Evaluation of Undergraduate Research Course Using Stufflebeam's Context, Input, Process, Product Model

*Angelo A. Acenas**
Department of Mechanical Engineering, Cebu Institute of Technology University, Cebu City, Philippines

*angeloacenas@gmail.com

ABSTRACT

An undergraduate research course is often considered the pinnacle of a student's college experience, as it allows them to apply both the soft and hard skills acquired during their academic journey. In order to ensure students gain relevant experiences that align with desired learning outcomes, the evaluation of such courses is essential. This study explores the perceptions of graduating research students regarding their experiences in undergraduate research courses. Using a descriptive survey, data was collected from 60 students to investigate their views. The assessment of their evaluation of the course was based on their level of agreement with statements related to context, input, process, and outcomes of their Undergraduate Research Experience (URE). The majority of students indicated strong agreement with most statements. However, their agreement was only moderate concerning the availability and usefulness of library and laboratory resources, the financial support available for research, and the accessibility of research advisors. In conclusion, the students' perceptions suggest that the undergraduate research course aligns well with the intended outcomes. Nevertheless, the findings highlight the necessity to evaluate and enhance laboratory and library resources to better support engineering research. Moreover, implementing financial support mechanisms to alleviate financial barriers in conducting studies and optimizing the support provided by research advisors is recommended.

Keywords: *research, evaluation, CIPP, undergraduate research*

Introduction

Research plays a pivotal role in our daily lives, boasting a range of practical applications such as uncovering medical breakthroughs, propelling technological advancements, and dissecting and resolving issues in education, business, the economy, and society. It serves as a foundational framework for subsequent investigations and project planning, thus enhancing the quality of life by streamlining convenience and comfort. Moreover, research delves into historical understanding to offer remedies for contemporary societal challenges, while simultaneously challenging individuals to evolve by assimilating novel ideas, perspectives, and skills (Avilla, 2016).

In developing nations like the Philippines, universities have traditionally excelled in teaching but lagged in research endeavors. To address this, the Philippine Commission on Higher Education (CHED) has implemented policies and directives aimed at fostering enhanced research productivity. CHED ardently advocates for heightened research orientation within Higher Education Institutions (Clemeña & Acosta, 2007) and underscores the importance of research skills by integrating research courses and activities into nearly all higher education curricula (Arrelano, Morano & Nepomuceno, 2012).

The significance of Research and Development (R&D) finds resonance across diverse sectors including agriculture, manufacturing, education, and healthcare. Within this context, the Cebu Institute of Technology University, as a Higher Education Institution, is tasked by CHED with producing graduates actively engaged in generating novel knowledge and contributing to research and development initiatives. Responding to this mandate, the university has established the Innovation and Technology Support Office (ITSO) and Research and Development Coordinating Office (RDCO). Additionally, the Department of Mechanical Engineering strives to equip graduates with the competence to excel in professional practice and pursue graduate studies or research endeavors. The integration of the ME Project Study in the BSME Curriculum, employed as an undergraduate research course, serves as a means to achieve this objective. However, it is worth noting that no prior assessment has been conducted to gauge the efficacy of the undergraduate research course.

This study endeavors to evaluate the undergraduate research course, encompassing all stages from project ideation and inception to execution and implementation. By employing a comprehensive evaluation approach—assessing context, input, process, and product—this investigation aims to furnish an analytical and reasoned foundation for decision-making regarding course enhancement.

Literature Review

In an article entitled "Understanding Research" from Education and Training Unit, research is defined as "the organized and systematic method of finding answers to questions. It is systematic because it is a process broken up into clear steps that lead to conclusions." Additionally, "research is organized because there is a planned structure or method used to reach the conclusion". Research is said to be successful only if "we find answers, whether we like these answers or not." Research is important because the decisions that government, business, institutions, labor, organizations and society in general needs to be based on valid and reliable information and thorough analysis.

