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A Conscious Research Implementation: Research Integration in the Classroom

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A Conscious Research Implementation: Research Integration in the Classroom

Abstract

The American Society for Engineering Education's Engineering Technology Council advocates

The degree is engineering technology, the career is engineering™.

However, motivating and supporting Engineering Technology students to persist in pursuing a career in engineering continues to be a significant educational challenge. The researchers have identified an area that appears to be lacking but has the potential to support students as they navigate this and other challenges. This paper is the first of many that will explore the integration of research in an applied program. While future work will include the construction and implementation of a novel framework on Conscious Research (CR), this work verifies the level that research is implemented in the classroom so that additional work to implement the CR framework can be further defined.

The researchers suggest that faculty can provide substantially more effective and engaging instruction in freshman through senior courses when students are continuously involved in the use of research throughout the educational experience. For example, the CR cycle can be used to *formulate a question, conduct a literature survey, re-formulate the question, propose a solution, an improvement, or an updated approach, design/build/implement the proposed approach, and present to others. In this cycle, the search for discovery and innovation materializes.*

This preliminary work investigates the use of research materials, introduction of practices, and those performing this kind of work in the classroom, at every level. This study is done at a large research institution where research is pervasive throughout and there are many engineering technology students. Researchers chose the Student Perception of Research Integration Questionnaire (SPRIQ) to assess student perception of research in their learning environment. The first step in assessing the implementation of CR in a program. The results from this assessment will provide an understanding of how research is utilized in engineering technology programs with the basic assumption that the utilization of research attracts, motivates, and engages students and faculty alike in a sustainable culture of excellence vertically within each program, horizontally across engineering technology, and upwardly to the graduate program. The result of engaging in critical research is a better-prepared graduate to enter the engineering profession or advance to graduate school and tackle the demands of the 21st-century engineering industry.

Background

World events of the 1940s-50s led to the 1955 Grinter report [1] urging faculty to revamp the curricula and embrace a much higher math and science-based approach to engineering education. As this transformational change proceeded in the ensuing decades, over 100 U.S. institutions of higher education developed ABET-accredited BS degrees in Engineering Technology (BSET) [2].

Engineering Technology (ET) units are organized as programs within engineering departments, or as departments within a college or school of engineering, technology, applied science, professional studies, management, or a combination of these names. Despite the variety of organizational structures and unit names, common to all is the educational philosophy of ET: *using mathematics, science, and engineering fundamentals in the analysis and implementation of technology-based solutions to industry problems*. "Technology" in this context refers to (i) *hardware*: any physical equipment, artifact, or tool utilized in an engineering field (e.g., any device, instrument, machine, sensor/transducer/actuator, data acquisition/processing card, materials); (ii) *software*: any computer-aided engineering simulation, analysis, or design tool; and (iii) *techniques*: any engineering design method, process or algorithm described in a textbook, a patent, or any other scholarly or trade publication. As such, ET pedagogy is strongly based on the application of current and emerging technology to solving engineering problems; it introduces experiential learning activities in virtually every course; and emphasizes hands-on laboratory activities while de-emphasizing the abstract manipulation of mathematics. In many circles ET is described as hands-on or as applied engineering. Ethics of the engineering profession also requires that graduates be mindful of the impact that technological advances have on society, its culture, and the economy and the environment.

Therefore, the importance of understanding the use of research in the educational environment is significant. Understanding changes, how to interpret current findings, and develop ways to incorporate those changes in ongoing projects is critical to the continued progress of technology and our society. With a clear focus on the engineering technology student and the tool used to assess their experience of research in the classroom this work will set a precedence for this implementation to continue.

Development of Engineering Technology Major

Engineering Technology (ET) units are organized as programs within engineering departments, or as departments within a college or school of engineering, technology, applied science, professional studies, management, or a combination of these names. Despite the variety of organizational structures and unit names, common to all is the educational philosophy of ET: *using mathematics, science, and engineering fundamentals in the analysis and implementation of technology-based solutions to industry problems*. "Technology" in this context refers to (i) *hardware*: any physical equipment, artifact, or tool utilized in an engineering field (e.g., any device, instrument, machine, sensor/transducer/actuator, data acquisition/processing card, materials); (ii) *software*: any computer-aided engineering simulation, analysis, or design tool; and (iii) *techniques*: any engineering design method, process or algorithm described in a textbook, a patent, or any other scholarly or trade publication. As such, ET pedagogy is strongly based on the application of current and emerging technology to solving engineering problems; it introduces experiential learning activities in virtually every course; and emphasizes hands-on laboratory activities while de-emphasizing the abstract manipulation of mathematics. In many circles ET is described as hands-on or as applied engineering.

