Faculty-student partnership in conducting chemical engineering undergraduate research projects: The UPV-SBIRG experience

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Highlights

- Small Budget In-house Research Grant (SBIRG) is a unique UPV funding model for undergraduate researches promoting cooperation between faculty, students and the administration
- Chemical engineering program of UPV has been an active recipient of SBIRG
- SBIRG provides students topic flexibility including selecting advanced fields of researches
- Junior faculty members without personal grants can apply for SBIRG to implement research proposals together with students
- SBIRG-funded ChE studies have been shown to be productive in delivering research output

Abstract

The conduct of research in institutionalized courses like thesis and special problem is an important aspect of engineering education. This develops the students' research abilities training them to become critical thinkers and problem solvers – skills required in the practice of engineering as a profession. However, in the conduct of researches, students belonging to lower income brackets are burdened due to the high cost of performing experiments from reagents and glasswares acquisition to the characterization, analysis, design and fabrication of prototype equipment. To address this problem, in 2013, the UPV administration through the Office of the Vice Chancellor for Research and Extension, implemented a funding model exclusively for undergraduate researches. The Small Budget In-house Research Grant (SBIRG) aims to provide financial assistance to undergraduate researchers while at the same time foster research partnership between faculty members and students. The SBIRG not only helps students satisfy course requirements, but also provides them opportunity in the research dissemination such as co-authorship of SBIRG-funded papers and funding to research conferences where papers are accepted. The chemical engineering program (ChE) of the School of Technology has been an active recipient of the SBIRG. Based on the data gathered, SBIRG allows ChE students certain level of flexibility in terms of topic selection. SBIRG-funded ChE studies have also shown to be productive in contributing to the UPV research portfolio in the publication and presentation of SBIRG-funded studies in local and international conferences. Furthermore, junior faculty members without personal project grants can apply for SBIRG and work together with students to implement research proposals. Although there are aspects where SBIRG can still be improved, it has been demonstrated to be a helpful funding window not only in financing ChE student researches but also in incentivizing faculty members to do research and foster research culture in the School.

Key Words: Small budget in-house research grant; chemical engineering; undergraduate research

1. Introduction

An integral component of engineering education is the conduct of formal research in courses such as thesis and special problem. Several goals of performing research include training students to identify significant potential research problems, exhibit critical thinking skills in designing research experiments, conduct appropriate data gathering methods, process and analyze experimental data, prepare research reports and exemplify high ethical standard in experiments and paper writing. Conducting research have been shown to be beneficial in terms of enhancing cognitive and personal skills of students including

improvement in speech communication, literature analysis and having clear career goals (Zydney et al., 2002). Additionally, it has been demonstrated to increase students confidence in their research skills and improve their awareness of the environment in graduate school (Russell et al., 2007).

The initial crucial step in research is the selection of potential topic. ChE students in particular, are exposed to different fields of study including but not limited to water resource and conservation, wastewater treatment, air pollution, solid waste management, energy conservation and management, fuels, nanotechnology, food science, equipment design, treatment processes and many more. Because of this, many students want to explore various potential research problems in different disciplines and pursue topics related to their personal interest.

However, in crafting research proposals, an important consideration is the financial capacity of the researchers. This limits the choice of topics especially for financially challenged students. They are often forced to choose topics that are not in line with their interests. This results to students being discouraged in proposing research problems that they like and conduct studies they may have little interest in doing. Additionally, students are sometimes required to limit the scope of the research such as reducing variables in the study or removing important analysis due to personal financial constrains. This is a problem because it significantly affects the quality of the results.

Funding researches specifically for thesis students is a problem experienced by faculty members also. As an alternative to students funding their own research, faculty members usually adopt students in their own projects and use their faculty grants to cover the cost of raw materials, reagents and analysis of the students' thesis. While admirable, students are often presented with limited topic under a particular faculty due to the nature of the grant. There are also limitations to the number of students each faculty can supervise. Departments sometimes struggle with assigning thesis students to faculty members due to the huge number of students taking thesis courses and the low number of faculty members with grants compared to the number of students each can accommodate. Therefore it is common practice that even junior faculty members are assigned as advisers to thesis students. The problem with research funding then becomes more evident because in most cases, junior faculty members have yet to secure their own grants or start their own projects. For departments offering Master's and Doctoral courses, thesis students can sometimes be adopted by graduate students to cover the cost of reagents, glasswares and analyses. However, a lot of universities have yet to include graduate studies in their programs. For example in the University of the Philippines Visayas (UPV), the only engineering program offered currently is the undergraduate chemical engineering program.