In an article published by The National Academies Press (NAP) (1995), engineering research is concerned with "the discovery and systematic conceptual structuring of knowledge." Additionally, "engineers develop, design, produce or construct, and operate devices, structures, machines, and systems of economic and societal value." Also, "almost all university research in both science and engineering is performed as a component of the advanced education of students. For most engineering students, the goal of a career in industry motivates their pursuit of advanced study" and "engineering students' outlook on research tends to be predisposed toward the application in engineering practice." Undergraduate research is the exploration of a specific topic within a field by an undergraduate student that makes an original contribution to the discipline. According to Zupanc (2012) as cited in NAP (2017), "undergraduate research is sometimes thought to be a relatively recent development in higher education. However, faculty-mentored, apprentice-based undergraduate research has a long and rich history, dating back more than 200 years to Wilhelm von Humboldt." From the same article, it is mentioned that "undergraduate research has intensified among various national and regional groups across campuses, in response to the need to better prepare an increasingly diverse student population to face 21st century challenges."

Challenges in undergraduate research

Sharma and Mantri (2019) cited the lack of group participation (Knutson, Smith, Wallert & Provost, 2010 and Leeder & Shah, 2016) poor writing skills (Jaafar, Boumlik, & Alberts, 2018, and Wang & Correnti, 2016) and plagiarism (Šprajc, Urh, Jerebic, Trivan & Jereb, 2017) as some of the major challenges faced by industry/research organization in hiring graduates. The results of the study conducted by Jin, Li and Xu (2014) showed that the undergraduate research students writing level is generally poor, theoretical innovation and practical significance is lacked. In another study by Arellano, et al. (2012), conducted among 963 graduating students in a state-funded university in the Philippines, result showed that "students are able to identify factors when choosing research problem, formulate conclusions, from research findings, apply sampling techniques, correctly choose data gathering instrument and identify variables." However, "less than half are able to state hypothesis, choose appropriate scale of qualitative variables, identify appropriate statistical test, identify research design, and state elements of the introduction of a research proposal." Lastly, "students performed poorly in outlining general steps and procedures for carrying out a research project" and "majority of the students is not proficient in the lower order research competencies." In a study of Campillan (2019), "results revealed that students had difficulties in formulating their research problem, writing their review of related literature, sampling of their respondents, developing the research instruments, transcribing interviews, video production delays are among others. They also had problems in coordination, plagiarism processing, and other difficulties such as time constraints, absence of research partners, personal issues, and other conflicts." Mapolisa and Mafa (2012) (as cited in Bass, Washuta, Howison, Gonzales, & Maier, 2018), "identified three main categories of challenges that effect how successful a student's research experience is; mentor-student, student-related, and institution-related. The mentor-student challenge comprised the level of engagement between the advisor and student, advisor availability, and student interest in the topic. The students-student challenge identified personal issues in the student's lives that could affect their level of research, such as financial issues, motivation/commitment, and lack of knowledge. Lastly, the institution-related challenges stemmed from overcoming hurdles like lack of research materials and workshops to help foster a student's computer literacy."

"Time is another challenge to overcome with getting the students up to speed and conducting experiments. They have to maintain good academic standing, so they have to exercise effective time management. Time is also a consideration for the research advisor. As mentioned, initial training of the students takes a considerable amount of time. The students need to stay on track, stay productive, and stay excited about the research" (Bass, et al., 2018). The study concluded the challenges that arise includes "overcoming knowledge gaps, time management and pacing of topic delivery."