Misinformation about ET programs is unfortunately persistent, widespread, and caused by various reasons. Efforts that identify how B.S.ET and B.S. in Engineering programs can be mutually beneficial academically and for the future of the engineering profession include "2+n and 4+n (n = 2, 3, 4)" degree plans, "2+2 true articulations" with Community Colleges, and collaborations to expand graduate programs in ET [3]-[5]. At the national level, the Technology Accreditation Commission (TAC) was renamed the Engineering Technology Accreditation Commission (ETAC) at the March 24, 2012 ABET Board of Directors meeting. An industry survey [6] and later survey of graduates at this same institution [7] pondered among other questions "What position titles are occupied by BS Engineering and BSET graduates?" Industry surveys strongly corroborated anecdotal data indicating that for the most part and for most job titles, the sample of 200+ companies (large and small) will hire someone based on their skill set and their ability to show compatibility with the tasks of the particular job description, and not necessarily based on the name of the academic degree (BSE or BSET). Moreover, industry hires employees into 'engineering' positions and does not recognize positions labeled as 'engineering technologists.'

The individuals surveyed for purposes of exploring the use of research in the classroom come from this engineering technology major. Their opinions and experiences as related to research in the learning environment need to be examined. However, a review of what evidence exists that research is used to teach and inform students wither formally or informally. Student preparation for careers, and the instrument used to assess the presence of research will support the research questions set forth in this paper.

Research in the Undergraduate Classroom

Evidence shows that formal learning when supplemented by supporting material outside of the classroom encourages students to engage, develop their cognitive abilities, and are more prone to problem solve [8]. The researchers are intrigued with the level of research, evidence, and research interests that are introduced into the classroom. Much of this concern is rooted in the applied nature of engineering technology, and a concern that faculty may not be introducing this very important part of student learning into the curriculum. Further discussion regarding preparation and a means to assess the use of research in the classroom follow.

Career Preparation

Students that can problem solve, and use their cognitive abilities are those that are most successful as they move through different levels and types of work/learning environments. The responsibility for providing that knowledge and experiential [1] learning is the faculty and programs in the institutions of higher learning. While engineering technology programs garner a great deal of respect there is also a great deal of unknown that these students encounter related to their choice of major. As noted earlier the lack of knowledge or understanding of the major is persistent and a result of that is the fact that industry hires employees into 'engineering' positions and does not recognize degrees in engineering technology [9]. Further the experiences students have while pursuing their degree contribute to their relative success in whatever career direction they may pursue.

As noted previously, knowing, seeing, participating in, and interacting with faculty engaged in research is a part of the educational experience that may be missing in many if not most ET programs. The researchers have chosen a validated instrument to measure how much research is brought into that learning environment. Conscious Research (CR) is a novel ET pedagogical approach to learning based on the Study and Research Path (SRP) methodology that integrates four key components: (1) situated cognition; (2) engineering design & inquiry; (3) technology literacy; and (4) community of practice [10]. As such, CR enhances meeting course and student learning objectives; enables rich performance assessment tools to be applied in an ET program; links instruction practices across programs; ties faculty instruction and student learning to applied industry research, making graduates more competitive; and fosters cross-disciplinary collaboration.

Student Perception of Research Integration Questionnaire (SPRIQ) [11]

SPRIQ is a way to determine student perception of research involvement in their courses/programs. The instrument design helps to understand the instructional choices of faculty. An exploratory factor analysis (EFA) was used in the development of this measure to identify three constructs, research integration, quality, and beliefs. Research integration is a second order latent factor with four latent first order subscales - Reflection, Participation, Current Research, and Motivation [11]. The measure is a student self-report measure designed to capture students' experiences related to research in their programs. The reflection subscale provides insight into the research process and how it leads to results of a project or program. The Participation subscale provides insight into students' involvement in and contributions to scientific research. The Current Research subscale identifies the content related to research instructors are providing to their students as well as the general environment. Lastly, the Motivation subscale provides information about students' enthusiasm, and interest in learning more about available research opportunities. The first order latent constructs are quality and belief. Quality refers to the students' perceptions of the quality of teaching. Beliefs refers to students' beliefs of the importance of research to their learning.

The survey questions used in the SPRIQ can be found in Appendix A.

