

Competitive and Funded Undergraduate Research: A Case Study

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Abstract— The College of Engineering (CEN) at the American University of Sharjah (@ www.aus.edu) offers seven undergraduate programs. Six engineering programs in Civil, Chemical, Electrical, Computer, Industrial and Mechanical engineering, as well as a Computer Science major.

The college believes that developing and maintaining an undergraduate research program benefits both students and faculty mentors and the education experience in general. Incorporating a research component coupled with a sound academic curriculum enables students to develop independent critical thinking skills along with oral and written communication skills. A well-designed research experience impacts valuable learning objectives that would no doubt have a lasting influence as undergraduates prepare for their professional career.

At the beginning of Fall, 2021 semester, the college working with the Office of Research and Graduate Studies in the university initiated an undergraduate research program and allocated a sizable fund for it. A call for proposals was sent out to students, seeking individual or group proposals supervised by a faculty member. In Fall 2021, the committee responsible received a total of 19 proposals. Another call was sent out for the Spring 2022 semester. This experiment is repeated, with the numbers of proposals reaching 43 in Fall 2022 with the quality of the proposed work improving with every cycle because of the newly established competitive ecosystem among the students. The nature of the projects varied from theoretical, to simulation based to experimental. The deliverables ranged from a building working prototype, to winning a local or regional competition to publishing the outcomes of the work in a reputable professional conference or journal.

The aim of this article is to share the path followed to infuse this research experience into the existing college culture, to layout the mechanisms by which we intend to measure the effectiveness of this approach in enriching the undergraduate research experience for engineering students and finally identify ways of improving it.

I. INTRODUCTION

Undergraduate research holds significant importance for a variety of reasons including the following: it allows students to apply theoretical knowledge gained in the classroom to real-world problems and scenarios; research allows students to delve deeper into specific topics of interest, this depth of understanding goes beyond what is covered in standard coursework, providing a more comprehensive knowledge base. In some specializations, undergraduate research provides

students with practical or experimental experience in their field of study. By engaging in research, students develop critical thinking and problem-solving skills. Typically, research involves a range of skills such as data collection, analysis, evaluation, making informed decision, writing, and communication. These skills are transferable and applicable in various professional settings, contributing to a well-rounded skill set that is highly valued by employers.

For faculty benefits gained while mentoring undergraduate research include among others valuable support to mission of the department or institution, possibility for increase research scholarship in support of promotion or tenure and merit, valuable engagement with students, interaction with students in the research process can enhance teaching skills in the classroom, opportunities for external funding and support, and additionally supervising indigenous-related research problems leads to better ties with the community.

Major funding agencies has also recognized the value of undergrad research with the NSF as an example, allocating approximately \$33 million for the Research Experiences for Undergraduates Program in 2008 increasing it to approximately 75 million by 2020 [1-2].

A number of studies related to undergraduate research have been reported in the literature including the work completed in [3]. Here, researchers surveyed approximately 4500 undergraduates and 3600 faculty, graduate student, and postdoc mentors who participated during a 2002 or 2003 in undergraduate research opportunities funded by eight NSF programs with a substantial undergraduate research component. Undergraduate respondents indicated that their understanding of how to conduct a research project increased, 83% said their confidence in their research skills increased, and 73% said their awareness of what graduate school has increased.

Next, we discuss some of the reported undergraduate research-related efforts by different universities. A comprehensive survey of such efforts is beyond the scope of this paper.

In [4], faculty from Washington State University, using an NSF funded through the REU (Research Experiences for Undergraduates) program, implemented four modes of engaging undergraduates in research including paid part-time research during the school year, research for credit and a full time summer research option. Through the life of the program over 100 students have participated in it. Some of their important

reported findings emphasized the presumption that participation in such programs by students improve the retention rate in engineering and STEM fields, and all student end up benefiting from the experience not only students with high GPAs. Interestingly, they observed that students with below 3.0 GPAs had their GPA improved following the participation in the research experience. They also found out that students prefer to present their work in an interactive poster session format because of the personal interaction during the presentations that seems to be a rewarding experience to them.

Results pointing to the convergence of high levels of self-efficacy toward producing and presenting scholarly products as well as increased confidence levels in conducting research gained through the challenges and successes of original research experiences in natural Hazards Engineering Research Infrastructure are reported in [5].