Benefits in undergraduate research course

Knutson, Smith, Wallert and Provost's study (as cited in Sharma et al., 2019) said that undergraduate research experience (URE) and scientific investigations performed by students result in their cognitive skills enhancement which not only benefit them in the interview protocols and other phases of recruitment process but also in their long term careers. They also cited important studies reported by Kardash (2000) and Zydney et al. (2013) in the past reveal the fact that engaging students in scientific investigations foster their ability to think critically and develop cognitive & personal skills. Sharma and Mantri (2019) cited another study by Wang and Correnti (2016) & Leeder and Shah (2016) that reveals that URE not only improves cognitive skills but also boosts critical thinking and problem-solving skills of

students, which helps in cultivation and development of habits to have deeper insights and understanding of the topics. Descriptions of student-identified benefits of undergraduate research experiences are drawn from analysis of 76 first-round student interviews. As part of the interview protocol, students commented on a checklist of possible benefits derived from the literature. Students were overwhelmingly positive: 91% of all statements referenced gains from their experiences. The benefits described were of seven different kinds. Expressed as percentages of all reported gains, they were personal/professional gains (28%); "thinking and working like a scientist" (28%); gains in various skills (19%); clarification/confirmation of career plans (including graduate school) (12%); enhanced career/graduate school preparation (9%); shifts in attitudes to learning and working as a researcher (4%); and other benefits (1%) (Seymour, Hunter, Laursen & DeAntoni, 2004). According to Petrella and Jung (2008), the research process impacts valuable learning objectives that have lasting influence as undergraduates prepare for professional service. Faculty members at teaching intensive institutions can enhance learning experiences for students while benefiting from a productive research agenda. The university in turn benefits from presentations and publications that serve to increase visibility in the scientific community. Whether projects are derived through student-generated or mentor-generated means, students benefit from completion of exposure to the hypothesis-driven scientific method. When it comes to the opportunity in enhancing research experiences, Jin et al. (2014) recommended ways in improving the quality the quality of undergraduate theses. These are: (a) promoting field research and maintaining academic integrity, (b) improving management and monitoring system, (c) emphasis on ethics and enhancing responsible awareness, (d) enhancing daily training and establishing writing courses.

Context, Input, Process and Product (CIPP) evaluation Model

According to an article from Yale Poorvu Center for Teaching and Learning, "the CIPP model was created in the 1960s by Daniel Stufflebeam and is considered a decision-oriented model that systematically collects information about a program to identify strengths and limitations in content or delivery, to improve program effectiveness or plan for the future of a program. Users of this model are often focused on management-oriented evaluation, as this Model combines four stages of evaluation. The focus is on continuous improvement by concentrating on four areas of a program: the overall goals or mission Context Evaluation); the plans and resources (Input Evaluation); the activities or components (Process Evaluation); and the outcomes or objectives (Product Evaluation)." Also, "the CIPP model provides a comprehensive Model for conducting both formative and summative evaluations of programs, projects, personnel, products, and organizations by focusing on context, input, process, and product" (Frey, 2018).

Methodology

This study employed a descriptive research design. A total of 60 undergraduate research students participated in the study. These participants were requested to express their level of agreement with various statements using a researcher-developed Likert Scale instrument. The survey was conducted using Google Forms. The degree of agreement indicated by the participants served as a measure to assess their perception of different aspects related to their undergraduate research experience.

To evaluate the students' perceptions of their undergraduate research experience, the researchers utilized the levels of agreement as indicators. The analysis of the gathered data involved comparing the weighted means and standard deviations for each statement in the Likert Scale.

In addition to rating their agreement with the provided statements, the students were also prompted to encapsulate their undergraduate research experience in a single word. These responses were subjected to thematic analysis, complementing the quantitative findings and providing a qualitative dimension to the study's results.

Results

The study sought to evaluate the undergraduate research course in terms of the context, input, process, and product variable. The interpretation of the level of agreement is based on the table below.

Table 1. The extent of agreement of the students to the context variable

Weighted Mean	Level of agreement
1.0 - 1.7	Very weak
1.8 – 2.5	Low

2.6 – 3.3	Average
3.4 – 4.1	High
4.2 – 5.0	Very high

Context Variable

The context variable revolves around the objectives, mission, and goal statements presented in the Program Educational Objectives (PEO) and Program Outcomes (PO) of the BSME program, as outlined in the course syllabus. The findings indicate that ninety-two percent of the statements received a 'very high' level of agreement, while eight percent garnered a 'high' level of agreement. The aspects that gained the highest level of acceptance encompass utilizing research to design systems, components, or processes in order to fulfill specific needs within identified realistic constraints, conducting research to identify, formulate, and resolve engineering problems, and employing research to apply appropriate techniques, skills, and modern engineering technology.

