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AUTHOR(S)

Ritesh M. Pabari

CITATION

Pabari, Ritesh M. (2016): Development and implementation of research placement programme for the organisations undergraduate students in the research group.. Royal College of Surgeons in Ireland. Thesis. https://doi.org/10.25419/rcsi.10813805.v1

DOI

10.25419/rcsi.10813805.v1

Development and implementation of research placement programme for the organisations undergraduate students in the research group

Ritesh M. Pabari BPharm, MSc (Pharm Tech), PhD

A Dissertation submitted in part fulfilment of the degree of MSc in Leadership (2014-2016), Institute of Leadership, Royal College of Surgeons in Ireland

2016

Student ID: 06178626

Submission Date: 12th May 2016

Word Count: 16,473

Facilitator: Liam Duffy, Chief Executive, Beaumont Hospital, Dublin, Ireland

Ireland

RCSI Reservoir House,
Ballymoss Road,
Sandyford,
Dublin 18,
Ireland.

Bahrain

PO Box 15503,
Building No. 2441,
Road 2835,
Busaiteen 436,
Kingdom of Bahrain.

Dubai

4th Floor A/P25,
Dubai Healthcare City,
Dubai,
PO Box 505095,
United Arab Emirates

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Declaration:

"I hereby certify that this material, which I now submit for assessment for the Project Dissertation Module on the MSc in Leadership is entirely my own work and has not been submitted as an exercise for assessment at this or any other University."

Student's Signature(s): Ritesh Pabari

Date: 12-05-2016

Student's Number (s): 06178626

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Acknowledgements

I wish to thank the programme directors, lecturers and colleagues at the Institute of Leadership, and my colleagues at work who supported the change described in this project.

I also wish to thank Lynda, Mum, Dad, my siblings and in-laws for their support and patience.

Abstract

Aim: The aim of this research project was to develop the organisation's undergraduate (UG) student research skills and maximise the productivity and outputs within the research group. **Rationale:** Productivity and research outputs are known to be directly proportional to the size of the research group. The development of both undergraduates research skills and group's research performance is in line with the organisations vision and mission statement. **Change Process:** HSE model was used; the stakeholders were involved at all the levels within the group, through all the stages of change. **Evaluation:** The objectives were evaluated by using qualitative comparison against the standards, whereas training was evaluated by the Kirkpatrick model and the project as a whole was evaluated by CIPP model. **Results:** Results showed that the UG students, with extended training period of 1.5 weeks were able to successfully apply their training, and the data generated by the student under supervision and with minimal supervision was found to be robust. Thus this data would form part of the PhD thesis and culminate into a research paper, resulting in a quick research publication. The research group acknowledged the co-supervisory experience gained. Feedback from the students demonstrated that their research experience have resulted in nurturing skills such as innovative thinking which will contribute to their success as undergraduates, and will aid in their career development. **Conclusion:** The recruitment of UG students within the research group proved to be advantageous to the UG student, the research group and the principal investigator (PI).

CHAPTER 1: INTRODUCTION

1.0 Background

In an academic setting Principal investigators (PIs) require research grants in order to continue high-level cutting-edge research within their group. Successful research grant applications depends on a number of factors including the quality of the research project proposed by the applicant i.e. the PI, as well as PI's research paper publication record. Published research papers in reputable journals reflect research findings and thus demonstrate successful research activity within the PI's research group. The research paper publication record and citation record of the PI is a measure of the impact and relevance of their research.

Productivity of the research group in terms of published research papers is known to be dependent on the size of research group (Cummings et al., 2013). The large size of the research group could be advantageous and reflects more resources in hand to complete the planned tasks, in other words, parts of the task can be distributed among the members of the research group, thus potentially resulting in higher productivity. Moreover, since each member of the group would perform part of the task, the stress levels is expected to be lower, potentially resulting in efficient planning and high-quality research outputs as research publications.

PI's can increase the size of their research group by virtue of a successful grant application. Another way PI can increase the size of their research group is by recruiting my academic organisations undergraduate (UG) student for a 6-8 week research project. In my organisation, the UG students have to carry out a mandatory 6-week research project as part of the requirements of their UG curriculum. Consequently, every year the PI of the research group has an opportunity to take on UG students for their research project. This includes Pharmacy and Medical students who have to undertake research projects as part of their UG curriculum in their final Year (Senior Cycle 1 (SC1)) and third year (Student Selected Component (SSC)), respectively. In addition, my organisation runs Research Summer School (RSS) every year where UG students are provided with an opportunity to build their research skills by working on 8-week research project in PI's group during the summer.

However, some PI's and research group would show resistance with the idea of taking on a UG student for a 6-8 weeks research project given the considerable

amount of time it would take for the research group to train the UG student(s) in their research projects. Moreover, PI and research group are concerned that many a times the data generated by the UG students might not form a part of the PhD student's project and neither culminates into a paper, therefore resulting in the waste of time, efforts and resources during the 6-week student project. In addition, the other concern is that at times after the project has started the student may not be as enthusiastic to work on a lab based research project as they were while choosing the research project in our lab, which may significantly impact the quality of data, productivity and research output from the UG students project.

1.1 The proposed project that will be implemented (incl. aim and objectives)

I propose in my organisational development (OD) project to recruit organisations UG student in our group, and I will design the research project in line with the project of our research group so that the data generated by the UG students during their 6/8-week research projects complements the research groups data, so that the data generated by the research group and UG student can together culminate into a research paper. Training the UG student will be scheduled around the research group's availability and in line with their work so that the training occurs while the research group is doing their own work. Inclusion of the UG student for the 6/8 week project would mean larger size of the research group which will help in generation of research data in a relatively short time-frame for a research paper, which will be advantageous to the PI as well as the research group. In addition, my organisations UG student can also gain worthwhile lab based research experience while they work on this 6-week research project as part of their UG curriculum. Moreover, this is in line with the organisations mission: To promote and support research that enhances the quality of organisations health science. A survey carried out by Houlden et al (Houlden et al., 2004) reported that a mandatory research elective carried out by medical students in their second year as part of their UG curriculum was beneficial in the development of their critical thinking skills which helped some students to pursue careers in medical research. Moreover, it has been proven that UG students when given a right platform have contributed to an invention in a scientific research lab. For instance, recently in the USA, teenage high school graduate students namely Angela Zhang from California (2011) and Jack Andraka from Maryland (2012) have

been instrumental in developing nanotechnology to treat cancer and an early detection test for three types of cancer, respectively (TED, 2013, TEDx, 2012).

Further advantages of this initiative to the PI/research group and the UG student(s) (generate buy-ins) is outlined in section 1.3. Potential threats to implementation of this initiative (potential resistance and hurdles) and potential resolution is outlined in section 1.6 of this chapter

The **aim** of the proposed OD project was to maximize productivity within the research group while fostering development of research skills of organisations UG student.

Objectives

1. Write SSC research projects in line with the standards for quality research as described by The National Research Council (Gersten et al., 2000, Greenhalgh, 1997, Shavelson and Towne, 2002, Ragin et al., 2004), and submit this to the stakeholders: group member(s) and supervisor for review by 31st October.
2. Submit the SSC research project, prepared in collaboration with the stakeholders and in compliance with the research group project criteria (Appendix II), to the UG project coordinator by 30th November.
3. Order all consumables and resources required for the smooth running of the project as identified as part of the project plan (Appendix III), by 31st December 2015.
4. Brief the SSC students on their research projects and allow time for the research student to put together a good quality literature review (Maier, 2013) about the project during the 1st week of the SSC project. At this stage use questionnaire method of data collection to measure enthusiasm of the UG student about the project (Appendix IV).
5. Train SSC project students on both, basic and advanced research methods in the 2nd week of the project, and statistical analysis in the 3rd week. In the 3rd week the student will work as per the project plan, under the supervision of the experienced member of the team.

6. During the weeks 4th-5.5th of the SSC project, student will proceed with the project as per the project plan with limited supervision to generate a good quality data.
7. SSC student will statistically analyse and present the data at the end of each week (week 4th-5.5th) during meetings with the research group (Calvert, 2009).
8. Last 0.5 week the student will write a quality report on the project, including data analysis and interpretation (Kockelman, 2008).
9. By March 2016, questionnaire method will be used to take the feedback from the students about their experience with working on a research project within our group (Appendix IV). Feedback will also be taken from the research group.

1.2 Organisational Context

In line with the organisational mission of commitment to educational excellence, UG students are given an opportunity to develop their research skills by providing €500-1000, to carry out research projects with the PI. This money is usually used for spending towards the consumables required to run the project. The PIs get an opportunity to take on UG students for their research projects throughout the year, as follows,

UG, 3rd year, SSC Medical student project: January – May

UG, 4th year, Pharmacy student project: October-November

Research Summer School student project: June-July

At the end of the projects, Medical and Pharmacy UG students are asked to produce a report based on their research outcomes and required to make a presentation on their research. The UG students are graded for this project which is added to the final marks for that UG year. This project accounts for 20% of their final 3rd year mark (10% for their report, 5% is for their presentation, 5% for Intro to SSC).

