

# IN ACHIEVING THE MOST OF LIMITED RESEARCH BUDGET FOR ENGINEERING RESEARCH PROJECTS: A CASE STUDY AT SULTAN QABOOS UNIVERSITY

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**ABSTRACT:** Motivating engineering research in universities with limited or tight research budgets is a challenging task. There is always a conflict between researchers attempting to secure enough funds to ease their own research, and funding bodies and universities trying to achieve high quality research while lowering research expenses. This conflict leads to a situation where universities and researchers cannot achieve their goals altogether. This study attempts to partially resolve this issue by optimizing research expenditure for the benefit of both universities and researchers and suggests some policies regarding what type of research (modelling based or experimental based) universities should support. Other factors related to the components of research expenditure (effect of local and international collaboration, hiring research assistants (RAs), establishing research laboratories, and buying professional engineering software) are also considered.

**Keywords:** Research expenses; Research budget; Research fund; Research collaboration; Research types.

## تحقيق الأفضل من المشاريع البحثية الهندسية في ظل ميزانية محدودة: دراسة حالة بجامعة السلطان قابوس

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**المخلص:** يعد تحفيز البحوث الهندسية في الجامعات - ذات ميزانية بحث محدودة أو صغيرة - مهمة صعبة للجامعات. هناك نوع من الصراع الدائم بين الباحثين الذين يحاولون الحصول على الدعم المادي لإجراء بحوثهم العلمية بسهولة ويسر، وبين هيئات و جهات التمويل والجامعات التي تحاول تحقيق أبحاث عالية الجودة مع خفض نفقات هذه الأبحاث. يؤدي هذا الصراع إلى وضع لا تستطيع فيه الجامعات والباحثين تحقيق أهدافهم البحثية في أن واحد وجميعاً. وتحاول هذه الدراسة حل هذه المشكلة جزئياً من خلال التوجيه الأفضل لميزانية البحث العلمي بحيث تخدم كلا الطرفين: الجامعات والجهات الممولة من جهة والباحثين من جهة أخرى. كما تقدم الدراسة بعض المقترحات الإجرائية المتعلقة باختيار البحوث المناسبة للدعم المادي في ظل ميزانية دعم محدودة، وهذه المقترحات تتعلق بعدة جوانب منها: اختيار نوعية البحث (اعتماد البحث على التجارب العملية أو على النمذجة والمحاكاة والتصميم الرياضي)، التعاون المحلي والدولي، توظيف مساعدي البحوث، شراء أجهزة اختبار علمية، وشراء البرامج الهندسية المتخصصة.

**الكلمات المفتاحية:** منصرفات البحوث العلمية؛ ميزانية البحث العلمي؛ الدعم المالي للبحوث؛ التعاون في البحوث العلمية؛ أنواع البحوث العلمية.

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## 1. BACKGROUND AND OBJECTIVES

Universities in general rely heavily on public funds to support their research expenditure. The Federal government of the United States, for example, spends billions of dollars each year to support R&D at universities and that huge amount of money still does not cover what these universities actually spend on R&D (Evan 2017 and Daridah 2014). As a result, universities still have to spend on researchers from their own resources. In many cases, universities all over the world are facing more restrictions on getting public fund for their research (Faridah 2014). Regardless of the amount that universities contribute to the research from their own resources, that fund should be spent wisely and efficiently (Paul and Beth 2014). There is an important fact that is usually overlooked which is, universities and researchers do not share the same view on research and its expenditure. Universities attempt to spend less on research while seeking to have a large revenue from it. Conducting a large amount of high quality research makes universities more reputable and can attract more postgraduate students, and funds from both public and private sectors. On the other hand, researchers seem to care less about the research expenses as long as they can secure funds for their research. The tendency of most researchers is to publish in highly reputed journals (Bennis 2005, Elisha 2018) and there is evidence that professors and researchers mainly publish to obtain different academic rewards such as promotion (Rajaeian 2018) and joining a better institutions and universities. These two different objectives of conducting research, make it hard to balance research funding against research expenses. Research spending in engineering is related to the cost of carrying out the research itself (such as equipment, experiments, software, etc.) and the cost of hiring researchers to conduct it. This paper attempts to investigate some factors that can lead to research satisfaction for both researchers and universities. These factors include whether universities with limited research budgets should focus on modeling or experimentally based research, and how they would distribute available funds among research projects. Questions include: whether it is better for universities, with limited research budgets, to fund a large number of less costly research projects or whether they should focus more on the quality of the research regardless of its cost? Is it advisable for universities to focus more on local or international collaboration? How can universities optimize their spending between hiring researchers, buying professional engineering software, and establishing or improving labs for experiments? The objective of this paper is to address the aforementioned points. Sultan Qaboos University (SQU) is considered to be one of the highly reputable universities in the region and it is very much concerned with its research progress. The questionnaire on which this study is based was carried at SQU Department of Mechanical and Industrial Engineering.