Conversely, the statements that achieved the lowest weighted mean scores are those related to utilizing research to develop effective communication, leveraging research to work efficiently within a team, and employing research to cultivate an awareness of contemporary issues. The presence of varying standard deviations across different statements suggests a diversity in the levels of agreement and attitudes towards specific objectives.

Table 2: Extent of agreement of the students to the context variable

Statements	WM	STD	Interpretation
I took research to apply knowledge of mathematics, engineering sciences and physical/natural sciences to solve mechanical engineering problems.	4.33	0.57	Very high
I took research to design or conduct experiments as well as analyze and interpret data.	4.27	0.66	Very High
I took research to design a system, component or process to meet desired needs within identified realistic constraints.	4.37	0.66	Very high
I took research to develop working effectively as a team.	4.20	0.71	Very High
I took research to identify, formulate and solve engineering problems.	4.37	0.61	Very high
I took research to develop communicating effectively.	4.07	0.80	High
I took research to recognize professional, social, and ethical responsibility.	4.23	0.70	Very High
I took research to understand the importance of engineering solutions in a global, economic, environmental, and societal context.	4.30	0.72	Very high
I took research to recognize the need for and engage in life-long learning.	4.28	0.69	Very High
I took research to be aware of contemporary issues.	4.20	0.71	Very High
I took research to use appropriate techniques, skills, and modern engineering technology.	4.37	0.58	Very high
I took research to know the principles of engineering management.	4.22	0.69	Very High

Input Variable

The input variables were assessed in terms of resources, infrastructures, and curriculum content associated with the undergraduate research course, and they can be categorized as student-related, teacher-related, and institution-related factors. All statements received a 'high' level of agreement from one hundred percent of the students. Among the input variables, those related to teachers garnered the highest level of agreement from the students, while the ones related to the institution received the lowest level of agreement.

The statements with the lowest level of acceptance pertain to students' confidence in their financial capacity to support their studies, the availability of university laboratory facilities for their area of interest, and the accessibility of university library resources. On the other hand, the statements that garnered the highest levels of confidence were related to students' motivation and commitment, the research instructor's proficiency in conducting research, and their engagement with the chosen topic.

The varying standard deviations across different statements indicate a diverse range of agreement levels, reflecting differing attitudes towards specific inputs.

Table 3: Extent of agreement of the students to the input variable

Statements	Mean	STD	Interpretation
Teacher-related input variables			
I am confident of the knowledge of my instructor in teaching research.	4.00	0.78	High
I am confident of the knowledge of my instructor in doing research.	4.05	0.79	High
I am confident of the availability of a research adviser for my topic of interest.	3.93	0.88	High
I am confident of the ability of my adviser in directing our research study.	3.92	0.89	High
Average	**3.98**		**High**
Student-related input variables			
I have interest in my research topic.	4.05	0.79	High
I am motivated, committed in doing research.	4.15	0.71	High
I am confident with my writing level in doing research.	3.87	0.81	High
I am confident in my theoretical knowledge in mechanical engineering for my research.	3.82	0.70	High
I am confident in my knowledge of mechanical design in doing research.	3.83	0.72	High
I am confident in my knowledge of doing computer-aided drawings/drafting.	3.90	0.68	High
I am confident of my financial capacity to support my research study.	3.42	1.06	High
Average	**3.86**		**High**
Institution-related input variables			
I find the subject description accurately reflected the content of the course.	3.88	0.85	High
I find that expectations were clearly outlined in the syllabus.	3.97	0.80	High
I find the university laboratory facilities available for my topic of interest.	3.50	1.08	High
I find the university library resources available for my topic of interest.	3.67	0.93	High
Average	**3.76**		**High**

Process Variable

The research course's teaching-learning process was evaluated through various process variables, encompassing project initiation, proposal preparation and approval, design, fabrication, data analysis, and final paper preparation. The results indicated that 94 percent of the statements received a 'high' level of agreement from the students, while 6 percent achieved an 'average' level of agreement.