1.3 Rationale for selecting the project

This project will offer following advantages to the UG student on a research project, as well as to the PI's research group.

1.3.1 Advantages for the UG student on a research project

1. Given the publication record of novel patented technology and peer-reviewed research papers in leading scientific journals from our lab, UG students will learn various research techniques and contribute to complex research endeavours in finding answers for questions in the biomedical science.
2. Moreover, students will gain transferrable skills such as project planning, and data analysis, communication skills by participating in laboratory meetings, ability to work independently or as part of the team. When specific aspects of the project are beyond the capability or experience of the student, then this provides an opportunity for the student to learn and to receive direction.

1.3.2 Advantages for the PI's research group

1. The effort the research group puts in benefits them by return set of results that can contribute towards a publication and/or form part of the PhD student's thesis.
2. Collaborative efforts in generating data can possibly result in quicker generation of the data without compromising the quality of the data, which can possibly culminate into research publication for the research group, thus potentially contributing in availing more grant funding for the research group as well as for the organisation.
3. The researcher group can gain vital co-supervisory experience which can contribute to their career progression.
4. In the future the project could also be designed such that the student can develop a research method and Standard Operating Procedures, as part of their research project, which would be continued to be used and implemented by other members of the research team to generate data with this new method.
5. Funding of €500-1000, that comes with the student project would mean less economical pressure on research group's grant.

1.4 Role of the MSc student in the process

1. MSc (leadership) student will initially write and design a quality research project, in line with the research projects of the group, carry out stakeholder

analysis and submit the research project to the relevant co-ordinator of the UG projects.

2. Subsequently MSc student will put together a weekly schedule for the next 6-8-weeks of the UG student project. This weekly schedule will incorporate training of the UG student on various research methodologies and relevant equipment's, followed by daily experimental schedule.
3. MSc student will prepare relevant Standard Operating Procedures (SOPs) and protocols, and provide this to the UG student in advance of the work.
4. Once the research project starts, the MSc student will brief the project so that the UG student understands the goal and objectives of the research project.
5. MSc student will train himself or delegate a group member to train the UG student on various research methodologies associated with the project.
6. As and when required, MSc student will also provide support to the UG project students in carrying out complex experimental methodology
7. MSc student in collaboration with the PI will conduct weekly review meetings so that the progress of the UG research project can be determined
8. Finally feedback will be taken from the stakeholders, i.e. UG students and the group; this will measure the success of this change and bring ideas as to how this change initiative can be improved.

1.5 Organisational impact and expected outcome(s)

At the end of their six-eight week project, UG students are required to complete a final report. The organisation recognises student's hard work and commitment to the project by awarding for the best project. For instance this year in 2015, one of the 3rd year medical student's in the Intermediate Cycle carrying out his 6-week Student-Selected Component (SSC) project was awarded Fennessy Hogan Medal for Best Research Project. Organisations UG student will potentially have established research skills by the time they graduate.

1.6 Potential threats to implementation

Potential threat 1: Taking on project students is on the basis of the commitment that research group can provide a quality research project , which the UG students can

submit as part of their UG medical/pharmacy curriculum. Therefore the project has to be approved by the relevant project co-ordinators before it can be implemented.

Resolution: Research projects will be designed as a whole as part of the bigger research strategy and the rationale of the project will be clearly specified, as opposed to in the form of bits of scattered work. This will ensure quality requirements of the research project (objective 1) and thus will be potentially approved by the relevant UG project co-ordinators.

Potential threat 2: Some PIs would be reluctant to take any UG students because the work generated may not necessarily form part of the PhD student's thesis or culminate into a research publication which can result in a waste of time and resources for the research group.

Resolution: Therefore efforts will be made such that the student projects are designed and planned to align with the research groups projects so that the data generated by the UG student projects can contribute to the researcher group's project, and thus contribute in increasing the number and/or quality of research publications.

Potential threat 3: Students may not be that enthusiastic after the research project has started, which might affect the quality of the data or the amount of data generated during the course of the project.

Resolution: Interesting scientific discussion with students about the project and showing them the bigger picture as to how their work will potentially contribute in making a difference in future treatment options, can probably encourage the UG students in their project.

Potential threat 4: Research Project may run overtime, leading to immediate failure

Resolution: Research Project will be designed and reviewed by the senior as well as junior members of the team to ensure that the project is realistic in terms of the amount of work and timelines.

1.7 Proposed method(s) of evaluation

Each of the objectives, as outlined in section 1.1 will be evaluated as follows:

1. The project written by the change agent will be evaluated for quality as described by The National Research Council (Gersten et al., 2000, Greenhalgh, 1997, Shavelson and Towne, 2002, Ragin et al., 2004).
2. The UG project will be evaluated for compliance with the research group project criteria (Appendix II) and subsequently submitted to the UG project co-ordinators for selection by the UG, 3rd year medical students, from the list of projects made available to them from various other PIs.
3. Consumables required for the course of the UG student project will be ordered and compared against the list outlined in Appendix III.
4. UG student's enthusiasm at the start of the project will be measured by questionnaire method of data collection (Appendix IV). Students understanding of the rationale of the project will be measured by comparing the literature review submitted by the SSC student against the standards (Maier, 2013).
5. The training carried out on the 2nd week and application of the training by the UG student on the 3rd week, under the supervision of an experienced researcher, will be evaluated by the Kirkpatrick model (Kirkpatrick, 1996).
6. The quality of the data generated by the UG student from weeks 4-5.5, under minimal supervision, will be measured by comparison against the replicates generated by experienced individuals in the lab.
7. At the end of the week group meetings, UG student's presentation will be evaluated for clarity. Moreover, students ability to analyse and interpret the data will be evaluated by using the relevant standards as published by Matt Calvert, University of Wisconsin, USA (Calvert, 2009).
8. The end of the quality of the project report submitted by the student will be compared against the standards outlined by Kara Kockelman, University of Texas, Austin, USA (Kockelman, 2008).
9. Feedback will be taken from the stakeholders i.e. UG student and the research group, in order to assess as to how introduction of this new culture of recruiting UG students within our research group has been advantageous to all the stakeholders (Appendix IV), and moreover, which is consistent with the organisations vision and mission statement.

1.8 Requirements for ethical approval within your organisation

This project does not require any ethical approval. Evaluation and Feedback from the organisations students does not require ethical approval.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this current environment of competition for obtaining government funding for education and research there are stronger pressures on the individual academic lecturer to combine lecturing with the role of a Principal Investigator (PI) of a research project and to conform and work as per the priorities and incentive policies that have been put in place by the government/funding body in order to maintain the performance and national and international reputation of the University. This includes reaffirming university's place in its pursuit of knowledge through research activities, and working towards the right of society to get the university to demonstrate progress to the solution of society's problems. Due to the use of public funds in financing university based research, the pressures are exacerbated to encourage greater productivity and efficiency, as well as demands for greater responsiveness and enhanced application of the research findings into an innovative product (Bleiklie and Powell, 2005). As the research is becoming increasingly recognised as a vital component to innovative products and technology as well as national economic growth, research education and production of more number of researchers has become a matter of urgency for both government and public. Therefore 'research training' has emerged as an important aspect of the agenda for research and research funding being promoted by the national governments (Pearson and Brew, 2002).

2.2 Search Strategy

This chapter elaborates the literature review on two important aspect of this project,

1. Why university based research is a very important contributor to the society, making it as one of the national priorities and how the research outputs can be enhanced?
2. Why research training experience is beneficial to the UG, not only for the student's personal and professional growth but also as a way of providing them with some career directions for the societal and economic benefits.

A literature review outlining the imperative role of the PI to establish a high performing and productive research group and publish research outputs in order to apply for grant funding to maintain research activity in line with the national priorities,

for their and university's ranking and reputation, and how recruitment of UG students can contribute to higher and efficient research activity and performance and production of knowledge by virtue of larger group size has also been described here.

2.3 Themes

2.3.1 Role of an academic lecturer

Appointment of a suitable candidate to the lecturing position in an academic setting is on the basis of the commitment that the appointed candidate will not only lecture to UG and postgraduate students but is also highly motivated to act as a PI to engage in existing research programmes and undertake independent high level research. Thus the role of the academic is a combination of Teaching, Research and Knowledge Transfer.

In line with this it is expected that the candidate will not only have teaching experience, but will also have good research profile which will enable the appointed candidate to prepare grant applications and make bids to a range of funding agencies and obtain research grant funding to develop a research group of PhD students/post-doctorates who can help support the research activities within the group (Seglen and Aksnes, 2000). It is also expected that the PI will publish research outputs as high quality research papers in a leading peer-reviewed international journals or as patents. This will contribute in maintaining institutions national/international reputation and culture of driving cutting edge translational research. This will also be instrumental in securing more grant funding from government and public funds to maintain the high level research within his/her research group.

Hirsch et al (Hirsch, 2005) has reported an h-index which is easily computable and defined as the number of papers with citation number >*h,* and demonstrates impact and significance of research accomplishments from a scientist. This index is an important evaluation criterion of scientific achievement and hence has been used by many funding agencies as a useful yardstick to compare and choose in an unbiased way from a range of scientists who are competing for the same resource (grant funds). Moreover, Nobel prizes are often awarded as a result of maximum productivity of the researchers.