Research Questions

This tool allows the researchers to pursue their quest to understand the use in the classroom, not from their perspective, but from the perspective of the student. Realizing and understanding the tools presented to them will encourage use and engagement with research in the future, this paper strives to answer the following questions:

- *Do students believe that research is presented as part of their curriculum?*
- *Do students feel that they are motivated to learn more or become part of the research process?*
- *Do students find the current research interesting and relevant to the material they are learning?*
- *How important is the incorporation of research to their learning?*

Methodology

The research institution utilized for this part of the project has nearly 50,000 overall student population, with 1231 as of 12/31/2022 in engineering technology, making it one of the largest engineering technology programs in the United States. The enrolled student population at Purdue University-Main Campus is 58.4% White, 8.24% Asian, 5.26% Hispanic or Latino, 3.23% Two or More Races, 2.82% Black or African American, 0.123% American Indian or Alaska Native, and 0.0571% Native Hawaiian or Other Pacific Islanders. This institution was chosen because of its size and representation of the engineering technology program.

1231 students were sent the survey link via a list serv and N=57 participated in the survey, based on the SPRIQ. The survey was built using questions provided by Vissar-Wijnveen, et al [11] provided in their Table 6. Each item included in the subscales was rated on a Likert scale from 1 to 10. A score from 1, which indicated respondents strongly disagreed with the statement of the item, to 10, which indicated respondents Strongly Agree with the statement of the item.

Data Analysis

Of the 57 survey responses, 23 were excluded from the analysis due to missing values on all responses for the subscales; therefore, 34 responses were evaluated.

As a result of the limited research on engineering technology students' perceptions of research in their programs, the main focus of this study was to assess students' perceptions of research in their respective programs. Mean levels and standard deviations were derived for each item and subscale. Frequencies for responses to each subscale were also calculated and reported below.

Findings

This section is divided into two parts. The first part is of the demographics of respondents while the second is a close look at a limited amount of data using the criteria set forth by the SPRIQ instrument.

Demographics

Participants completed several questions focused on their demographics. They include:

- Age: 18-20, 21-23, 24-26, 30+
- Identification: Male, Female, Prefer not to say
- Race: White, Asian, Black or African, Mixed, Other
- Program Year: Freshman, Sophomore, Junior, Senior, Senior+
- Major: Mechanical Engineering Technology (MET), Manufacturing Engineering Technology (MFET), Industrial Engineering Technology (ECET), and Other majors

The 57 students who chose to participate in the survey are represented in the following demographics.

Age. 29 students were aged 18-20 (50.9%), 22 students were aged 21-23 (38.6%), 1 student was aged 24-26 (1.8%), and 5 students were aged 30+ (8.8%).

Identification. 44 of those who responded self-reported themselves as male (77.2%), 12 were female (21.1%), and 1 student preferred not to say (1.8%).

Race. 45 students were White (78.9%), 4 students were Asian (7.0%), 2 students were Black/ African American (3.5%), 4 students were mixed race (7.0%), and 3 students self-reported as Other (5.3%).

Program Year. 16 of the students were freshman (28.6%), 6 students were sophomores (10.7%), 13 students were juniors (23.2%), 18 students were seniors (32.1%), and 3 students were senior+ (5.4%).

Engineering Technology Specific Major. Of the participants, the major of 28 of the students was MET, 13 students majored in ECET, 6 students majored in MFET, 4 students majored in IET, and 6 students had a major not mentioned in the list (10.5%).

Table 1 provides the mean levels and standard deviations for each item used to derive the latent subscales of Reflection, Participation, Current Research, Motivation, Quality, and Belief. Each of the items based off of the SPRIQ instrument used to derive the subscales are listed in the table.

Table 1. Means and SDs for Each Item Used in The Analysis

Item	*Mean*	*SD*
NQ11	3.8750	0.83280
NQ12	3.8387	0.85011
NQ17	3.3214	1.30678
NQ20	5.9286	2.56657
NQ26	5.3182	2.83492
NQ28	3.5000	1.21106
NQ36	2.3448	0.72091
NQ39	5.1364	2.98082
NQ42	4.5263	2.79620
NQ22	4.7333	2.74092
NQ27	4.4545	3.01942
NQ33	5.1200	3.23161
NQ34	5.1429	3.20548
NQ41	2.0455	0.57547
NQ18	7.1875	2.29217
NQ25	3.5909	1.18157
NQ35	5.9583	2.89646
NQ43	5.6429	2.85728
NQ47	5.8148	2.67520
NQ48	6.5862	2.47151
NQ49	6.6897	2.66060

NQ50	6.2400	2.74287
NQ52	3.8800	1.36382
NQ53	3.8000	1.43637

Table 2 details the mean levels and standard deviations for each of the SPRIQ subscales. The mean level for Reflection indicates student perceive the prevalence of research as being slightly less than neutral or lacking an emphasis on the scientific process and research as a whole. The mean level for Participation reveals students disagree that the opportunities to participate in research in their current programs is meaningful, or important. Though the students' perceptions of their involvement in research was less emphasized, the mean level of the Current Research subscale indicates they believe to be aware of the current research projects going on within their programs. The mean level of Motivation suggests students' perceptions of their desire to learn more about research in their fields and actively participate in research has been bolstered by the current curriculum. The data also revealed through the mean level of Quality that students perceive their instructors to be delivering quality instruction through effective content delivery and clear expectations. The mean level for students' Belief subscale reveals relatively neutral perceptions of the importance and purpose of research in their learning.