Additionally, universities strive to improve not only their teaching performance but also their research portfolios. UPV in particular, highlights the importance of the university as a research university. Therefore, there is a need to incentivize students, faculty and research staff to conduct high quality research, publish in peer-reviewed journals and increase UPV visibility in more local and international research conferences through oral or poster presentation. Moreover, having strong undergraduate research program can help the university in terms of improving its reputation towards prospective students and developing alumni and community networks (Hoffman, 2009).

To provide solution to these problems, the UPV administration through the Office of the Vice Chancellor for Research and Extension (OVCRE) started offering the Small Budget In-house Research Grant (SBIRG) in 2013, a funding window for faculty members to finance researches exclusively for undergraduate students taking thesis and special problem courses.

The aim of the SBIRG is threefold. Primarily, it aims to allow faculty members handling research courses to finance the study of the undergraduate students regardless of the scope of the topic but subject to a

screening process. This means that under the SBIRG model, faculty members can propose researches in wide variety of topics. For ChE junior faculty members in particular, this is a welcome opportunity due to the nature of the extensive disciplines overlapping with the course. Secondly, the SBIRG encourages faculty members to do research by giving financial incentives after successful completion of a study by publication in a peer-reviewed journal or through a patented technology. Lastly, the university benefits through fostering a research culture inside the campus reflected in more paper outputs of faculty members and chemical engineering students.

In this paper, the rationale, application and implementation process of the SBIRG is presented. The impact of this unique funding model in supporting researches in the chemical engineering undergraduate research program of the School of Technology (SOTECH), UPV is also discussed. Finally, the experiences of faculty members benefitting from SBIRG is also presented.

2. The SBIRG model

Until 2012, UPV has four (4) research funding windows. These are the Thesis/Dissertation support grant, the Regular in-house research grant, the Mentored research grant, and the Leveraged research grant. None of the four however, explicitly caters to undergraduate students in the conduct of their thesis. Additionally, because most programs such as in the chemical engineering require students to perform research experiments, students who are financially challenged experience difficulties in covering for the cost of the experiment.

In 2013, then Vice Chancellor for Research and Extension Dr. Ricardo P. Babaran, proposed the Small budget in-house research grant (SBIRG) and approved by the UPV Executive Committee. For effective implementation, the SBIRG guideline was revised in September 2014. SBIRG seeks to mobilize research funds for use by undergraduate students with courses in Special Problem or Undegraduate Thesis, enhance the capacity of faculty members to cater to the needs of their students, and maximize the outputs from funded research projects. More than just a financial grant, the aim of the SBIRG is also to improve faculty-student partnership in doing research and incentivizing faculty members with honoraria for research outputs such as paper publication or patented technology. The benefits of the SBIRG model for students, faculty members and the university is presented in Figure 1.

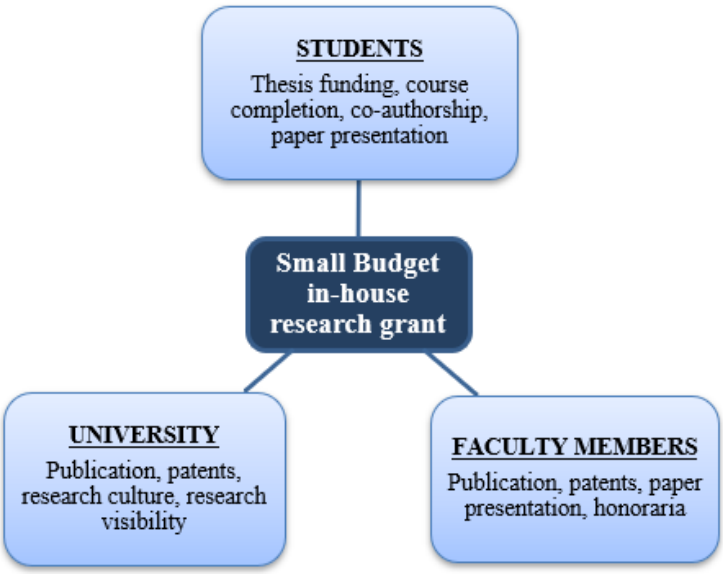

Figure 1. The benefits for students, faculty members and the university through the SBIRG.

The students are also included as co-authors in papers or funded in research conferences if papers as a result of the SBIRG are accepted. The funding model also serves as an avenue for training students in designing researches, preparing budget research proposal, enabling students to perform the research topics of their interest and develop their skills in research. The funding model provides opportunity to students who want to apply the concepts in development of a design, processes and products that can be useful in the community.