2.3.2 University based scientific research, research training and its impact on the society

Traditionally universities are seen as an organisation of the production of graduates with higher research degrees such as PhD. Universities are also known for the generation of new knowledge and novel basic science through research activities (Bleiklie and Powell, 2005, Hicks, 2012).

2.3.2.1 Research and its impact on the society

In the universities, research is carried out in various scientific areas such as cancer care or inflammation care and is a core activity integrated with Learning & Teaching and Knowledge Transfer. Thus universities play a central role in the national system of invention of innovative products for the benefit of the society (Bleiklie and Powell, 2005, Hicks, 2012). University based research can lead to the generation of proprietary knowledge regime which has been linked to ‘‘academic capitalism’’, whereby universities are increasingly similar to commercial enterprises which produces and sells research and education services on the marketplace (Bleiklie and Powell, 2005).

This reflects the greater involvement of universities in the marketplace showing a strong correlation between economic growth and universities role as knowledge producers and research in science and technology. Moreover, state and university share a relationship of knowledge and power whereby knowledge from the university and the scholarly expertise can be used by the state to establish the credibility of government policies and also derive political decisions about qualifications for professional employment, and standards of public contracting (Bleiklie and Powell, 2005).

2.3.2.2 Research training and its impact on the society

Graduate education and research training can greatly contribute and enhance the national academic labour market, and could result in an increase in the doctoral candidates, thus helping in strengthening the industrial R&D sector, facilitating innovation, and contributing to societal and economic growth (Bleiklie and Powell, 2005).

A peculiar and interesting characteristic of the German university's pattern for doctoral degree training is that it tends to serve a wider function in terms of fulfilling the demands of the labour market as a considerable number of candidates who have gained doctorates are actively pursuing and successfully gaining employment in the market, outside the higher education and research systems. Nevertheless, now a day's doctoral research project comprises of interdisciplinary and multidisciplinary research and crosses organisational boarders in order to advance fundamental understanding which is regarded as an essential driver for innovation. Multidisciplinary research brings ample of challenges and opportunities in this world of interdependent systems and training which will contribute in diversifying/broadening the competencies of researcher, which will influence the researcher's career development and make them eligible to fit into wide range of career opportunities in line with the knowledge and skill needs of the market (Bleiklie and Powell, 2005). Thus research training also results in explicit skills formation, which includes development of skills as future researchers as well as for the other modes of employment (Pearson and Brew, 2002).

2.4 Major factors influencing scientific productivity (research outputs)

The impact of the research productivity is assessed by the measure of cumulative publications and citations in various research databases such as the ISI Web of Science (Cummings et al., 2013).

2.4.1 Research funding

Research funding has been reported to exhibit a positive impact on the scientific productivity by virtue of attracting the best talent and potentially generating more research positions and capacity to buy consumables to carry out cutting edge research (Seglen and Aksnes, 2000). University sector research funding is usually obtained by applying to the research funding programme supported directly by the government. Recently there has been a surge in funding opportunities from the private funding agencies such as from industries who are investing in academic university based research. Nevertheless public funding is still a predominant source of funding for university research groups.

In current policies surrounding scientific literature, competition mechanisms amongst the research groups for research funding and research output related financial incentives are observed as a way of making university systems efficient and productive (Auranen and Nieminen, 2010). Allocating the funding based on historical research performance results has been reported to create a general incentive to other PIs/research groups to work on their research activities, output and performance in order to receive grant funding. Thus this makes the grant application for a research funding very competitive and will stimulate less/under-performing PIs/research groups to perform (Auranen and Nieminen, 2010). This will contribute in improving the capacity and quality of university-based research which is thought to be a vital contribution to innovation, including social innovation (Hicks, 2012). Therefore competitive research funding also allows an opportunity to demonstrate research performance through boost in the productivity such as research outputs as research papers in leading scientific journals.

2.4.2 Collaboration

Collaboration takes place between two groups/labs sharing similar interests and has been reported to be mutually beneficial to research groups, institutions, and exhibit a positive effect on the scientific research and publishing productivity, with a correlation between the number of peer-reviewed journal papers and the number of collaborators. Collaborative research amongst various university based researchers/scientists as well as with industry and other commercial partners has been on rise mainly related to the interdisciplinary, complex, and costly characteristics of modern science. Funding agencies, particularly government agencies, are increasingly encouraging scientists and facilitating involvement in active research collaboration as part of their funding conditions (Lee and Bozeman, 2005).

Research groups are seeking collaborations primarily for research strategies such as for strong scientific impact and reputation or for bringing together various complementary skills or resources to optimally fit research needs, thus resulting in the great productivity gains.

2.4.3 Size of the research group

Scientific research is increasingly conducted in groups rather than by individual scientists, the evidence of this change in research is demonstrated with the increasing numbers of co-authored scientific papers. It has been reported that the large group size are more productive and can exhibit a positive effect on the quality as well as quantity of research output and scientific performance, resulting in competitive research, in comparison to the smaller groups (Cummings et al., 2013, Seglen and Aksnes, 2000).

Large group size and the associated wide range of talent spanning across disciplines and universities is beneficial as scientists gain a lot from exposure to various approaches to troubleshooting and tackling complex topics in research. Consequently, group heterogeneity is promoted because groups consisting individual members from various discipline is beneficial in terms of the flow of the ideas and contributions from different experts of various fields of science, brining an integrated and innovative approach to problem solving. This contributes to higher research productivity gains and results in impactful research (Cummings et al., 2013). On the contrary, reports also suggest that by increasing the heterogeneity and size of research groups, i.e. recruiting and adding experts from various disciplines, might lower the productivity and pace of achieving research groups goals as individuals coming from different disciplines are less likely to share the same social identity as the rest of the group. The large size of the group would also result in bigger motivation and coordination challenges such as the use of tools to arrange meeting, share resources, and understand each-others perspectives and skills. (Cummings et al., 2013, Seglen and Aksnes, 2000).

Therefore an extra effort would be required to promote strong group identification and cohesiveness by developing trust and overcoming differences of language and norms about the research process. In addition, carrying out informal collegial communication can contribute to identification with the group and addressing heterogeneity (Cummings et al., 2013). Seglen et al (Seglen and Aksnes, 2000) concludes that the proven way to increase the overall scientific research output from a well-structured group is to increase the number of research staff i.e. research assistants, PhDs, post-docs and research students.

2.5 Advantages of the undergraduate research student to the research group

A research supervisor is a ‘critical friend’ or a ‘gate-keeper of science’ who guides the ‘student’ through the scholarly maze of literature and research work which will potentially culminate in a good research project/research paper or doctoral thesis. In order for the students to develop appropriate expertise and attributes in various institutional, disciplinary and professional contexts for employment, there is a generic process by which the supervisors need to engage in with the students for effective supervision (Pearson and Brew, 2002).

By supervising an UG research student the team members can potentially gain expertise in supervisory skills some of which are as follows, (Pearson and Brew, 2002)

1. Greater awareness of own concept of the research project and higher competency in research and supervisory practice,
2. Experience in interaction, negotiation and communication skills in the context of critical engagement and strategies for maintaining dialogue about the research strategy and results generated by research activity
3. Experience in giving feedback which is constructive, supportive and salient to the emergent issues and challenges of research
4. Understanding of leadership skills to facilitate student learning in a productive scientific research learning environment

2.6 Research project: a medium for the growth of undergraduate students

2.6.1 The Role of Undergraduate Research in the development of Students’ skills

National Science Foundation defines effective UG research as, “an inquiry or investigation conducted by an undergraduate that makes an original intellectual or creative contribution to the discipline” (Hunter et al., 2007). A lab based scientific research project has a number of hallmarks of an authentic/original research that include developing research questions whose answers are currently unknown, addressing the answers to the research questions by systematically planning and designing experiments with go/no-go goals, collaborate among lab peers, interpret data, and present lab results.

How learning occurs is very important factor encouraging both, cognitive and personal growth of the student at various levels during their UG college years. Hunter et al reported that the faculty highlighted that the student gains as professional growth, socialization into the sciences and social constructivist learning and development of professional identity is vital. Social constructivist learning is where the students are urged to be actively involved in their own process of learning. In other words both teacher and students see knowledge as a dynamic, ever-changing which is constructed based on the observations and data generated from the research activities (Brownell et al., 2012, Hunter et al., 2007).

Communities of UG research practice have been reported to effectively contribute to the processes of constructivist learning, students' epistemological, and interpersonal and intrapersonal development. UG research also encourages students personal, cognitive and intellectual development during their college years (Hunter et al., 2007).