Table 2. Means and SDs For the Subscales

Subscale	*Mean*	*SD*
Reflection	4.1742	1.12333
Participation	3.6276	1.63443
Current Research	4.0389	2.30439
Motivation	5.6162	1.86327
Quality	6.2722	2.34500
Beliefs	4.6310	1.72751

Table 3 provides insight into the response rates for each of the subscales to show students'' perceptions of research use and instruction in their current programs. The table indicates which subscales are more or less present in the current curriculum format for undergraduate engineering technology students. The Reflection subscale shows mostly neutral and disagreement responses from the sample, revealing the students' perception that research methodology is not a main component of their current curriculum. The Participation subscale responses indicate neutral and some disagreement about opportunities to participate in research in their current curriculums and respective programs. Current Research subscale has the most concentrated disagreement responses from students that show their perceptions of a lack of awareness regarding research carried out by their instructors and links from research to practice. Though there seem to be some areas for intervention to enhance the research opportunities and focus within the engineering technology programs, the students still perceive their instruction to be of high quality and clear. The responses on the beliefs subscale indicate a lack of awareness in realizing the foundational aspect research in their programs, and an area for research methodology to take focus.

Table 3. Response Frequency Table SPRIQ Subscales

Likert Scale Value	Category					
	Reflection	Participation	Current Research	Motivation	Quality	Beliefs
1.00-1.99	-	8.8%	17.6%	-	-	8.8%
2.00-2.99	11.7%	29.2%	17.5%	11.6%	11.7%	8.8%
3.00-3.99	26.4%	17.6%	17.5%	5.8%	2.9%	2.9%
4.00-4.99	26.4%	11.6%	17.4%	16.7%	8.8%	11.8%
5.00-5.99	23.5%	20.4%	5.8%	8.8%	11.7%	26.4%
6.00-6.99	5.9%	2.9%	5.8%	20.5%	11.7%	20.6%
7.00-7.99	-	2.9%	5.8%	20.6%	8.8%	2.9%
8.00-8.99	-	-	8.8%	11.7%	26.4%	-
9.00-9.99	-	-	-	-	2.9%	-
10.00	-	-	-	-	2.9%	-
Missing	2.9%	5.9%	2.9%	2.9%	11.8%	17.6%

Discussion

This initial study, though limited in responses, revealed a variety of points for future comparison and intervention by way of demonstrating students' perspectives of the role research in their current programs and applicability to their future careers. Students surveyed seem to be motivated to increase their involvement in research methodology related to their respective programs. Additionally, incorporating a research methodology framework in the engineering technology programs to enhance the perspective of students to know how skills acquired through research can serve them in their careers would be helpful, given the Belief sub scale responses. Through more targeted research incorporation, students would learn how to think through problems and link the problem-solving thought process to their future work. The mean scores indicated that according to students' perspectives the quality of their instruction has not been adversely affected by their limited research opportunities; however, the responses also indicate students may be unaware of how research skills, like problem solving, can be an asset in their careers.

The items related to students' perceptions about research being presented as part of their curriculum yielded the highest percentage of responses that disagree with those statements. The responses indicate that most students do not consider research as a main component of their curriculum, or even an influential part of it. Students do not seem to be engaging with the most current research in their fields, or they do not perceive the information presented by instructors as framed in that way. When looking at the item level means for the subscale Current Research, most of the means were at best, neutral, but mostly in disagreement about the curriculum having a research focus when content is presented in coursework. This finding provides a clear indication for an opportunity to frame research findings discussed in class as such and place more emphasis on the research aspect of their learning context.

The motivation subscale responses are interesting due to the disparate responses across the scale. The differences in responses could speak to some students who are beginning to engage in research and are seeking more opportunities for participating in the research process. The responses also cross the neutral into agreement indicating students perceive themselves to be motivated to learn more about and participate in research opportunities. The only other subscale that had a percentage of responses close to that is the students' perception of the quality of instruction they are receiving.