Among the aspects evaluated, students exhibited the least confidence in the process of selecting a research adviser, the perceived utility of university laboratory equipment, and the effectiveness of library resources. Conversely, students expressed high levels of confidence in collaborating within their research groups, conducting data measurement and collection, and receiving input from their adviser or instructor.

It is noteworthy that the standard deviation observed in this variable is notably higher compared to the other variables assessed using the CIPP framework. This suggests a range of agreement levels and, consequently, varying attitudes towards specific processes.

Table 4. Extent of agreement of the students to the process variable

Statements	Mean	STD	Interpretation
I find the process of finding a research adviser relatively easy.	3.38	1.03	Average
I find the input from my adviser/instructor helpful in doing my research.	3.88	0.94	High
I find the instructor/adviser engaged in the process of doing my research.	3.83	0.99	High
I find the teaching method of the research teacher effective.	3.90	0.99	High
I am confident of the process of identifying the research topic and title defense.	3.72	0.96	High
I am confident of the process of proposal paper preparation.	3.73	0.95	High

I am confident of the process of defending our project proposal.	3.80	0.88	High
I am confident of the process of doing literature review.	3.75	0.84	High
I am confident of the process of designing the instrument/machine.	3.80	0.82	High
I am confident of the process of fabricating the machine.	3.83	0.92	High
I am confident of the process of data measurement and collection.	3.93	0.80	High
I am confident of the process of data analysis and interpretation.	3.82	0.77	High
I am confident of the process of preparing the final research paper.	3.73	0.88	High
I am confident of the process of defending the final research paper.	3.75	0.89	High
I am confident in selecting my research group.	3.82	1.03	High
I am confident in working with my research group.	3.95	1.03	High
I find laboratory equipment in the university useful in the research process.	3.43	0.98	High
I find the library resources in the university useful in the research process.	3.58	0.91	High

Product Variable

The product variable assessed the skills, values, attitudes, and outcomes of the undergraduate research course, as perceived by the students. These outcomes align with the Program Educational Objectives (PEOs) of the BSME program. All statements garnered a high level of agreement from the participants, totaling one hundred percent. However, there were variations in the students' confidence levels across different areas. While the students displayed lower confidence in pursuing graduate studies, achieving the study's objectives, and developing research skills, they exhibited higher confidence in the practical applicability of their research to end-users, the contribution of their work to the advancement of knowledge in mechanical engineering, and the pursuit of careers in research. Analysis of the standard deviations across various statements indicates a diverse range of attitudes towards the evaluated products.

Table 5: Extent of agreement of the students to the product variable

Statements	Mean	STD	Interpretation
I am confident that we are able to achieve the objective of our study.	3.75	0.68	High
I am confident that our research contributed to advancement of knowledge in mechanical engineering.	3.82	0.72	High
I am confident that the result of our research is useful to the end user.	4.15	0.71	High
After doing my research study, I am confident of my research skill.	3.77	0.67	High
After doing my research study, I am confident in pursuing work related to doing research.	3.82	0.77	High
After doing my research study, I am confident in pursuing work related to doing research.	3.78	0.80	High
After doing my research study, I am confident in pursuing graduate study (master's and doctorate).	3.60	0.92	High

Discussion

Combining the four variables of CIPP, the findings demonstrate the students' perception of their undergraduate research experience (URE). The results indicate a high level of satisfaction among students with their URE.