3. SBIRG application and implementation

The SBIRG application process starts during the 1st semester of the Academic Year in August, with faculty members drafting research proposal for two to three groups of students as his/her advisees. The faculty members can consult and involve the students in creating the proposal so that there is balance between the expertise of the faculty and the interests of the students. Then, after all the paperwork has been properly accomplished, the proposal is referred to the Research Committee of the units. In SOTECH, the advisees of ChE faculty members with SBIRG application, present their proposal to the SOTECH Research Committee composed of faculty members of the School. A representative of the OVCRE is also present during the proposal review. The committee will then evaluate, comment and provide constructive criticisms in order to improve the proposal. After submission of revised proposal and all other forms to the OVCRE, a contract is signed between the faculty, students and the OVCRE. The contract stipulates the responsibilities of the researchers, the amount of financial support, required output and incentives for the researchers. A brief summary of the application process is presented in Figure 2.

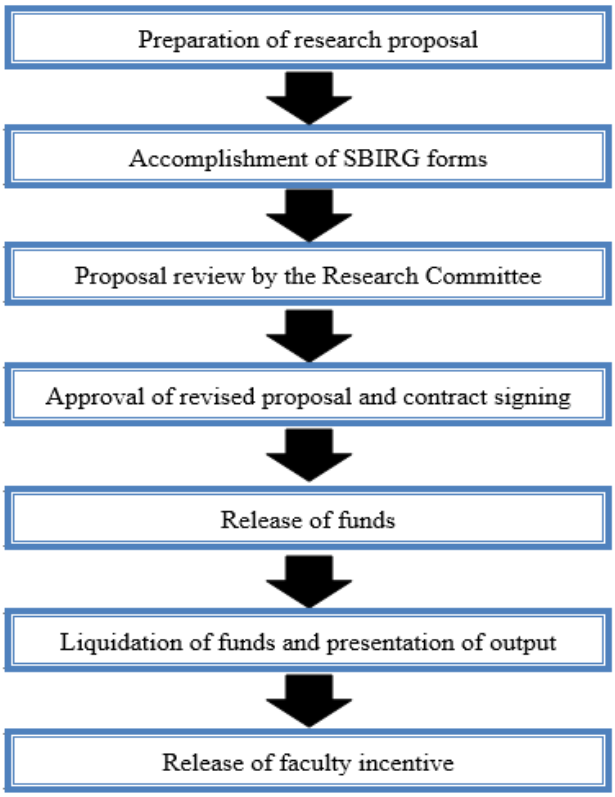

Figure 2. Process flowchart of the application and implementation of SBIRG-funded studies.

The faculty members and thesis students are expected to conduct researches within their discipline and the required outputs include successful completion of mentored students and either of the following: (1) accepted manuscript in a peer-reviewed journal or as part of proceedings, (2) patented technology, or (3) copyrighted product. Ressearchers are also expected to properly liquidate all financial disbursements. For the OVCRE, the SBIRG provides a maximum of Php 100,000.00 per faculty for an academic year. Out of this amount, a maximum of Php 50,000.00 is provided for the conduct of student research. Typical allotment per group is Php 15,000.00 for each of the 3 groups. The faculty can apply for the remaining Php 5,000.00 under justifiable reasons. The other Php 50,000.00 serves as honoraria for the faculty after successful completion of the required outputs.

4. SBIRG in UPV undergraduate ChE research

In the conduct of ChE special problem researches, the research course sections (ChE 198: Special problem) are assigned to faculty members depending on the total load of the program for a particular semester. Table 1 shows the breakdown of research students assigned per section for the past 5 years. Data was taken from the Computerized Registration System of UPV with databank for enrollees of all courses and sections taken in UPV since 2007.

Table 1. Number of UPV ChE 198 students per section for the past 5 years.

	A.Y.2018-2019	*A.Y.2017-2018*	*A.Y.2016-2017*	*A.Y.2015-2016*	*A.Y.2014-2015*
Section 1	13	12	17	16	10
Section 2	15	14	17	11	11
Section 3	-	-	-	-	12
TOTAL	**28**	**26**	**34**	**27**	**33**

There are various methods in how undergraduate research can be implemented. This includes the apprenticeship model where students work under the supervision of an academic staff and work with problems generally under the expertise of the staff; and the industry project model where students work on complex problems they are more likely to come across with as they practice their professon (Zimbardi and Myatt, 2014). The model practiced in the School is close to the apprenticeship model where each section is assigned to a faculty member who will serve as the adviser of the students. The students are then divided with 3 to 4 students in a group. This is to improve the quality of faculty mentoring per group and to reduce research costs charged per student. In consultation with their adviser, the students will then choose their research problem. Co-advisership with other faculty members not teaching ChE 198 is also practiced.