## 2. SURVEY METHOD AND RESULTS

The questionnaire used in this study was developed by the author in English and it was distributed to the entire academic staff at the Department of Mechanical and Industrial Engineering of Sultan Qaboos University (SQU). The questionnaire was handed in person to the target group. Two questionnaires were prepared for each staff member, one to measure the impact of a conference research and the other is to evaluate the impact of a peer-reviewed journals published research. 28 of the 29 academic staff responded successfully to the questionnaire – each staff member completed the two questionnaires-with an almost 97% response rate, and 54 questionnaires were collected. Some follow-up attempts were made to ensure this high response percentage, and all the staff members who received the questionnaire showed a willingness to participate. Every staff member was given two questionnaires, one of which is concerned with research that has led to a recent publication in a peer-reviewed journal, and the second is about recent research that has led to a conference publication. The author referred to the recent publications lists (2016 and 2017) of the Department of Mechanical and Industrial Engineering and picked one journal paper and one conference paper for almost each staff member. Since the questionnaire requires knowledge about the research details (such as cost and funding, collaboration, people involved, etc.), the author selected only those papers in which the researcher was the first author. The questions were clear and direct as shown in Table 1 (see Appendix).

## 3. RESULTS AND DISCUSSION

The overall summary of the results is presented in Fig.1 and each factor is discussed separately in the following subsections

### 3.1 Modeling-Based Vs Experimental Based Research

Modeling-based research is the research that was carried out only at the modelling, mathematical, and/or simulation level, without experimental verifications of the results. Mathematical based modelling seems to be underestimated in many cases and almost the whole weight is given to experimental results which are not always true. A model might be needed, however, to interpret data or to confirm or reject a hypothesis via generating predictions and they are essential to the experimental analysis (Mazur 2006, and Mobius and Laan 2015). They can also be used to predict or control responses (Mazur 2006). When there is not enough budget to carry out experimental work, researchers have no other choice than focusing on modelling-based research. Although research that is only modelling-based is usually cheaper to conduct, on the other hand researchers are usually unable to publish their results in a highly reputed journal and that might also affect their promotion. Most reviewers in reputed journal ask for experimental verification of the modelled results. It can be noticed from the survey results (Fig.1.a) that

a large portion of the research was only based on modelling (almost 37%). On the other hand, the low cost of modelling based research can be proved by checking the cost of this type of research. 36.8% of this research type cost less than OMR 100 (compared to only 15% in the experimental based research) and almost 63% of the modelling based research cost below OMR 2000 (compared to only 40% in the purely experimental based research). Modelling based research usually requires design or analysis via professional engineering software. It is found that 36.8% of modelling based papers used software that was not provided by SQU. This indicates that SQU should increase college budget in purchasing engineering software which will increase the number of this type of research. Another point that was noticed from the survey results is that 63% of the modelling based research involved research assistants and postgraduate students which will definitely, and unnecessary, increase the cost of this type of research. Common practice in universities is to involve research assistants and postgraduates in practical research and/or in creating new research kits that could further lead to a more experimental-based research. Staff can conduct their modelling research on their own provided that enough training is provided for the staff about the particular engineering software that they are interested in.