Regarding the context variable, respondents strongly agree on the significance of the undergraduate research course for achieving the Program Educational Objectives (PEO) and Program Outcomes (PO) of the BSME Program. Statements with notably high agreement levels suggest that students anticipate research will aid them in designing systems, components, or processes to meet practical needs within identified constraints, identifying and solving engineering problems, and utilizing modern engineering technology. Petrella and Jung (2008) note that the research process impacts valuable learning objectives that have lasting influence as undergraduates prepare for professional service. The results also suggest that students prioritize the development of communication, effective teamwork, and

contemporary issue awareness less. This could be attributed to the engineering research focus on preparing students for tasks such as designing, constructing, and operating devices and systems with economic and societal value (NAP, 1995). However, skills like communication, collaboration, and awareness of contemporary issues are essential for success in the 21st century information age. Thus, there is an opportunity for research instructors to continually integrate these skills into the course's teaching-learning process.

In relation to the input variable, results indicate that students perceive the resources, infrastructure, curriculum, and content of the research course as valuable for their research experience. Nevertheless, the fact that not all statements reached a 'very high' rating implies areas needing improvement. Enhancements could involve establishing financial support or research funds for student-conducted studies, as noted by Petrella and Jung (2008), where monetary constraints often limit established undergraduate research curricula. Attention is also needed for establishing laboratory and library resources aligned with students' research interests, as evidenced by students outsourcing fabrication and testing due to limited facilities. Given that practical work in labs involves hypothesis forming, experimental design, methodology, and result evaluation (Edward, 2016), aligning these processes with research activities becomes crucial. The evaluation of library resources might stem from underutilization, possibly due to students' lack of awareness or underestimation of their importance for studies (Gunasekera, 2010). Comprehensive information literacy programs should thus be conducted to raise awareness among students about available resources for their research. Among the input variables, students value their motivation, commitment, instructor knowledge, and research topic interest. Mapolisa and Mafa's study (2012), cited in Bass et al. (2018), highlights factors like engagement between advisors and students, advisor availability, student interest, and motivation/commitment influencing students' evaluation of their URE. Consequently, emphasis should be placed on institution-related input variables when planning for improvements.

Concerning the process variable, gathered data demonstrates high agreement among students, indicating their confidence in research processes. However, the majority of ratings falling short of 'very high' suggests areas for improvement. The evaluation of research adviser selection and the utility of lab and library resources in the research process appear as areas requiring more attention than other process variables. This aligns with the input variable results emphasizing the importance of research adviser engagement, lab equipment, and library resources. Conversely, students express satisfaction with group collaboration, data collection, and input from advisors/instructors during research.

Lastly, the product variable garners high agreement among students. Similar to the other variables, there's room for improvement in achieving a 'very high' level of agreement regarding the outcomes of students' research experiences. Based on the study's results, confidence in pursuing graduate study, confidence in achieving research objectives, and research skill development require improvement compared to other areas. This aligns with the fact that only a small number of BSME graduates pursue further studies. Enhancing research skills would benefit students in graduate study, as Ruchina et al. (2015) emphasize the role of research work in master's student training. Improved research skills would bolster students' confidence in pursuing advanced studies. While students might not be highly confident about achieving research objectives, they express high confidence in their research results' usefulness to end users. This aligns with their perception of the contribution of their research to mechanical engineering knowledge and their confidence in research-related careers. These results suggest a positive outcome for undergraduate study in supporting the ME department's mission to produce graduates competent in practicing the profession, pursuing graduate study, and engaging in research work.

Conclusion and Recommendation

Based on the findings of the study, it can be concluded that the undergraduate research experience for students aligns with the overarching objectives of a research-oriented course and the educational goals set forth by the department. However, there exists a challenge in enhancing the student researchers' experience by providing essential facilities and support. These include, but are not limited to, access to well-equipped laboratories, comprehensive library resources, financial backing, and effective communication with research advisors.