The ChE program of SOTECH currently has 5 active faculty members excluding substitutes and faculty on study leave. Among the active faculty members, 3 have experience applying for SBIRG for thesis students. Table 2 shows a summary of the faculty members and their highest educational attainment.

Table 2. UPV ChE faculty profile as of A.Y. 2019-2020.

Highest educational attainment	No. of faculty
Ph.D.	3
DiSDS	1
M.S.	1
M.S. (study leave)	1
Substitute	2
TOTAL	**8**

Among the 5 active faculty members, 2 have not applied for SBIRG due to various reasons. In terms of faculty loading, only 2 to 3 sections of ChE 198:Special problem are offered every first semester. This means that due to the limited sections, not all faculty members are assigned the research course. Hence, not all faculty members can apply for the SBIRG every year. Additionally, some of the faculty members can also accommodate the students in their own projects.

For those faculty members who have been awarded the SBIRG, Table 3 presents information on their SBIRG-funded research groups.

Table 3. Information on ChE SBIRG-funded researches including required outputs.

	Student research groups since 2014	*SBIRG funded groups since 2014*	*Average funding per group (Php)*	*SBIRG funded studies published as of Aug. 2019*	*SBIRG funded studies presented (oral or poster)*	*SBIRG funded studies with pending utility model application*
Faculty 1	4	3	15,000.00	1	2	-
Faculty 2	6	6	15,000.00	2	3	-
Faculty 3	8	6	15,000.00	2	3	2
TOTAL	**18**	**15**	15,000.00 (ave)	**5**	**8**	**2**

As presented in Table 3, 83.33% (15/18) of the student research groups have been funded by SBIRG of which 53.33% (8/15) of the studies have been presented in international and local research conferences. Additionally, 33.33% (5/15) resulted in publication in international and local peer-reviewed journals. Table 4 presents the classification of these publication.

Table 4. SBIRG-based researches in local and international publication since 2014.*

	SBIRG funded studies published as of Aug. 2019	*Local (peer-reviewed)*	*International (Web of Science or Scopus)*
Faculty 1	1	0	1
Faculty 2	2	2	0
Faculty 3	2	1	1
TOTAL	**5**	**3**	**2**

*The titles of the publication are listed in the reference section.

In both publication and presentation, faculty and students always serve as co-authors and the SBIRG funding is always acknowledged. For the students, the funding allows them not only to conduct research for course completion, but more importantly they are involved in the dissemination of the research work. In Table 3, there are also 2 pending utility model application due to the SBIRG funding.

The impact of the SBIRG on faculty research publication was measured by comparing the total number of publication of the active ChE faculty members and the number of SBIRG-based researches that resulted into publication. This is presented in Table 5.

Table 5. Impact of SBIRG on active ChE faculty research publication since 2014.

	Total publication	*Publication (SBIRG-based)*	*Percent of research publication that is SBIRG-based*
Faculty 1	2	1	50.0%
Faculty 2	3	2	66.7%
Faculty 3	3	2	66.7%
Faculty 4	7	0	0.0%

Faculty 5	4	0	0.0%
TOTAL	**19**	**5**	**26.3%**

As shown in Table 5, SBIRG-based publication contributed to almost 27% of the total ChE publication since 2014. SBIRG-funded ChE researches have been productive in delivering the required research output as envisioned in the SBIRG model, contributing to UPV publication and research portfolio.

Another aspect of the advantage of SBIRG is the flexibility in choosing research topics. The research topics funded by SBIRG vary greatly in discipline. Table 6 shows the various topics applied by ChE faculty members under SBIRG since 2014.