In a community of practice engaged in the generation of new knowledge as well as producing skills for their own future employability, the UG research student who is new to the lab is socialized into the practice of the community (such as the practice of the community of scientific researchers), through mutual engagement, direction and support from the research group consisting of the PI, research fellow and PhD student. In this the enthusiasm of the student is paramount and of prime/utmost importance as development of the concept and practice of this model is centered on students whereby the student actively participates in the research group and initiates "legitimate peripheral participation", such as learning through ongoing opportunities of self-expression and reflective thinking facilitated by an experienced research member of the team. This construct describes the process whereby the UG student is slowly, but increasingly, inducted and guided into the knowledge and skills required to conduct the research project under the guidance and expertise of the experienced member of the research group. As times passes, the students gain research lab based skills and progressively assume more responsibility for their learning and moves from the periphery toward full membership in the research group (Hunter et al., 2007).

In the scientific research lab, the UG student learn to deal capably with ambiguity and uncertainty—an aspect which is more relevant to the field of scientific research.

The authors further report that this teaches the UG student how to think and act satisfactorily, interpret results and plan future course of experiments. Moreover, it gives a good platform for the UG student to learn useful, reliable knowledge based on the consensual agreement of the research group comprising how to deal with ill-defined, complex and risky situations. This will help students to make personal sense of the construction of knowledge claims by allowing student to engage in knowledge construction from their own perspectives which involves validation of the students as knowers and facilitates learning in the students' own perspectives (Hunter et al., 2007).

2.6.2 Providing career direction

It is widely believed that research training at the UG level is valuable and enhances the educational experience of UG students of science, as well as attracts, supports and retains talented and innovative students to career development in science and technology, and also acts as a pathway to encourage and motivate students to plan their careers in science (Hunter et al., 2007, Lopatto, 2007).

This will eventually result in increasing number of graduates entering into science career, which will ultimately result in the production of greater numbers of professional scientists leading to an increase in innovation and contributing to the economy and improving the quality of life of the society.

2.7 Conclusion

This literature review outlines the benefits of the university based research and research training to the national economy and society, as well as to the development of various skills of the UG students.

CHAPTER 3: ORGANISATIONAL DEVELOPMENT PROCESS

3.1 Introduction

This chapter will describe the initiation, planning and implementation aspect of the organisational development (OD) project proposed in the chapter 1 of this dissertation. OD is considered to be the: “System-wide application of behavioural science knowledge to the planned development and reinforcement of organisational strategies, structure, and processes for improving an organisation’s effectiveness” (Cacioppe and Edwards, 2005, Cummings and Worley, 2014).

3.2 Critical Review of Approaches to Organisational Development

Initiating and implementing change is considered to be difficult to handle with 50-70% companies reported to fail in introducing change initiatives in the early stage (Kofter, 2007, Young, 2009). Change is complex and challenging because there is always doubt and insecurity amongst the employees regarding the success of change and therefore the employees are threatened and consequently are resistant to change. When confronted by the organisational change, the employees are reported to undergo through a reaction process which consists of four phases: initial denial, resistance, gradual exploration and eventual commitment (Bovey and Hede, 2001).

Thus managing uncertain and unpredictable nature of change via a fundamental valid framework consisting of strategies and techniques are required to aid successful implementation and management of organisational change. A range of change models have been reported in the literature ranging from Lewins field planned change model (Lewin, 1951, Lewin, 1997) to Kotters step planned change model (Kofter, 2007, Kotter, 1997, Kotter and Schlesinger, 2008) and more advanced and integrated organisational development models such as HSE (HSE, 2008) and Senior & Swailes (Senior and Swailes, 2010). The core components are reported to be consistent across all models (Young, 2009).

3.3 Rationale for OD Model Selected

Change models such as Lewins and Kotters have been reported to be too simple and linear. Planned perspective in Lewins model has been reported to be effective for certain organisations only where the conditions are more stable. Change is very

difficult to be planned in a detailed and distinct manner in organisations with dynamic conditions. Change involves a continuous process of adaptation to changing circumstances (Biedenbach and Söderholm, 2008).

Furthermore, Lewins and Kotters change model is reported to take place in a focused directive manner which relates to top-down, management driven approach change. In other words the timetables, objectives and methods related to change is laid down by the senior managers without involving the stakeholders at all the levels. This could be a major disadvantage for an organisation because senior managers may not have completely understood the consequences of their actions in an environment that is changing rapidly (Todnem By, 2005). Moreover, it presumes that all stakeholders will accept and implement change, and thus it fails to include the stakeholder resistance (Dawson, 1997).

On the other hand the HSE model recognises the non-linear and complex nature of change and approaches change as a continuous and adaptive process whereby all of the stages of change are regarded as interdependent on each other. This model also places particular emphasis on engaging with stakeholders at all levels who need to play their part in initiating and implementing change thus supporting collaboration and both, a top-down and a bottom-up approach to change. The HSE model also recognises that change happens at every level within the organisation, and therefore the responsibility to manage change should be located at the individuals at various levels within the organisation, as also in an academic organisation (McAuliffe and Van Vaerenbergh, 2006). Therefore for the purpose of this project, HSE change model was used.

3.4 HSE Model OD Model

HSE change model outlines four stages in which the change should be carried out, namely initiation, planning, implementation and mainstreaming.

3.4.1 Initiation: Preparing to lead the change

The model emphasises that initiation stage which is “preparing to lead the change” creates readiness and thus contributes significantly to the successful implementation of change. In this stage early preparation takes place whereby the breadth and depth of the change effort is presented to all the stakeholders in order to create a sense of

responsibility towards organisational change. Thus initiation stage helps to build a solid foundation for change. At this stage the key stakeholders who will be directly affected by the change effort were involved. PESTLE analysis was carried out to identify triggers for change and to explore key leverage points and opportunities for change.

3.4.1.2 PESTLE Analysis

PESTLE analysis is carried out to identify other triggers that are exerted on an organisation to change which can be political, economical, social, technological, legal and ethical influences. These influences may also assist in providing a framework for implementing the change.

Political

The research group providing hands-on training to the UG student on a research project contributes to a wide range of transferrable and employable skills of the student. Consequently it is anticipated that this will increase UG student's employability, and can potentially contribute to the new generation of researchers entering the market. This will eventually contribute to building good national and international reputation of the institute and will improve institutes ranking and attract more prospective students to the institute for their UG studies. This is in line with the organisations vision.

Economical

The UG student project comes with a €500 which could be spent towards buying any consumables/materials for the project. This would mean less pressure on the research grants of the group. Moreover, any potential invention resulting from the student project can contribute towards filing a patent and this intellectual property can eventually spur innovative start-ups.

Social

The UG student have an opportunity to present at the national and international conference thus this will enable UG student to show his/her research and also demonstrate research carried out by the PI and the research group which can lift the

reputation of the research group. A research conference will facilitate the UG student to connect and bond with other researchers, which might encourage the UG student to consider research as one of the career paths.

Technological

UG students can bring with them any research or technical skills they might have gained during the previous experience in another lab through various programs of the organisation. This experience might enable the student to bring new technological expertise to our lab chosen by the student to carry our UG research activities.

Legal

Providing research training to the UG students is in line with the organisations mission statement.

Ethical

Ethically the research group will not have to pay any wages as the UG student is carrying out a research project as part of their mandatory UG curriculum therefore the research group will get a UG student to work on the research project to generate data and will not have to pay any wage to the student.

3.4.1.3 Lewins Force Field Analysis

Lewins Force field analysis distinguishes and evaluates various driving forces that maybe for the change or restraining forces that may be against the proposed change thus it takes an account of many varied forces existing around the change initiative. It also measures readiness and capacity for change. In order to implement and maintain change, it is very important to have a better understanding of the opportunities i.e. driving forces as well as the challenges i.e. restraining forces that are the obstacle for the change to take place. In this project, Force Field analysis was used as a tool to assist in the management of change by examining the balance of power between the driving and restraining forces surrounding the change initiative, so that strategies can be designed to address restraining forces. Successful implementation of change can occur when the state of equilibrium is

destabilised, i.e. when the forces driving for the change are sufficiently strengthened and outweigh the restraining forces that are against the change (Lewin, 1951).

Table 1 Lewins Force Field Analysis

Driving forces	Restraining forces
1. Change initiative is in-line with the organisations mission & vision	1. UG student chooses the project as opposed to the research group getting an opportunity to interview and choose from a list of interested students
2. Organisations UG student will get an opportunity to develop personal and professional skills by getting training in a research lab	2. UG student may have lost the enthusiasm after the project has started which can impact on the students ability to get trained and apply his training in doing the experiments
3. Size of the research group increases, which has been reported to be directly proportional to the quality and quantity of research outputs	3. UG student have to be able to follow the protocol and SOP precisely otherwise this will impact on the quality of data generated
4. More research outputs would mean more research papers and higher chances for the PI to secure a grant funding to maintain the high-level research	4. After the initial training, the UG student will have to be able to work independently otherwise this will take a lot of time and efforts from the research group during the course of 6-weeks
5. UG student can present the work from this project in a national/international conference which will enhance reputation of the PI and the research group as well as of the institution	5. If the UG students project is very different from the groups project then the research group will have no set of data to gain in return, for the time and effort offered to the student

3.4.1.4 Stakeholder analysis

Organisational change takes place across all the levels in an organisation therefore for the change to be successfully implemented the change phenomena has to be

accepted at all the levels in an organisation therefore is regarded as a “distributed phenomenon”.