Furthermore, the research course should expand its scope to offer increased opportunities for nurturing not only research skills but also skills in communication, collaboration, and social awareness. This multifaceted approach will instill greater confidence in researchers when pursuing advanced studies and striving to attain their research aspirations.

Conversely, for the research course to maintain its high standards, it must continually foster students' motivation and dedication. This involves ensuring a knowledgeable instructor is available to offer valuable insights, sustaining students' interest in relevant topics, enabling them to identify, formulate, design, and solve engineering problems. This collective effort contributes to the overall progression of knowledge within the field and bolsters students' confidence in pursuing research-related careers.

Based on the shortcomings highlighted through the CIPP evaluation, the following recommendations are put forth by the researcher:

a) Conduct an assessment of students' laboratory facility requirements and establish well-equipped laboratories that support activities such as hypothesis formulation, experimental design, methodology execution, and result evaluation.

b) Launch an information campaign to heighten students' awareness regarding the accessibility and utility of library resources for their research endeavors. This entails updating library resources to cater to diverse research interests.
c) Institute funding initiatives aimed at supporting undergraduate research students, thereby removing financial barriers that hinder the pursuit of novel, innovative, and high-impact research projects.
d) Incorporate soft skill development, including effective communication, collaboration, and an understanding of contemporary issues, into the teaching-learning process.
e) Implement the aforementioned recommendations through action research and subsequent re-evaluation within the department.

By implementing these measures, the department can actively address the highlighted areas of improvement and enhance the overall quality of the undergraduate research experience. This approach not only aligns with the goals of the research course but also ensures continuous progress and refinement in preparing students for successful careers in research and related fields.

Contributions of Authors

The authors confirm the equal contribution in each part of this work. All authors reviewed and approved the final version of this work.

Funding

This work received no specific grant from any funding agency.

Conflict of Interests

All authors declare that they have no conflicts of interest

Acknowledgment

The authors thank the project advisory board for helpful guidance and suggestions.

References

Arellano, E.R., Morano, L. N., and Nepomuceno, C.T. (2012). *Assessing Undergraduate Research Competence: Readiness for Research-oriented Jobs*. Development *Education* Journal of Multidisciplinary Research, 1(2). https://ejournals.ph/article.php?id=6621

Avilla, R.A. (2016). *Practical Research 1*. Diwa Learnings Systems Inc.

Belino, M., and Bosshard, H.F. (2011). *Towards an Outcomes-Based Mechanical Engineering Education in the Philippines and the Mapua Institute of Technology School of Mechanical Engineering Experience*. doi: 10.5281/zenodo.1236048

Butler, M. (2004). *Outcomes Based/Outcomes Focused Education Overview.* Retrieved from www.kfshrc.edu.sa//files/Outcomes%20Based%20Education.doc.

Campillan, R.G. (2019). *Difficulties in Research Writing among Communication Students in a Private University*. Augustinian, 2(1). https://ejournals.ph/article.php?id=14786

Chinta, R., Kebritchi, M., Ellias, J. (2016). *A Conceptual Model for Evaluating Higher Education Institutions*. International Journal of Educational Management, 30(6), 989-1002. http://dx.doi.org/10.1108/IJEM-09-2015-0120

CIPP Model (n.d.). Retrieved from https://poorvucenter.yale.edu/CIPP

Clemeña, R.M., and Acosta, S.A. (2007). *Developing Research Culture in Philippine Higher Education Institutions: Perspectives of University Faculty*. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000157869_eng

Creswell, J.W. (2014). *Educational Research, Planning, Conducting and Evaluating Quantitative and Qualitative Research*. Pearson Education Inc., 4th ed.