At the University of Illinois-Urbana [6], based on students' initiative to gain research experience, a group of students, faculty, and staff co-developed an undergraduate research mentorship program focused on work in the field of soft robotics. The idea is to expose students to research in the early undergraduate years. Students were involved in research related activities such as attending conferences, co-authoring papers and mentoring other undergraduate students.

The involvement of undergraduate students in the area of quantum computing research is discussed in [7]. Case studies of four projects involving six students are described, lessons learned were summarized and recommended best practices for undergraduate research are detailed as well.

II. BACKGROUND AND MOTIVATION

The College of Engineering at the American University of Sharjah (<https://www.aus.edu/cen>) is the largest of four colleges with a population of approximately 2260 students. It offers seven undergraduate programs in Chemical, Civil, Industrial, Electrical, Computer and Mechanical engineering as well as a degree in computer science. All the programs are ABET accredited. It offers nine master programs and two Ph.Ds. The college follows the American model of education with engineering requiring the completion of 132 credit hours for graduation and computer science 124 credit hours, for a total of 8 semesters. All programs require a capstone design sequence consisting of 2 courses completed in subsequent semesters by teams of 3 to 4 students under the supervision of one or two faculty members.

Approximately 65% of the college students join with a high school average of 95% or above, and 30% between 90 and 95%. Employers in UAE have rated AUS engineering Alumnus as the number one in the region (QS ranking 2022) [8]. All programs require a capstone senior design project that is completed in two subsequent semesters. Faculty are active in research with an average of two journals per year, and often seek to engage students in undergraduate research through individual efforts.

In 2021, the office of Research and Graduate studies in the university, and in cooperation with the college initiated a competitive funded undergraduate research initiative dedicated to introducing students to the culture of research and its associated benefits.

Some key points about the importance and benefits of funded undergraduate research include:

1. **Increased Motivation:** Knowing that their work is valued and supported financially can increase students' motivation and commitment to their research projects. This can lead to more dedicated and fruitful research outcomes.
2. **Enhanced Learning Experience:** The financial backing for research projects can enhance the overall learning experience for undergraduates. It provides them with a more immersive and comprehensive understanding of the research process, from project inception to completion.
3. **Access to Resources:** Funding allows students to access resources, such as laboratory equipment, research materials, and specialized software, that may be essential for their research projects. This ensures that students can conduct high-quality research with the necessary tools and facilities.
4. **Professional Development:** Funded research often comes with opportunities for professional development. This may include attending conferences, workshops, or presenting research findings, allowing students to enhance their communication and networking skills.
5. **Competitive Edge:** Students with funded research experience often stand out in graduate school applications or job searches. It demonstrates initiative, dedication, and the ability to secure and manage research funding—an essential skill in many research-oriented fields.
6. **Contribution to Research Output:** Funded undergraduate research projects can lead to meaningful contributions to the academic community. Whether through publications, presentations, or other forms of dissemination, students can contribute to the advancement of knowledge in their respective fields.

In its first run, the budget allocated for the program was approximately sixty thousand US dollars. In early Fall 2021, a call for proposals was developed and shared with students and faculty. A committee chaired by the Associate Dean for Undergraduate Studies and includes a representative from each department in its membership was formed. Its mandate was to review the submitted proposals, and identify those that are worthy of funding.

III. PROCESS

Initially, a call for proposals was shared with all students and faculty in the college. The call stated the objective of the initiative as follows: to encourage CEN undergraduate students from all programs to participate in and disseminate independent research, scholarly, and creative (RSC) activities under the mentorship of college faculty. RSC activities are conducted by students under the supervision of a faculty member, and can take diverse forms, such as independent study, a term project, a senior design project with a research flavor, or engagement in a large ongoing study. A set of guidelines is included in the call as well.

The guidelines clearly specify that proposals are to be written by students(s) and endorsed by a faculty member. Additional items in the guidelines include the deadlines,

eligibility conditions, maximum funding possible for individual or group projects, grant period and expected compliance information. For consistency, a template for the proposal write-up and expected contents is also shared with students. A copy of the template is shown in Figure 1.