Stakeholders are defined as ‘all parties who will be affected by or will affect the organisations strategy’ (Nutt and Backoff, 1992). HSE model promotes inclusiveness of the stakeholders for better management of the change effort (Johnson et al., 2008, MacPhee, 2007). Stakeholder form a central and vital part of the change project and it requires individual stakeholders to embody change thereby involving change in stakeholders thinking, attitudes, behaviours and values thereby contributing in sustainable development (Caldwell, 2003, Millar et al., 2012, Whelan-Berry and Somerville, 2010). Therefore stakeholder analysis is one of the very vital steps which can enable to identify stakeholder’s interest and address their concerns. This will allow engagement with the key stakeholders and form a powerful coalition which can result in successful implementation of the change project.

Key stakeholders identified in this project were PI, research group and the UG student. Stakeholder analysis was carried out to understand the level of interest and active support and also to assess the level of potential resistance/antagonism.

Stakeholder power-interest matrix was carried out in order to obtain knowledge about interest and power of stakeholders to assess the level of power held by various stakeholders to influence the implementation and streamlining the change initiative and the level of interest from various stakeholders. It is anticipated that the stakeholders who are directly affected by the change will be more interested in understanding change and from whom most resistance may occur. This will enable to understand the level of engagement required from various stakeholders and it can be prioritised in order to keep them engaged and various strategies can be included in order to manage potential resistance (Bryson, 2004, Reed et al., 2009).

Table 2: Power-Interest matrix

High power	Research office UG project co-ordinators Lab Manager Context Setters: consult/ empower, Keep Satisfied	Principal Investigator (PI), Research group Players: Collaborate Manage closely
Low power	Members of other group in the lab Crowd: Inform Monitor "minimum effort"	UG student Subjects: Involve Keep informed
	Low impact/Stake holding	**High impact/Stake holding**

Table 3: Stakeholder analysis

Stakeholder	**Position**	**Support/Oppose /Neutral**	**Interest (Advantage–A/ disadvantage–D)**
Principal Investigator (PI) (Internal)	Team leader	Neutral	**A1:** will increase the size of the research group therefore possibility for a quick research publication **A2:** UG student will present this work in a conference which will reflect positively on the PIs reputation and CV **A3:** in line with organisations mission/vision **D1:** How much time of the research group will be invested in training the student? **D1:** will the UG student be able to work independently after the initial training from the research team, otherwise constant hands-on support from the research team throughout the course of the project might contribute to lower productivity instead?
Colleague (Internal)	PhD	Neutral	**A1:** support for the research group in terms of generation of data which can also contribute to the PhD thesis/towards a publication **A2:** Valuable co-supervisory experience **D1:** will the UG student be able to follow the protocol/SOP accurately, as per the training so that the data generated is reliable and reproducible?
Lab Manager (External)	Context setter	Neutral	Since it is a shared lab space, no more than 2 students were allowed per PI
UG student (External)	Subject	N/A	Working on a research project for 6-weeks will be in line with the requirements of the UG curriculum. The student will gain lab based experience in an established research group which will help student's future career prospects.

3.4.2 Planning

3.4.2.1 Building commitment

It is difficult to predict as to how the stakeholders will respond to the change initiative. If the change initiative match's with their own agenda such as making their tasks easier or connects positively with their roles, values and competencies, then they will respond positively to change. On the other hand if the peoples identity or position are threatened by the change initiative then there will be a lot of challenges and resistance from the stakeholders (Karp and Tveteraas Helgø, 2009). Resistance could also be due to the lack of trust that the change will be good for the organisation, or probably due to the fear of inability to learn the new skills that may be required as a result of the change initiative (Kotter and Schlesinger, 2008, Gill, 2011).

As outlined in the power-interest matrix/grid (Table 2), the Principal Investigator (PI) of research group has the highest power who can influence the change initiative and also has a major interest/stakeholder. This is because PI is the head of the research group. Moreover, any work originating from this project will be presented by the UG student at national or international conference, which will contribute greatly towards PI's reputation who is the corresponding author on the presentation. On the other hand, although the team members consisting of the PhD student and Postdoctoral researcher have lesser power than the PI to influence the change initiative, the team members are equally impacted by the change as they will be responsible to train the UG student(s). Moreover, team members will also be interested in this change initiative because the perceived higher research outputs due to an increase in size of the group as a result of recruiting the UG student would more than likely contribute to peer–reviewed publication(s) where PhD student and post-doctoral researcher will also be authors, along with the PI being a corresponding/lead author. In addition the team members can gain co-supervisory experience by co-supervising the UG students.

The change initiative has generated some interest in the PI as well as the research team. The PI and the research team understand the advantages/driving forces of taking the UG student as outlined in Table 3. The main advantages for the PI are that this will increase in the group size and result in potentially more research

publications. Moreover, training UG student is in line with the organisations mission and vision statements. Similarly, the team members understand the advantages that an additional team member would mean more help for them in terms of data generation.

Despite these driving forces (advantages), as outlined in the stakeholder analysis (Table 3), the stakeholders showed some resistance with the idea of taking on a UG student for the 6 weeks project. In other words, both PI and the team members are not actively supporting the change because they cite certain disadvantages/restraining forces.

Firstly, the UG student gets to choose from a list of projects provided to them as opposed to the PI having an opportunity to interview interested students and selecting the best from the pool of candidates. Secondly the PI is concerned whether taking on the UG student will impact negatively on the productivity because if the UG student is not enthusiastic and proactive in doing the research project then there is high probability that even after the initial training the UG student will require constant help throughout the course of the project. This will eventually impact on the productivity of the rest of the team members and might contribute in an overall decrease in the productivity and research outputs. Therefore there was some resistance from the PI against this initiative due to the perceived underlying risk Resistance from the PI was due to the perceived negative impact on the productivity due to the time and effort it will take from the research team to train the student.. Similarly team members are concerned whether the UG student will be able to follow the protocol/SOP precisely, a prerequisite in order to generate a reliable and reproducible data which will otherwise negatively impact on the quality of data generated.

The resistance from the PI and the team members was expected due to their direct involvement in recruiting and training the student, and conducting weekly meetings to review the progress of the student. The resistance from the stakeholders was valued and was regarded as a form of feedback to improve the planning of change initiative (Ford et al., 2008, Senior and Swailes, 2010). It is vital to be sensitive to the stakeholders concern about how the change initiative will affect them and ascertain the emotional readiness for change.

Good communication, negotiation, education and discussion about the change process and particularly discussing stakeholder's views about the change was an effective approach in order to maintain continued engagement and commitment from the stakeholders (Dixon-Woods et al., 2012, HSE, 2008, Kotter and Schlesinger, 2008). Resistance could be related to a differing assessment of the cost-benefit associated with the change. The reason for the resistance to the change initiative could be related to the stakeholder's different perceptions about the change. Leaders should built coalition and relationships with the stakeholders. Direction of the change can be influenced by changing the communication in the organisation.

In this project, meeting was held to engage with the stakeholders and it was discussed that the students to be recruited for the UG research project were third year medical student therefore relatively less risk was associated in anticipating positives that the UG student will be able to apply their training and follow the SOP/protocol precisely resulting in good quality and reproducible dataset. It was acknowledged that the medical students would not have lab based skills unless the student has previous lab based experience. Therefore training the student on the basic lab skills was vital before the student is been trained on the advanced skills required to carry out the experiment outlined in the project.

Moreover the UG student will be marked for this project and this marks will contribute to their year of the UG curriculum therefore it is expected that the UG student will be committed to complete the project they have chosen. Since they have chosen to do the project it is anticipated that the interest levels about the project will be high.

The research project in this change initiative would be relevant to the ongoing project of the research group was articulated. No resources needed to be allocated with this change project, which was highlighted during the meeting with the stakeholders, as the UG student project comes with €500 for spending towards consumables that may be required to run the project. Therefore essentially the project will be cost neutral for the stakeholders.

It has been reported that articulating alignment of the objectives of change with the organisations mission and vision is regarded as one of the effective approaches to influence the stakeholders and gain commitment for change (Kotter and Schlesinger, 2008). Consequently it was further emphasised that that the change initiative of this project was in line with the organisations mission and vision statement.

All the issues highlighted at this initiation stage were discussed and a decision was reached in collaboration with the stakeholders that this project should be continued to the implementation stage. Achieving small gains can act as a motivation factor towards the change effort (Kotter and Schlesinger, 2008). It has been reported that it is vital to involve and consult the stakeholders and promote their active participation and engage and collaborate with them at various phases of the change initiative such as learning, planning and implementation phases as this can help to build considerable commitment and motivation from them to gain their buy-in to the new vision of the change initiative and can also contribute in lowering potential resistance (Kotter and Schlesinger, 2008, Waddell and Sohal, 1998). Empowering stakeholders, encouraging ownership of change and supporting change are reported to be one of the best ways of promoting responsible followership (Grint and Holt, 2011). Details of the change were determined in the next stage of this change effort.

