyze their homes for the types of natural disasters that could affect them and propose measures to help minimize damage. Students used state and national maps of fault zones, volcanic activity, floods, or other processes to find the necessary data for their project. They also looked at the layout and features of their homes to see where changes may be helpful. This project was done in the second half of the course, after students had enough knowledge on the course topics to effectively collect and compile their data.

Associated Learning Outcomes:

- Apply classroom knowledge to non-academic daily life
- Recognize how earth processes affect students' lives
- Communicate scientific information in writing
- Observe local earth features to independently collect data
- Critically analyze and interpret data

Make It Personal

The students in this project were not generating "new" data, but they were exploring and compiling existing information in a way that was new and relevant to them.

Assessment:

- The project was assigned as homework and done entirely outside of class. Students had their fall break to complete the project, which gave them time, but also allowed them to analyze their parents'/family members' homes if they went to them during that time.
- In their two-page report, students provided a list of natural disasters that could affect their home and explained how they determined this information. They also listed mitigation and protection strategies, again explaining why they would be useful.

Findings/Recommendations:

- This project emphasized the human impact and the direct relevance of the course content. Students had the opportunity to apply their knowledge in a more familiar setting to them. Their homes became their laboratories for the project.
- This project was not a huge component of the course, but it allowed students to use research methods and common resources within the field of geology and geohazard mitigation.

Source:

MacMillan, I. (2005) Natural disaster risk at home. Retrieved from https://serc.carleton.edu/introgeo/studentresearch/examples/HomeDisaster.html

Course Outcomes Relating to Undergraduate Research

Skills/Abilities Relating to Undergraduate Research	**Course Learning Outcomes Examples** **By the end of the course, students will be expected to:**
Access and use resources	Critically evaluate information from many sources including engineering publications, data processing, and engineering analysis (Bradford, Ukwatta, Komeili & Wu, 2019) Use library, database, or other search tools to search for relevant research on the course topics (Center for Experiential Learning, n.d.)
Apply knowledge in research field	Identify and use appropriate research methodologies (Center for Experiential Learning, n.d.) Use correct terminology, concepts, and theory related to the discipline (Center for Experiential Learning, n.d.)
Formulate research questions	Articulate a clear research problem or question (Center for Experiential Learning, n.d.) Articulate a timely and important research question (The University of Utah) Formulate a hypothesis (Center for Experiential Learning, n.d.)
Collect and analyze data	Differentiate between viable and nonviable data (Potter et al., 2018) Collect data independently by observing course concepts in real life actions (MacMillan, 2005) Critically analyze and interpret data (MacMillan, 2005) Apply quantitative reasoning skills to analyze student-collected research data (Fisher et al. 2018) Use appropriate apparatus, sensors and instruments to collect data and analyze fluid flow (Binns & Lubitz, 2019)

Design and conduct research	Plan and execute experimental investigations to test hypotheses (Santos, 2019) Perform quantitative analyses of water resources and the effects of human activities on these water resources (Bradford, 2019) Design future research based on experimental findings and analysis (Potter et al., 2018) Participate in the design, experimentation, and communication of small research projects (Auchincloss et al., 2014) Work autonomously, setting and meeting appropriate deadlines (Center for Experiential Learning, n.d.)
Deepen understanding of course content through research and its application	Recognize how course content affects students' lives (MacMillan, 2005) Apply classroom knowledge to non-academic daily life (MacMillan, 2005) Identify and articulate the relevance of research to the course content and the discipline (Center for Experiential Learning, n.d.)
Work with others	Give and receive constructive peer feedback (Castillo, 2015) Work collaboratively, using listening and communication skills with peers (Center for Experiential Learning, n.d.)
Reflect	Reflect on the research experience, identifying strengths and areas to improve (Center for Experiential Learning, n.d.) Reflect on the research experience, identifying how the experience informs the future educational and career goals (The University of Utah)
Communicate	Communicate research effectively with peers, graduate students, and instructors (Center for Experiential Learning, n.d.) Articulate the findings of their research in written format (Fisher et al., 2018)

	Communicate the results of critical evaluations of water resources issues and proposed solutions (Bradford, 2019) Discuss and justify the analysis and conclusion of research with peers (Potter et al., 2018) Identify and articulate the relevance of research to the course content and the discipline (Center for Experiential Learning, n.d.)
Professional capacity and development	Demonstrate increased confidence in research skills (Fisher et al., 2018) Develop and exhibit expert-like attitudes and motivation in the domain (Fisher et al., 2018) Acknowledge the iterative process of research (Auchincloss et al., 2014) Identify and practice research ethics and responsible research conduct (Center for Experiential Learning, n.d.) Articulate the value of a research experience for the future academic, personal, and career goals (The University of Utah)