A complete proposal package must have the following components:

- a. **Proposal Coversheet**
- b. **Research Project Support:**
 - i. **Project Description (4 pages maximum):** The description must state the proposed work in a clear, concise, and understandable manner. It is suggested to include the following:
 1. Definition of project objectives. The proposal should explicitly state what the project will accomplish. Be sure to state clearly what the central ideas, hypothesis, and/or purposes are.
 2. Background: Provide a review of previous work conducted in the area related to the proposed work (if applicable).
 3. Methodology. Describe the specific steps and/or tasks that will be accomplished (including how data/information will be obtained), in order to achieve the purpose of the proposed project.
 4. Anticipated outcome(s) and impact. Describe expected results/outcomes and identify how they may make an original intellectual or creative contribution to the discipline or practice. In other words, there should be a description of:
 - the importance of the proposed project in the discipline,
 - the value of the proposed work, and
 - the contribution of the proposed original, intellectual, or creative work to the discipline.
 5. Qualification of the primary applicant and her/his team. Justify why the primary applicant has had sufficient skills and knowledge to carry out the project. For a group project, clearly identify the role of each group member.
 6. Other available resources and support. State clearly, in addition to this grant being applied, if any other resources and support (e.g., fund, equipment, supplies, etc.) are available for executing the project.
 - ii. **Work Plan (1 page maximum)**
 - iii. **References (2 pages maximum)**
 - iv. **Travel funding support (if needed)**
- c. **Budget and Budget Justification (2 pages maximum)**
- d. **Health and Safety Issues:** Include a statement if the project will involve health and safety issues, use of chemicals or explosives, etc.
- e. **Endorsement Letter from Primary Faculty Mentor (2 pages maximum)**
- f. **AUS RSC Compliance Form for CEN-URG** (if needed - please see Appendix E)

Fig. 1. Proposal Package

Following the deadline, the Associate Dean arranges for a meeting with the committee members. The associate dean office prepares sharable folders with all the proposals and related documents. These folders are shared with the committee members. In the meeting the process of reviewing the proposals is outlined and the deadlines are set. The instrument used to evaluate the quality of each proposals is shown in Figure 2.

IV. STATISTICS

Table 1 displays the allocated budget per academic year. Table 2 below summarizes the number of proposals submitted and those that were funded since the inception of initiative. Since projects typically commence in Fall, we see more of a surge in applications during this semester.

TABLE I. BUDGET ALLOCATED PER ACADEMIC YEAR

Semester	Allocated Budget (US dollars)
Fall 2021-Spring 2022	60,000.00
Fall 2022-Spring 2023	76,000.00
Fall 2023-Spring 2024	65,000.00

TABLE II. NUMBER OF PROPOSALS SUBMITTED/FUNDED

Dept.	# of Proposals per Dept	Funded	Dept.	# of Proposals per Dept	Funded
Fall 2021	19	16	Spring 2022	13	12
CHE	1	1	CHE	2	2
CSE	4	3	CSE	2	2
CVE	1	1	CVE	2	2
ELE	7	5	ELE	3	3
INE	0	0	INE	1	0
MCE	6	6	MCE	3	3
Fall 2022	43	36	Spring 2023	14	9
CHE	4	3	CHE	1	0
CSE	19	15	CSE	4	3
CVE	5	4	CVE	3	2
ELE	3	2	ELE	3	2
INE	2	2	INE	0	0
MCE	10	10	MCE	3	2
Fall 2023	38	28	Spring 2024	0	0
CHE	1	1	CHE		
CSE	17	14	CSE		

CVE	6	5	CVE		
ELE	7	3	ELE		
INE	0	0	INE		
MCE	7	5	MCE		

Depending on the budget justification, it is often the case that the committee would provide partial funding to the project and not the fully requested amount. The award letter would specify the exact amount.

A sample of the funded projects includes the following:

“Prediction of the eutectic temperatures of binary ionic liquid mixtures for their design as phase change materials in biopharmaceutical delivery” (from Chemical Engineering)

“Investigating the Performance of Concrete Beams Reinforced with High Strength Steel Rebars” (from Civil Engineering)

“Cloud Detection on Satellite Data Using Deep Learning” (from Computer Science)

“IoT-Based Road Bridges Health Monitoring & Warning Systems” (from Computer Engineering)

“Barriers to primary healthcare access at MOHAP primary healthcare” (from Industrial Engineering)

“Microwave-based vibration monitoring smart robots” (from Electrical Engineering)

“Manta Ray Inspired Underwater Vehicle Propulsion System for Scouting and Data Collection” (from Mechanical Engineering)

V. SUMMARY OF FINDING

Upon examining the related data obtained in the 5 semesters, the following observations are made:

- During its 5 semesters life, a total of 101 projects are funded.
- A total of 363 students and 48 (out of 80) faculty participated in the program.
- Most of the submitted proposals were group-based with very few individually researched projects seeking funding.
- A sizable portion of the requested funding was to purchase hardware gear and material for experimental work, or subscription to cloud services.
- So far, 10 papers are published in Scopus indexed conferences with additional ones under preparation, all based on results obtained from funded projects.
- A preliminary concern is the lack of student and faculty participation from Industrial Engineering program is noted. The Associate Dean and the Head of Department will increase efforts to recruit faculty mentors and students from this program.