For students to be able to identify the scientific processes they are using in their engineering technology programs, the process needs to be explained and identified when engaging in experiential learning by their instructors. In order to better prepare students for the scenarios they will be dealing with in their careers a more focused research integration mechanism would allow students to more easily identify the skills required to address their assignments in the field. The importance of early and consistent exposure to the research process is essential to more meaningful work during training and while completing capstone research projects. If students are engaging in research processes and taught about the process early on, the projects and questions they will answer will be more meaningful to them.

Conclusion/Limitations

Even though the student responses indicate a limited exposure and emphasis on research methodology in their programs, they are motivated and eager to engage in research opportunities. This interest and motivation would likely increase with more targeted emphasis and exposure to research skills that would be helpful and meaningful to the students in their future careers. The student responses on the Beliefs subscale would indicate the demonstrations of research the students do experience do not explicitly expose the links from research to their future career practices in their respective fields. Based on the findings from this study, students may not perceive their exposure to research as an important component, either because of limited exposure or exposure without explicit links to their practice.

One of the limitations of this study was the small size of student respondents. The original number of participants was 64 and resulting cleaning of data due to lack of completion diminished the amount of data available to the researchers. The cross-sectional design also prohibits inferences of causation. The sample included in the analysis was also not as ethnically diverse as we would have hoped to include for more generalizable findings. When broken down by program focus, the sample was not equally representative of each engineering technology program either, which may contribute to the differences in research exposure, which would speak to the importance on continuity of research utilization across engineering technology programs.

Future Work

In the future, we plan to include a wider audience of ET students from Institutions across the nation to draw a more complete picture of the premises posed in this paper. The first step is to launch the study at the University of Houston, Main and Downtown campuses covering approximately 1,600 students. This will be important not only because of the size of the student population but also its demographics. In Spring 2022, the University of Houston's (Main campus) enrollment data is summarized in Table 4. In addition, we plan to secure funding to implement the CR approach in multiple Institutions together with a longitudinal assessment of its effectiveness over a period of 3-5 years.

Table 4. University of Houston Spring 2022 Demographics

		Male	Female	White	AA/H/NA*
Total	43,314	47.9%	52.1%	21.5%	43.7%
ET**	1,348	76.3%	23.7%	14.9%	52.6%

*** African American / Hispanic / Native American**
**** Biotechnology, Computer ET, Electrical Power ET, Mechanical ET**

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Appendix A

Student Perception of Research Integration Questionnaire (SPRIQ) Survey Questions

Reflection:
1: I assimilate knowledge about research findings?
2: I learned to pay attention to how research is carried out.
3. I developed an academic disposition. (feel more academic than industrial)
7. The scientific research process was an essential part of the curriculum
9. My understanding of engineering technology concepts has increased
10. Attention was paid to research methodology.
11. I felt part of the university's academic community.
13. My faculty members encouraged me not to be satisfied with an explanation too quickly.
21. I was stimulated to critically assess literature.
27. I learned the ways in which research can be conducted in engineering technology.
28. The faculty encouraged us to ask critical questions about our work.

Participation:
4. There are opportunities to talk to academic researchers.
5. There were opportunities to talk with researchers about scientific research.
14. We searched for answers to unanswered research questions together with the faculty.
16. My contribution to the research was valued.
18. My participation in the research was important.
19. I got the opportunity to hear about and/or read current scientific research.
20. I became familiar with the results of scientific research.
22. I felt involved in the university's research culture.
26. I made a contribution to development in my field.
29. As a student I felt involved with the research.
30. I had opportunities to socially interact with researchers within the university.
32. I became involved in my faculty members' research.

Current Research:
6. Attention was paid to recent developments in the field.
12. I became familiar with the research carried out by my faculty members.
17. I came in contact with my faculty members' research.
23. My awareness of the research issues that researchers are currently contributing to was increased.
24. I learned what kind of studies have been carried out in engineering technology.
31. Links to current research practices were made.

Motivation:
8. I was inspired to learn more about engineering technology.
15. I became enthusiastic about my research.
25. My interest in research in this area was increased.
33. My faculty members encouraged personal interest and enthusiasm for research in this field.

Quality:

34. The faculty members had sufficient time to support me in my learning process.
37. The faculty members carried out their instruction adequately.
38. My faculty members were able to explain the subject matter effectively.
39. I developed an accurate picture of what was expected of me.

Beliefs:
40. My learning is stimulated when education is grounded in research.
41. It is important to me that my faculty conduct research.
42. Education in which scientific research is central stimulates my learning.
43. The research culture at the university stimulates my learning process.