### 3.2 Level of Collaboration

Findings from a dataset on all the researchers from the engineering departments in the UK in the past 20 year, showed that research collaboration with industry not only benefits knowledge transfer, attracts funds for research, and increases economic impacts, but it also positively affects the rate of publication for researchers (Bonet *et al.* 2008). On the other hand, international collaboration with other universities and research groups may indicate negative issues like resource dependence, less research experience for needing help, and high concern of researchers to advance their own career. It may also indicate that collaborators are working in a narrow or very specialized fields (Iglić *et al.* 2017).

There is evidence that the rate of publication increases within a certain threshold of collaboration between researchers and industry, but too much collaboration will have a negative impact on the rate of publication. This section investigates issues related to conducting research such as, availability of research equipment and research assistants and postgraduates. The survey shows that a large portion of the research conducted (almost 63%) was experimentally based, and almost only half of these experiments (53%) were conducted inside SQU labs (Fig.1.b). This is a good sign of research collaboration in terms of conducting research outside SQU labs (inside and outside Oman). The results also show that most of these experiments that involved external collaboration were carried out with

international institutions (87%) and only 13% were carried out inside Oman, but not in SQU. These results obviously show dependence on external international resources and low collaboration within Oman. Even though international collaboration is recommended sometimes to attract more research funds, SQU should have their own laboratories to attract local and regional companies. In terms of research human resources, surprisingly the survey showed that 35.3% of the experiments were conducted by the professors themselves without any help of research assistants and postgraduate students. This will inevitably affect teaching quality and other duties of the professors and put more burdens on them.