3.4.2.2 Determining the detail of change

Usually the third year UG medical students start their projects in rotations between January – May, and it was agreed that one student will be taken in January and the second one in February. The project to be started on January was based on establishing the in-vitro inflammation model, and details of the project such as what type of experiments including the type of cells and the type and level of inflammatory mediators were all planned collaboratively amongst the stakeholders, as also advised by Overveit et al, as this was also an opportunity to refine the project plan (Øvretveit and Gustafson, 2002). Similarly, the project to be started in February was also planned in detailed, in collaboration with the stakeholders and was based on screening of the anti-inflammatory compounds in the inflammation model established in January by the first UG student. The type and the level of the inflammatory compounds was also discussed and agreed in detail in collaboration with the stakeholders. It was agreed that the change agent will draft the research project for the 6-week student project as discussed with the stakeholders.

The specific objectives of the project and what was expected as an outcome of the project was determined in consultation with the stakeholder (Hastings et al., 2014, Avolio et al., 2009). This was to ensure that all the stakeholders are aware of the objectives and outcomes of the project.

It was agreed that the change agent will design a detailed draft of the project proposal and will ensure that this is essentially in line with the project of the research group so that the time and effort spent by the research team to train the student can gain a set of data in return generated by the student. The final design of the project needed will take into account the initial training period

In order to ensure that the project goes as per the time lines, a gnatt chart was mapped out (Appendix I) which will helped to monitor how the project was progressing and to keep track of project goals and milestones, so that the project is focused. This will enable to establish a network of stakeholders which can contribute in implementing the change successfully (Harlos et al., 2012). Given the considerable uncertain nature of the scientific research such as certain activities taking more or less time or experiments showing different results than originally estimated, certain issues that might arise during the project would be gradually resolved and thus the project would also evolve after initiation. Thus it was acknowledged that this might potentially disrupt numerous schedule (Herroelen and Leus, 2005). This will allow time to reflect on whether a change in strategy is required and also allow time for adaptation to change. Thus, go/no go goals were also included as part of the project plan, so that if one experiment doesn't work the plan outlines what steps can be taken in the subsequent experiments.

Weekly meetings during the course of the 6-week project i.e. end of the week review meeting with the stakeholders was also incorporated in the plan where the UG student will present the data generated during the week, which was reported to be one of the vital factors for a successful change (Øvretveit and Gustafson, 2002). This will allow opportunity to discuss the quality of results/data generated from the experiments during the week so any repeat experiments or retraining or a change in strategy can be included in the plan for subsequent week(s). It was also discussed that the €500 that will come with the project will be used buy consumables that will be required to conduct the experiments for the student project. This will be arranged before the project actually starts so that the materials are ready for the student to start the work in line with the schedule.

Protocols and SOPs of all the methods and equipment's that would be required during the course of the UG project were prepared and collated by the change agent and was forwarded on to the team leader and team members for their approval.

3.4.2.3 Developing the implementation plan

Planning is reported to be a crucial for the success of the change initiative (Øvretveit and Gustafson, 2002). The project was planned by the change agent such that first week was allocated for training on basic research methods and on the SOPs and protocols which were required to be followed in subsequent weeks in order to generate data independently for the project. The 2nd week was allocated for the student to carry out experiments by applying their training, whilst being supervised by the experienced member of the team. At this stage it was planned to train the student on the statistical analysis of the data being generated by the student, as well as provide any support required while preparing for the end of the week meeting and presentation. The rest of the 4 weeks of the project was allocated for the student to carry out the work as per the project plan, under minimal supervision; however, the UG student was encouraged to approach any of the experienced team members in the face of difficulty.

A meeting was arranged with the stakeholders to discuss the 6-week project drafted by the change agent. The change agent faced some resistance about the plan which was seen as a feedback by the change agent. Some parts of the proposed project were accepted with minimal change, whereas other parts required substantial changes to fit in with the availability of the research team members for training the UG student. For instance, it was agreed that the student will be trained on the confocal microscope at a later date, i.e. week 4/5 of the project when the student actually requires using it so that the training is fresh in students mind. This would suit with the availability of the designated team member as well.

Thus training was arranged to coincide with the availability of the team members or the project was be designed such that the UG student would join the team members doing the similar work. This will maximise the training and team member's time as the student will get more hands-on experience from the very initial stages of the project.

The points raised during the stakeholder analysis were leveraged and applied in order to demonstrate that this change initiative supported and was a good fit with the stakeholder needs (Harlos et al., 2012).

Similarly, other feedback from the stakeholders was taken on board and the timelines of the plan was changed. Time was allocated for the student to write the

literature review at the start of the project and writing up the results at the end of the project.

The first week was allocated to the literature review whereby the UG student will carry out a literature review related to the project. This is expected to give them a strong grounding on the literature related to the UG project. In addition, last 0.5 week has now been allocated so that the student writes-up the project for submission to the research team.

Therefore the 2nd week is now allocated to training, 3rd week is allocated for the UG student to carry out the work under supervision. This would mean that the time for the independent experimental lab work to be carried out by the student was shortened, and thus week 4th to 5.5th i.e. 1.5 week the student will get an opportunity to carry out the work independently, i.e. under minimal supervision. This should give the UG student confidence in working independently, on his/her own initiative, decision making and meeting deadlines.

Once mutually agreed with the various stakeholders, the project was forwarded on to the UG project co-ordinators for approval and was subsequently made available to the UG students who can choose from the list of projects been made available to them.

3.4.3 Implementation: Implementing change

UG project co-ordinator approved the 6-week project submitted by the change agent as this was a good quality research project (Gersten et al., 2000, Greenhalgh, 1997, Ragin et al., 2004, Shavelson and Towne, 2002), and made this available to the UG students. The research group were notified that the students chose our project and the first student was due to start on the project in January. The consumables required for the project was ordered in advance to ensure readiness of the research team.

On the first day, the student was introduced to the research team and the lab. The student was briefed on the outline of the project and asked if he/she had any question. The student asked some intriguing questions about the project, which was an indication about their enthusiasm for the project. Subsequently the student carried out a literature review for the 1st week, as planned in the project timelines. This literature review submitted by the UG student was reviewed by the member of the

research group at the end of the week 1. The literature review reflected that student had gained a good theoretical grounding of the project and understands the rationale of the project. It is anticipated that this literature review would also help the student in writing a good scientific report at the end of the project. At the end of week 1 the student demonstrated enthusiasm to start the experimental lab work aspect of the project.

Week 2 comprised of intensive training programme. The student was trained on the basic research skills such as gowning, pipetting, weighing and carrying out math calculations as required for the experiment. The student was subsequently trained on the advanced lab skills required to carry out the project i.e. training on the basic cell culture techniques such as trypsinising, counting and seeding the cells. The UG student was then taken through various steps of the protocol/SOP and was also provided hands-on training. The student was also trained on various equipment's such as flow cytometry required as part of the project.

During week 3 the student carried out the experiment under supervision. It was noticed that the student required some re-training on certain things such as basic cell culture technique and math calculations related to the experiment. The student was re-trained on week 3, this meant that the student could not complete all the tasks allocated to week 3. The student was also trained on the statistical analysis in week 3. At the end of the week team meeting it was discovered that 50% of the planned work was completed for that week.

Stakeholders raised concerns about the project therefore meeting was held with the stakeholders and it was discussed that the UG student had no previous lab experience therefore re-training was required. Positives from this week's work carried out by the UG student was highlighted i.e. the data generated by the student was of good quality, evident from the fact that it matched with the first replicate carried out by one of the experienced person from the research team.

Interestingly, the student was able to work with minimal supervision in Week 4 – 5.5. The UG student was trained on the confocal microscope in week 5, as was agreed to be carried out when the UG student required. As planned, in the last 0.5 week the student wrote the report of the work carried out.

Regular weekly meetings were held, at the end of each week, with the UG student and the stakeholders where the student presented the findings of the week with

statistical analysis. This helped to ascertain the progress and direction of the process and whether any change in the project planning and implementation was required based on the results generated. Regular meeting has been reported as an important feature dictating the success of the change initiative (Øvretveit and Gustafson, 2002).

Given that the 2nd student is also a medical student, stakeholders were in the view that more training time should be allocated so that the student is comfortable and confident with carrying out the subsequent work with minimal supervision. Consequently, initial week for the literature review was shortened from 1 week to 0.5 week, and the training time increased from 1 week to 1.5 weeks.

In order to build sustainability, adaptability to change is vital (Øvretveit and Gustafson, 2002, Scheirer and Dearing, 2011)

With the increased training time allocated, the second student who started in February was able to apply their training successfully and work with minimal supervision from week 4, while meeting the timelines as scheduled. The student was also able to work as per the go/no-go goals.

3.4.4 Mainstreaming

Carefully planning the project in collaboration with the stakeholders, coupled with ongoing review and communication with the stakeholders provided with an opportunity to identify any unintended consequences which could be addressed early in the project.

In order to mainstream the change, it is vital to anchor and embed the change in the organisation such that the change cannot be undone, which can build capacity and culture of change in the organisation (Senge et al., 1999, HSE, 2008, Kerridge, 2011). It has been reported that change/improvements in the organisation can be sustained through intentional planning, monitoring the change and regularly reviewing the data. This will ascertain that the change is now mainstreamed in an organisation (Nelson et al., 2011).