References

Auchincloss, L.C., Laursen, S. L., Branchaw, J.L., Eagan, K., Graham, M., Hanauer, D.I., Lawrie, G., McLinn, C.M., Pelaez, N., Rowland, S., Towns, M., Trautmann, N.M., Varma-Nelson, P., Weston, T.J., & Dolan, E.L. (2014). Assessment of course-based undergraduate research experiences: A meeting report. *CBE Life Sciences Education, 13*(1), 29-40. dx.doi.org/10.1187%2Fcbe.14-01-0004

Binns, A. & Lubitz, W. (2019). *Fluid mechanics.* University of Guelph. Retrieved from https://www.uoguelph.ca/engineering/system/files/2230.pdf

Bradford, A. (2019). *Water management.* University of Guelph. Retrieved from https://www.uoguelph.ca/engineering/system/files/2550.pdf

Brandford, A., Ukwatta, E., Komeili, A., & Wu, P. (2019). *Engineering and design III.* University of Guelph. Retrieved from https://www.uoguelph.ca/engineering/system/files/3100.pdf

Brown, D. (2013). Experimental mathematics for the first year student. *Problems, Resources, and Issues in Mathematics Undergraduate Studies, 24*(4), 281-293. doi.org/10.1080/10511970.2013.870264

Castillo, A. (2015). How to create physicists. Retrieved from https://teachingcommons.stanford.edu/teaching-talk/how-create-physicists

Center for Experiential Learning (n.d.). Learning Objectives for Undergraduate Researchers. Retrieved from https://www.luc.edu/media/lucedu/lurop/pdfs/Official%20List%20of%20Learning%20Objectives%20for%20Undergraduate%20Researchers.pdf

Davidson, C. N. (2018). Forward. In Hensel, N.H. (Eds.), *Course-based undergraduate research: Educational equity and high-impact practice*. Sterling, Virgina: Stylus Publishing, LLC.

Felts, J.W. (2019). From an inquiry-guided project to a CURE in general biology: testing repellent effects of essential oils and a parasitoid wasp against *Callosobruchus maculatus.* Retrieved from https://serc.carleton.edu/curenet/institutes/hampton/examples/199371.html

Fisher, G.R., Olimpo, J.T., McCabe, T.M., & Pevey, R.S. (2018). The *Tigriopus* CURE- A course-based undergraduate research experience with concomitant supplemental instruction. *Journal of Microbiology and Biology Education*, 19(1). doi.org.ezproxy.lib.ucalgary.ca/10.1128%2Fjmbe.v19i1.1503

Guertin, L. (2015). Are you looking for a CURE? (Course-based Undergraduate Research Experience). Retrieved from https://blogs.agu.org/geoedtrek/2015/07/15/are-you-looking-for-a-cure-course-based-undergraduate-research-experience/

Hensel, N. H. (2018). Crazy observations, audacious questions. In Hensel, N.H. (Eds.), *Course-based undergraduate research: Educational equity and high-impact practice* (pp. 1-11). Sterling, Virgina: Stylus Publishing, LLC.

Kumbhar, S. R., Attar, A. C., & Telsang, M. T. (2018). Undergraduate research experience (URE): A new dimension in curricular redesign. *Journal of Engineering Education Transformations*, special issue Jan 2018. doi: 10.16920/jeet/2018/v0i0/120927

MacMillan, I. (2005) Natural disaster risk at home. Retrieved from https://serc.carleton.edu/introgeo/studentresearch/examples/HomeDisaster.html

McRae, N. (2017). Experiential learning at Waterloo: build quality EL to prepare students for the future of work and learning. Retrieved from https://uwaterloo.ca/centre-for-teaching-excellence/sites/ca.centre-for-teaching-excellence/files/uploads/files/waterloo_exl_institute_norah.pdf

Pantoya, M., Hughes, P.C., & Hughes, J.S. (2015). A case study in active learning: teaching undergraduate research in an engineering classroom setting. *Engineering Education, 8*(2), 54-64. doi.org/10.11120/ened.2013.00014

Potter, L., Stone, R., Fyock, A., & Popejoy-Sheriff, D.F. (2018). Implementing a Course-based Undergraduate Research Experience (CURE) into an IE Curriculum. *2018 ASEE Annual Conference & Exposition.* https://peer.asee.org/30617

Reisel, J., Cancado, L., Walker, C., & Mitrayani, D. (2015). Defining a Successful Undergraduate Research Experience in Engineering. *2015 ASEE Annual Conference and Exposition Proceedings*. Retrieved from https://www.asee.org/public/conferences/56/papers/11108/view

Santos, R. (2019). *Atmospheric emission control: combustion systems*. University of Guelph. Retrieved from https://www.uoguelph.ca/engineering/system/files/4820.pdf

Sinapov, J. (2016). CS378: Autonomous Intelligent Robotics (FRI). Retrieved from http://www.cs.utexas.edu/~jsinapov/teaching/cs378/

The University of Utah (2019). Office of undergraduate research. Retrieved from https://our.utah.edu/about-our/learning-outcomes/