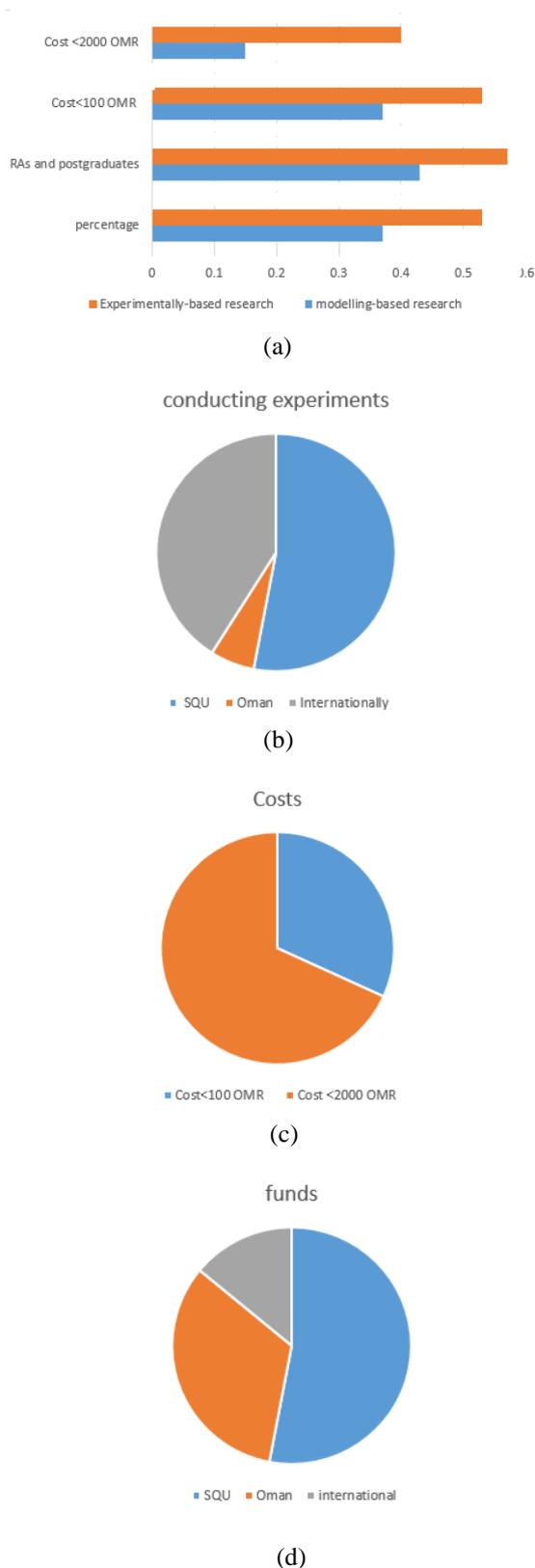
### 3.3 Costs Versus Funds

One of the main factors to consider is the research cost, so we should not treat projects that cost hundreds of thousands with those which cost only a few, or tens of thousands. Since research funds are limited in most cases, is it advisable to distribute the available fund to a larger number of research projects or spending it all in a lower number of research projects. The results in Fig.1.c show that almost 28% of the research is conducted at almost no cost (less than OMR 100) and nearly 60% of the research is conducted at a low cost (less than OMR 2000) which also indicates that a large portion of the research can be carried out at a very low cost. Hence, SQU can accommodate more research with the same budget.

The availability of research funds greatly affects both the quality and quantity of research produced. Universities always strategically plan to attract more external funds for research than using their own budget to fund research. With this in mind, the survey shows that more than half of the experimental research (53%) was funded by SQU, compared to 33% funded by local bodies in Oman (Fig.1.d). International bodies and institutions funded only 14% of the research. On the other hand, when comparing the modeling-based research and experimentally-based research, one expects that experimental research costs more but the results indicate that both experimental and modeling based research receives the same number of funds from SQU.

### 3.4 Level of Involvement of RAs and Postgraduate Students

Additional research cost comes from employing Research Assistants (RAs) and offering postgraduate scholarships, but it is obvious that the availability of research assistants and postgraduate students improves the quality as well as the quantity of research conducted. Even though, it is expected to see more RAs in experimental-based research, the result showed little difference between the two types of research (43% of the modeling-based research employs RAs as opposed to 57% in the experimentally based). When looking at both the RAs and post graduates involved in the research, it can be noticed from the results



**Figure 1.** Summary of the results (a): modeling-based vs experimental based research, (b): conducting research (c): research cost, (d): research fund.

that 63.2% of the modelling based research involved RAs and postgraduates as opposed to 64.5% of the experimental based research. Again, it is expected that the former should have much less percentage.

#### 4. CONCLUSION

Conducting good quality research is always a challenge that faces most universities, subsequently it is of major concern for researchers and faculties at universities. The main barrier from conducting high quality research is the limit in budget. Below are some recommendations based on observations from this study.

Universities with tight research budgets should give more attention to modeling-based research, which is normally cheaper to conduct than experimental research. The results show that this can reduce research expenses by 60% to 37%.

To achieve the aim of the above point, universities have to invest more in purchasing necessary engineering modeling software and to provide full training for the staff and researchers so that they can carry their research independently. This should reduce the cost associated with hiring RAs or giving scholarships for postgraduates.

To encourage researchers to publish modeling based papers, universities should avoid giving high value for publishing in a very highly reputable journals specially when promoting staff.

The results also recommend reducing unnecessary this appointments of RAs in modeling type research as it should be more limited to experimental based research.

The results also indicate clearly the high level of collaboration between SQU and international institutions compared to local collaboration. This scenario should be completely reversed through investing in research that is more relevant to local industry in Oman. A great portion of the university research budget can be allocated to establish new research infrastructure relevant to local industry. International collaboration is still needed to continue but it could be more limited to modeling based research as opposed to experimental research.

The results also show the high engagement of academic staff in conducting research experiments themselves. This issue can be tackled by directing RAs towards experimental research type.