Feedback from the UG students and the research group was crucial which was positive; otherwise any concerns would have been addressed and ironed out so that this change becomes an integral part of the culture of the research group.

The next step is the evaluation stage whereby the implemented project was evaluated which provided an opportunity to reflect how the change has helped the stakeholders and the organisation. Evaluation also provides an opportunity to learn from the mistakes and downfalls of the change effort which can be applied so that the change in the organisation can be successfully mainstreamed.

Overall evaluation of the change project will bring awareness of change initiative within the research group, and will eventually impact on the capacity of the research group to embrace change.

3.5 Conclusion

The stakeholders were highlighted of the advantages to the group and the UG student from this project, and alignment of this project with the organisations vision and mission. It was also discussed that everything learned from taking on two students in this change effort will be applied while planning to take on the other UG students for future research projects. The stakeholders were happy to discuss the prospect of taking on student(s) for 8-weeks during the summer of this year as part of organisations research summer school (RSS). This will further enable mainstreaming this change initiative.

CHAPTER 4: EVALUATION

4.1 Introduction

Evaluation has been defined by various authors in different ways. WHO defines evaluation as the “systematic examination and assessment of the features of an initiative and its effects, in order to produce information that can be used by those who have an interest in its improvement or effectiveness” (WHO, 1998). HSE defines evaluation as where the organisations experience of the change is systematically reviewed which will enable to determine whether the change is worthy or valuable so that any changes or future developments that may be required as a result of the change can be established (HSE, 2008). Similarly Patton defines evaluation as where the data/information about the activities and characteristics associated with change which can enable making judgments about the change and moreover provides ways of improving the effectiveness of change, and/or inform decisions about the change initiative (Patton, 2008).

Evaluation is reported to be one of the most important aspect as it allows to measure how the change initiative has affected the organisation. Evaluation has also been reported to provide an understanding of the reason why the change effort has/has not worked, which will enable to decide how to further pursue and improve this change initiative (Hodges, 2008, Parry et al., 2013). Thus eventually evaluation contributes in effectively managing the change effort, improve the performance and maximising the positive impact of the change effort on the organisation (Heinemann et al., 2006, Butler, 2002).

Moreover, empirically driven evaluation can also contribute in gaining common consensus across the stakeholders and thus can potentially influence in making decisions and eventually formulating policies (Zinovieff and Rotem, 2008).

A number of evaluation models are reported in the literature such as Kirkpatrick model, Jacobs model, Stufflebeam model (Zhang et al., 2011, Stufflebeam and Shinkfield, 2007).

Kirkpatrick model consists of four levels in which the evaluation is carried out which are reaction, learning, behaviour, results. This model is particularly designed to objectively evaluate the effectiveness of the training programmes by evaluating the changed behaviour as a result of learning from training schedule/programmes, which could eventually impact the organisation (Kirkpatrick, 1996). Kirkpatrick model is

focussed on the outcomes and describes it clearly. For instance Kirkpatrick rates the training as effective when there is a satisfied and are in favour with the training aspect (Level 1), the trainees learn and acquire the required knowledge, skills and attitude (Level 2), how do trainees apply their training to perform their work effectively with the right attitude (Level 3), and how beneficial and this been to the effectiveness of the organisation (Polowy et al., 2006).

Jacobs model comprises of evaluation at 5 levels, where the first three tiers are dedicated on the information related to the evaluation of the initial stages of the change process, whereas the last two tiers are related to determining/evaluating as to how the program has affected effectiveness of the organisation (Jacobs, 2003). Tier 1: assessment of needs at the pre-implementation i.e. planning stage of the evaluation, Tier 2: monitoring various activities related to the change and accountability centered at the stakeholders to attend the events organised to promote change effort, Tier 3: Clarification of the programme, which is determining at what stage the programme has reached, and review of its quality and what improvements are required. Tier 4: is to measure achievement of the short-term and long-term outcomes in line with the objectives of change, Tier 5: establishing impact of the change initiative on the organisation.

Stufflebeam or the CIPP evaluation model appears to be a further expansion of the Jacbos model, whereby the CIPP model provides a framework to achieve accountability by introducing the concept of learning by doing, and thus intends to improve the change initiative and can be a helpful tool to inform the decision makers about the effectiveness of the change effort. CIPP model comprises of the evaluation of four components which are complementary of each other, namely context, input, process, and product (Stufflebeam and Shinkfield, 2007, Stufflebeam, 2007).

“Context” relates to the identification of needs and assessment of the resources and impediments including the political environment that can assist in supporting the change initiative. This also includes identification of stakeholders and stakeholder analysis, finalising of goals and objectives as well as data collection methods and continuous communication with the stakeholders is advocated (Frye and Hemmer, 2012, Mertens, 2008). “Input” complements “context” and is designed to assess the quality of all the information collected such as goal and plan as well as strategy of the change initiative against the literature, and to ascertain whether the change

initiative is in line with the needs of the department/organisation. Assessing the quality of the change initiative is a key element of this model. “Process” is to assess the implementation activities including respective roles played by the stakeholder during implementation stages of the change effort. This will enable understanding the benefits of the implemented project and whether it will require any modification in order to improve the change effort. Lastly “Product” evaluation relates to assessment of the outcomes of the change effort and what impact this has had on the performance of the stakeholders and effectiveness of the organisation.

It has been reported that it is prudent that the evaluation model is chosen based in line with the requirements of the change process that is being evaluated so that the findings of the evaluation can appraise the positive impact of change and highlight areas of improvement for change (McNamara et al., 2010).

4.2 Significance of evaluation

On a broader perspective, it was important that the evaluation of this change initiative measured the quality of the research project and training of the UG student. Evaluation coupled with action for continuous improvements would ensure better outcomes in terms of quality of research project, and student training which will be reflected in the quality of data generated (Stufflebeam and Shinkfield, 2007). Moreover, this will be in line with the government’s investment in research to produce high quality innovation and trained researchers to fill in the vacancies of the R&D sector.

4.3 Evaluation

4.3.1 Aims

This chapter measures the objectives of the change initiative implemented in this project, as outlined in Chapter 1. The change effort in this thesis entails recruiting UG students for the 6-week research lab based project in the change agents research group, which will be advantageous for the student as well as the research group. Training organisations students in research is a central component of the organisations vision and mission statement.

The objectives were evaluated by using qualitative comparison against the standards published in the literature, whereas training was evaluated by the Kirkpatrick model and the project as a whole was evaluated by CIPP model.

The outcomes of this change initiative was evaluated by first measuring the quality of the research project submitted by the change agent, followed by measuring students enthusiasm and understanding of the rationale of the project, which was reflected by the quality of the literature review submitted by the student in the first week of the project. This was followed by evaluation of students training and their ability to apply the training under full and minimal supervision, measured by the reliability and reproducibility of the data generated by the student. Students ability to analyse, interpret and present the data, as well as the research project report submitted by the student at the end of the project was evaluated by comparing against the standards published in the literature (Stufflebeam, 2007, Zhang et al., 2011).

4.3.2 Methods & Measures

4.3.2.1 Evaluation of the objectives

Evaluation of Objective 1: The research project submitted by the change agent posed a significant and important question “how to establish in-vitro inflammatory model?” which will contribute to the knowledge based on the inflammatory models. In addition, the method applied to address this question was put together from various existing literature. This confirms that the UG project put together by the change agent fulfils the requirements of a good quality research project (NCDDR, 2005), (Gersten et al., 2000, Greenhalgh, 1997, Ragin et al., 2004, Shavelson and Towne, 2002).

Evaluation of Objective 2: The SSC/UG research project built in collaboration with the stakeholders was in line with the research group project (Appendix II). For instance, project of the first student was based on establishing in-vitro inflammatory model using Epithelial cells (Caco-2) & Caco-2/macrophages (Healthy & Inflamed). Whereas project of the second student was based on evaluating the efficacy of drug loaded nanoparticles using this inflammatory model established by the first student. These are in line with the criteria as outlined in Appendix II.

This will ensure that the data generated by the UG students during their 6-week research projects complements the research group's data, which can together culminate into a research paper and /or become part of the PhD student's thesis. This would mean that the research group can gain something in return for the time and effort spent in training the UG student. This will be fruitful for the UG student as well; being one of the co-authors on a manuscript published in one of the leading scientific journals will also motivate the SSC student about scientific research.

Evaluation of Objective 3: All the consumables required for the UG project were ordered, and were in line with the list of materials identified as required for the research project. This was carried out to ensure readiness of the resources to ensure that these are available in the laboratory before the students start their project. This is to avoid any delays once the UG student starts on their project.

Evaluation of Objective 4: The literature review submitted by the student was evaluated against the criteria published by Maier et al (Maier, 2013) such as critical review of what others have done and identification of knowledge gaps. The literature review reflected these criteria and hence was what constitutes a good literature review. "Students enthusiasm before the start of the project" is outlined under "Evaluation of Objective 9"

Evaluation of Objective 5 & 6: Training provided to the UG student on the basic and advanced research skills on week 2 and ability of the student to apply their training on week 3 was measured by the Kirkpatrick model which consists of four levels (Kirkpatrick, 1996),

Reaction: The students reacted favourably to the training by coming on time for the training in the lab and showed enthusiasm with learning new skills by asking questions related to the training.