Table 6. Some of the research topics with approved SBIRG funding since 2014

SBIRG-funded research topics
1. Synthesis and characterization of silver nanoparticles and their application in heavy metal detection
2. Use of silver nanoparticles in the photocatalytic degradation of azo dyes in distilled and natural water samples
3. Treatment of oil contaminated water by organic sorbents
4. Removal of oil in contaminated water by synthetic sorbents
5. Evaluation and comparison of oil and water sorption capacities of inorganic materials for oil removal in contaminated water
6. Liquid product properties of pyrolyzed bamboo sawdust
7. Design and fabrication of a fine biomass carbonizer
8. Capacity of bamboo and sugarcane charcoal as adsorption media for NO_3 removal from fish processing wastes
9. Effect of ageing and activation on the porosity and NO_3 adsorption of bagasse charcoal
10. Development of a composite material using bamboo charcoal and waste sludger as substitute for sand and cement
11. Development of self-igniting briquette from water hyacinth (*Eichhorniacrassipes*) molasses blend
12. Effects of biochar, vermi-compost and Mycorrhiza amendments on soil quality and plant growth

One of the problems envionsed to be addressed by the SBIRG is the flexibility in the topic selection of students. Although there are no formal research laboratory groups in SOTECH, as presented in Table 6, student researches funded by SBIRG vary greatly in terms of scope. Furthermore, based on feedback with student researchers, emerging fields of studies such as nanotechnology are not topic of choice by many because of the high cost of characterization analysis. Although for a nanotechnology research, a Php 15,000.00 grant is not enough, it is an additional source of funding to augment student expenses. Additionally in terms of topic flexibility, faculty member with research concept in line with the research thrust of the School can form group of students who are interested in the topical concept. The students may do revision of the proposal but retain the original research concept. Faculty members can also advise students to use materials and chemicals within the bound or limitation of the research funds. Hence, the students are trained to be resourceful to find materials and chemical substitutes that can be used in their research procedures.

Since SBIRG has been one of the sources of funding for ChE undergraduate researches, there are plenty of feedback from both faculty and students on how the funding model can be improved. For instance, an increase in the study grant from the current Php 15,000.00 per group is most welcome. This is to meet the demands of more advanced researches including reagent purchase, analysis and instrumentation. There are also suggestions to increase discounted prices for UPV students in analysis of samples in UPV institutes. However, aside from relying only on the SBIRG, faculty members are highly encouraged to avail of funding and grants provided by the DOST and other national agencies and collaborate with other universities. Long term plans such as offering graduate programs and developing specialized laboratories

such as in energy, environment and other fields can attract more graduate students and funding which can further improve the research environment in the School.

5. Conclusions

In the researches of UPV ChE faculty members and students, since 2014, SBIRG funding resulted to 5 peer-reviewed publication including in Web of Science-indexed journals; 8 presentations in local and international conferences; and 2 pending utility model applications. Since 2014, SBIRG-based publication contributed to almost 27% of the total UPV ChE publication. In all these papers, both students and faculty serve as co-author and the university funding is acknowledged. Although there are areas for improvement, the SBIRG is an exemplary model for supporting student undergraduate research and at the same time foster cooperation between faculty members, students and the administration.

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References

Hoffman JR. Applying a cost-benefit analysis to undergraduate research at a small comprehensive university. Council on Undergraduate Research Quarterly. 2009; 30:20-24.

Russell SH, Hancock MP & McCullough J. Benefits of Undergraduate Research Experiences. Science. 2007; 316(5824): 548-549.

Zimbardi K & Myatt P. Embedding undergraduate research experiences within the curriculum: a cross-disciplinary study of the key characteristics guiding implementation. Studies in Higher Education. 2014; 39(2): 233-250.

Zydney AL, Bennett JS, Shahid A & Bauer KW. Impact of Undergraduate Research Experience in Engineering. Journal of Engineering Education. 2002; 91(2):151-157.

SBIRG-based publication

Almaquer FEP, Ricacho JSY & Ronquillo RLG. Simple and rapid colorimetric sensing of Ni(II) ions in tap water based on aggregation of citrate-stabilized silver nanoparticles. Sustainable Environment Research. 2019; 29:23.

Carnaje NP, Canabal E, Daut P & Leccio R. Effect of ageing and activation on the porosity and surface area of charcoal from sugarcane bagasse. Philippine Journal of Natural Sciences. 2014; 19: 1-12.

Carnaje NP, Talagon RB, Peralta JP, Shah K & Paz-Ferrerio J. Development and characterization of charcoal briquettes from water hyacinth (Eichhorniacrassipes)-molasses blend. PLoS ONE. 2018; 13:11.

de Guzman LC, Borja JD, Fernando JF & Gonzaga PRA. Removal of oil in contaminated water by synthetic sorbents. Philippine Journal of Natural Sciences. 2015; 20 (1).

de Guzman LC, Flame RRF, Maganto FDB & Magdaug RPM. Treatment of oil contaminated water by organic sorbent. Philippine Journal of Natural Sciences. 2015; 20 (2).