VI. ASSESSMENT AND EVALUATION

By the conclusion of the sixth semester in Spring 2024, the following assessment steps will be carried out:

A survey will be developed to study the impact of this initiative on the students and how do they value the experience. The survey will attempt to find answers to questions such as:

Did the experience improve their performance academically and hence GPA?

Did the experience enhance their team work abilities?

How can the experience be improved?

How was the effect of the mentoring by faculty on the research experience?

What additional resources would be required to enhance this undergrads research experience?

What motivated them to participate?

At the college level, we will use the collected data to address the following:

Did the experience improve students' GPA?

Was the students' GPA a determinant factor on the quality of results produced?

Did the participation has an effect on future GPA of students?

Did it improve the quality of senior design projects?

How many of the participants eventually progressed to graduate schools?

Last, faculty mentors will as well be surveyed to gain insight into the limitations that might have surfaced during the mentoring process. They will also be queried on ways to improve this research undergraduate experience.

VII. CONCLUSION

Even though, AUS is primarily an undergraduate institution with heavy emphasis on quality teaching, in a strategic move in 2021, the college of engineering has embarked on establishing a culture that encourages undergraduate research as a mean of further enhancing the curriculum and the educational experience of its students. This is diffused into the existing structure via providing funding to promising undergraduate research proposals with clear value in complementing the students' classroom experience. The number of proposals submitted in the 5 semesters is evidence of the rise in interest among the student population. To further improve the initiative described in this paper, we intend to investigate the pros and cons of the approach used in this initiative to introduce students to undergraduate research. We will also examine, using a control group, if a relationship exists between participation in undergraduate research and overall academic performance. The number of co-authored and published papers with undergraduates and their faculty mentors will also be tallied and used as a performance indicator. Overall, all signs lead to a positive conclusion, nevertheless, using surveys and other instruments we will carefully analyze the impact of the experience and close the loop in an attempt to eliminate any shortcomings

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- [4] D. Bahr and M. Norton, "The Effectiveness of Active Undergraduate Research in Materials Science and Engineering", Journal of Materials Education, Vol. 28(1), 127-136, 2006.
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- [7] D. Hoe, M. Lowe and D. Binkley, "Undergraduate Research in Quantum Computing: Lessons Learned from Developing Student Researchers", 2023 ASEE Annual Conference
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CEN Undergraduate Research Grant Review Form

The purpose of the Undergraduate Research Grant Program is to encourage all undergraduate students from all disciplines to participate in research, scholarly, and creative projects under the mentorship of AUS faculty.

Primary Applicant Name and Department:

Project Number (in Excel File):

Project Title:

Reviewers Group: (please select one)

Type of Grant:

☐ Individual (up to AED 5,000)

☐ Group (up to AED 10,000)

Instructions: Rate each category from 1-3 (1 = Inadequate, 2 = Adequate, 3 = Exemplary)

1. Strength of the Proposal

	Neutral	1 - Inadequate	2 - Adequate	3 - Exemplary
A) Clear, concise, understandable (Overall impression)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B) Background theory	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C) Question/problem clearly defined	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D) Sound methodology	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E) Project impact	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. Timeline/Budget/Faculty Support:

	Neutral	1 - Inadequate	2 - Adequate	3 - Exemplary
A) Timeline/plan of action is reasonable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B) Budget and justification are appropriate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C) Strength of faculty mentor letter of support	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D) Sound Ethics/Compliance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. **For Group Proposals Only:**

Role of all group members clearly defined? ☐ Yes ☐ No ☐ N/A

4. **Reviewer's Overall Rating (1-3):**

☐ Neutral ☐ 1 - Inadequate ☐ 2 - Adequate ☐ 3 - Exemplary

5. **Additional Reviewer Comments:**

Fig. 2. Proposals' Review Instrument