The survey also shows that many research projects can be conducted by the staff at low cost. Hence, it is recommended - for certain allocated research budgets to increase the number of funded research projects while reducing the fund share for each project. This can also be achieved by distributing the fund of costly research projects into a larger number of less costly projects. In other words, universities should fund lower cost research rather than giving large funds to fewer

projects.

The results also suggest that the number of researchers and research projects can be increased by investing more in buying professional research software while providing sufficient training for the staff.

Following the above recommendations should definitely lead to involving more staff in research and/or involving staff in more research.

## CONFLICT OF INTEREST

The author declares no conflicts of interest.

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## Appendix A

Table A.1 Survey categories and questions.

Category	No.	Question
Type of research and publication	1	What is the type of research? Modelling based Experimental based Both
	2	Where the results were published? 2.1 peer-reviewed journal 2.2 conference proceeding
Availability of resources	3	If experimental data are used, what is the source? 3.1 Literature or no data was used 3.2 experiment carried at SQU 3.3 experiment carried outside SQU
	4	If any software used in the research, is it provided by SQU or not? 4.1 Yes 4.2 No
Availability of research assistants and postgraduates	5	What is the number of research assistants and postgraduates (if any) involved in the research with SQU? 5.1 MSc students (No.= ?) 5.2 PhD students (No.= ?) 5.3 Research Assistants (No.= ?)
Level of collaboration (locally and internationally)	6	Was there any collaboration with other universities or individuals? 6.1 None 6.2 within department 6.3 within SQU 6.4 Regional 6.5 International
Research cost and funding	7	What is cost for the research (rough estimation)? 8.1 0 to 100 in OMR 8.2 100 to 1000 8.3 1000 to 2000 8.4 2000 to 5000 8.5 5000 to 10,000 8.6 more than 10000
	9	Have you received any fund for the research from? 9.1 SQU, percentage of fund to cost = ? 9.2 Local bodies in Oman, percentage of fund to cost = ? 9.1 Bodies in Gulf region, percentage of fund to cost = ? 9.1 International bodies, percentage of fund to cost = ?

## Appendix B

Table B.1 Questionnaire response table.

	Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10
<b>journal papers</b>	11(1)	11(1)	7(1)	13(no)	4(1,1)	6(1)	4(1)	8(1,100)	14(1)	11(1)
	3(2)	6(2)	6(2)	13(yes)	3(2,1)	3(2)	3(2)	4(2,100)	2(2)	3(2)
	2(3)	7(3)	5(3)		8(3,1)	1(3)	3(3)	3(1&2, 100)	5(3)	5(3)
	4(4)	2(mix)	2(mix)		1(3,2)	6(4), 8(5)	5(4), 7(5), 3(6)	2(4)	4(4)	0(4)
	6(mix)		6(no)		10(no)	2(mix)	1(no)	1(1,4)	1(mix)	7(mix)
								8(0)		
<b>conference papers</b>	9(1)	8(1)	5(1)	14(no)	1(1,1)	7(1)	7(1)	9(1,100)	18(1)	17(1)
	7(2)	12(2)	9(2)	14(yes)	2(2,1) 1(2,2)	11(2)	8(2)	7(2,100)	2(2)	4(2)
	1(3)	8(3)	3(3)	-	10(3,1)	2(3)	3(3)	1(3, 100)	4(3)	3(3)
	6(4)	-	3(mix)	-	1(3,3)	3(4), 2(5)	2(4) 3(5) 2(6)	1(4)	3(4)	1(4)
	5(mix)	-	8(0)	-	1(mix) 1(0)	3(mix)	3(0)	10(no)	1(mix)	3(mix)

*Table keys:*

Q = question number in Questionnaire

x(y) = number of participants who chose answer (y)

(p,q) = multiple answers

mix = participants selected multiple choices

(0) = no or participants didn't answer

Q.5 = sum (postgraduates, RAs)

Q.8 = sum (funding body, percentage of fund)