Edward, N.S. (2002). *The Role of Laboratory Work in Engineering Education: Student and Staff Perceptions.* The International Journal of Electrical Engineering & Education. doi:10.7227/IJEEE.39.1.2

Frey, B.B. (2018). *CIPP Evaluation Model*. Retrieved from http://sk.sagepub.com/reference/sage-encyclopedia-of-educational-research-measurement-evaluation/i4690.xml

Gunasekera, C. (2010). *Students Usage of an Academic Library: a user survey conducted at the Main Library University of Peradeniya.* Journal of the University Librarians Association of Sri Lanka, 14(1), pp.43–60. DOI: http://doi.org/10.4038/jula.v14i1.2687

Holstein, W.K. (n.d.). *Research and development.* Retrieved from https://www.britannica.com/topic/research-and development

Howison, J., Gonzalez, R., Maier, C., Bass, P., and Washuta, N. (2018). *Benefits and Challenges of Undergraduate Research.* http://www.asee-se.org/proceedings/ASEE2018/papers2018/12.pdf

Jamieson, S. (2007). *Likert Scale. Encyclopedia of Epidemiology* (2007). Retrieved from https://www.britannica.com/topic/Likert-Scale

Jin, Z., Li, S., and Xu, J. (2014). *Quality Evaluation of Undergraduate Thesis as the Goal of Applied Talent's Cultivation --Based on the Self-Assessment Analysis of Accounting Major Theses*. doi: 10.2991/ermm-14.2014.42.

Mapa, D.S. (n.d.). *Research Culture in the Philippines*. Retrieved from nast.ph

National Academies of Sciences, Engineering, and Medicine. (1995). *Forces Shaping the U.S. Academic Engineering Research Enterprise*. Washington, DC: The National Academies Press https://www.nap.edu/read/4933/chapter/4

National Academies of Sciences, Engineering, and Medicine. (2017). *Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities*. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/24622.

Petrella, J. K., and Jung, A. P. (2008). *Undergraduate Research: Importance, Benefits, and Challenges*. International journal of exercise science, 1(3), 91–95.

PH lacks 19,000 scientists in research and dev't – Bam Aquino (2017). Retrieved from https://www.rappler.com/nation/philippines-lack-scientists-bam-aquino

Ruchina, A., Kuimova, M., Polyushko, D., Sentsov, A., Jin, Z. (2015). *The Role of Research Work in the Training of Master Students Studying at Technical University.* Procedia – Social and Behavioral Sciences. 215. 98-101. 10.1016/j.sbspro.2015.11.580.

Sancar, T., Hatice, B., Meltem, H., and Fadde, P. (2013). *Applying the Context, Input, Process, Product Evaluation Model for Evaluation, Research, and Redesign of an Online Master's Program*. International Review of Research in Open and Distance Learning. 14. 273-293. 10.19173/irrodl.v14i3.1485.

Seymour, E., Hunter, A.B., Laursen, S.L. and DeAntoni, T. (2004). *Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study*. Sci. Ed., 88: 493-534. doi:10.1002/sce.10131

Sharma, K., Sharma, Y., Mantri, A., and Sharma, R. (2020). *Inculcating the spirit and passion for research among Engineering students at Undergraduate level.* Procedia Computer Science, 172: 488-493. https://doi.org/10.1016/j.procs.2020.05.162.

Tan, E. (2011). *"It takes two to tango:" The language of research mentoring. The Asian Journal of Educational Research and Synergy, 3(1)*. Retrieved from http://ejournals.ph/form/cite.php?id=1147

Thurab-Nkhosi, D. (2019). *The Evaluation of a Blended Faculty Development Course Using the CIPP Model*. International Journal of Education and Development using Information and Communication Technology, 15(1).

Understanding Research. (n.d.). Retrieved from http://www.etu.org.za/toolbox/docs/development/research.html

Wayan, M.A. (2018). *Status of research and development in the Philippines.* Retrieved from https://www.pressreader.com/philippines/ sunstarbaguio/20181012/281629601233514

Zydney, A.L., Bennett, J.S., Shahid, A. and Bauer, K.W. (2002), Impact of Undergraduate Research Experience in Engineering. Journal of Engineering Education, 91: 151-157. doi:10.1002/j.2168-9830.2002.tb00687.x