Learning: The students actively participated in the training. After the training the students kindly took the trainer through everything they had acquired, thus it can be said that the trainee acquired the intended knowledge, skills and attitudes from the training.

Behaviour: in order to measure to what degree students applied their training in order to execute their experiments correctly and accurately, the students carried out the research project alongside experienced researcher. The data generated by the UG student matched with the data generated by the experienced researcher. Thus it can be said that the students had acquired the required skill-set to carry out the work outlined in the research project.

Results: Subsequently for the weeks 4-5.5, the SSC student worked with minimal supervision. SSC students were increasing the replicates of the work carried out previously by the experienced researcher which enabled continuous evaluation of the quality of data generated by the student, throughout the course of the project. The quality of the data generated by the student was found to be consistent with the results originally obtained by experienced PhD/post-doctoral researcher. Thus the data generated by the UG student was found to be reproducible and thus was reliable, robust and of good quality. This enabled to determine as to whether any further re-training was required.

Thus after the initial training, the research group were able to spend less time on the UG student and more time on their own work, this potentially resulted in an increase in the overall productivity of the group.

Data generated by the UG student was in line with the project timelines originally designed by the change agent, which enabled evaluation of UG student's time and project management skills.

Evaluation of Objective 7: At the end of the week group meetings the students presented the data-sets generated by them during the week, which would inform the stakeholders on an on-going basis about the results obtained, and thus would enable to decide whether it is required to change the trajectory of the project.

The student presentation was found to be clear and easy to follow, thus could be said as of good quality. The student's were able to apply the training from the statistical analysis, and consequently were able to analyse and interpret the data, reflected by the fact that the students point out the statistically different data set and were able to understand the trend in the data generated by themselves (University of Wisconsin, USA) (Calvert, 2009).

Evaluation of Objective 8: The project report submitted by the student at the end of the 6-weeks project was found to be clear and well organised. The student was able to understand and interpret their data and was also able to relate well to the literature (Kockelman, 2008). Thus UG students were able to write a good report at the end of 6-weeks, which is mandatory for submission as part of their UG curriculum. UG student will get marked on this lab based research project, which will contribute to the overall marks of their UG curriculum. A good report is beneficial for the PI/research group as this will allow easy transfer and merger of the report submitted by the UG student as part of their research project, with the research group's data and eventually towards a publication and/or PhD student's thesis.

Evaluation of Objective 9: Evaluation was carried out within our group to assess the benefits of employing UG research students for a research project. Members of the research group advised that after the student was trained, the student was able to apply their training and hence found the student contribution towards the work as helpful. Moreover the team acknowledged the vital supervisory experienced gained. Feedback from the students about their experience with working in our research group was taken using the questionnaire as outlined in the Appendix IV. Responses from the students were as follows,

1. **Students enthusiasm before the start of the project**

Student 1: "The weekend before the start of my first day in the project, I skimmed through some research papers done by the team just to familiarise myself with the relevant concepts involved; I found it overwhelming."

Student 2: "The members of PI's team invited me to carry out a project on pharmaceutics in Inflammatory Bowel Disease and I jumped at the opportunity."

2. **Students enthusiasm during the project**

Student 1: "The lab manger gave me a tutorial on cell culturing equipment and their use. My hands were badly shaking that I had difficulty in preforming the aseptic technique as I kept hitting the rim of the bottles. 'Another group member' was there and helped me gain confidence in myself till I eventually was able to do the technique properly. The lab manager and 'another group member' left me to practice

alone for a while, so I took my time practising. Later that week when I was changing cell culture media with the “change agent”, I accidentally drew in cell culture fluid into the pipette controller. I told the “change agent” about it and he reassured me that things like this happen and it is fine. He told the lab manager about the incident so the device could be sterilised and have its filter changed. The manager was annoyed and told me that I obviously hadn’t trained long enough. The “change agent” overheard her so he told me not feel down about this. With the support of both the “change agent” and ‘another group member’ I became more and more competent and confident not only in cell-culture skills, but also about myself in general.”

“There were a few amazing, and prohibitively expensive, machines that I was really excited to see/use and still happy that I have seen/used them.”

Student 2: “my weeks were organised to maximise data collection into minimal time. Teaching was structured into blocks based on what skills I would require for the next segment of the project. In this manner I was introduced to a variety of techniques such as specific cell culture techniques for an bowel epithelial cell line, as well as flow cytometry and confocal microscopy.”

3. **How research project has helped the student with the development of their skills**

Student 1: “My experience during the project was both a great learning and development opportunity. Having been exposed to the various experiences and opportunities mentioned above or otherwise, I felt more confident about my knowledge, skills and their limits. This has helped me immensely in my studies, as I now know how to use my time wisely studying what I need to know instead of studying things I already know out of lack of confidence.”

Student 2: “the team not only imparted on me technical skills but aided my wholistic development by allowing me more control in decision making, increased independence and a trust that allowed me to approach problems that came up with confidence.”

4. **Whether this research project has helped the student in their current studies and motivated them towards any future career directions?**

Student 1: “Also, the research placement motivated and inspired me to be in the lookout for potential research questions and improvement opportunities arising from my observations in clinical placements and studying. A year after my research placement, I have a few research ideas, including targeted therapy, that I intend to explore these ideas in my postgraduate career as a physician. The skillset and knowledge I gained during this project gave me a rough outline and insight on how I might proceed in my career as hopefully a future physician and researcher.”

Student 2: “All in all, I came away from the project with a desire to be involved in more research projects so that I could get a feel for the subject matters that I was truly passionate about. Whether lab based or clinical, I credit my desire to continue investing time in research to the combined effort of a great team of researchers.”

4.4 Results

Overall the change initiative/OD project was evaluated by using the CIPP model,

a. Context: UG student was recruited for a 6-week project
b. Input: the UG student was trained into various methods of the research project
c. Process: Initially the UG student was able to work under supervision, and subsequently worked successfully under minimal supervision
d. Output: recruiting UG student for a 6-week project helped the research group with the generation of the data and more importantly provided them with a co-supervisory experience. UG student also gained professional skills by working in a research lab.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

5.1 Introduction

Business environment is continuously evolving therefore in order to survive and succeed at work it is crucial for any organisation to introduce new strategies or policies and renew organisations direction, structure and capabilities. Bringing long term sustainable change is vital in order for the organisation to improve organisations effectiveness such as quality of project outputs, products and/or services while maintaining the cost effectiveness (Todnem By, 2005, Biedenbach and Söderholm, 2008).

Government is advocating increased scientific research activities through the investment in scientific research which is considered vital in order to maintain nation's international reputation in the R&D sector. After decades of basic research, recently translational research producing products to improve the quality of patient life has risen to the forefront of the University based research. Research PIs in the university setting are eligible to apply for research funds from various Government agencies which are available on a competitive basis. Securing funds is dependent on a number of factors including quality of the research project submitted by the PI and PIs research profile, number of peer-reviewed research and patent publications. Therefore in line with the government's desire to enhance national engagement with research activities and scientific discoveries, the research funds awarded could be utilised by the PIs to carry out high level, cutting edge, translational scientific research. In addition this will enable the universities to produce more number of highly qualified trained researchers who can fill the vacancies in the R&D sector and the labour market.

5.2 Project Impact

5.2.1 Stakeholders

Taking on the UG student in this project was impactful for all the stakeholders involved, i.e. the PI, the research group and the UG student, as well as overall to the organisation because,

1. Research is subjected to sponsorship, in other words, in order to carry out research one has to apply for a grant to the funding bodies in order to obtain funds for the staff (Research assistant/PhD student/Postdoc) to buy

consumables such as materials in order to initiate and maintain research activities within the group. National governments aspire to achieve uniform research “excellence” through the performance based research funding system (Hicks, 2012). Increasingly, government core funds have been allocated to the research groups mostly on the basis of research performance. This is related to the idea that if the funding is awarded to the PI/research group who have performed best, which will provide them a competitive edge and it will most likely produce higher quality research outputs. Research funding is available competitively on the basis of the publication and research performance of the PI. The literature demonstrates a correlation between the quality of research outputs and size of the research groups. One of the vital duties and responsibilities as a lecturer in an academic setting is of a Principal Investigator (PI), which entails applying for research grant funding to various governmental and private funding agencies in order to maintain high level research within the institution. Taking on the UG student helped in increasing the size of the research group and hence the productivity and research outputs.

2. Working on a research lab based project at an UG level trained the UG student and nurtured the development of a number of transferrable and broader set of skills such as ranging from critical learning skills, specific occupational skills, problem solving skills to project and time management skills.
3. The experience that the research group received by supervising/co-supervising the UG student in their research project would in turn help in the development of their supervisory skills and in improving the effectiveness and efficiency of the practice of research supervision and thus will present a flexible professional development programme for supervisors.

5.2.2 Practice and Theory

In the “best practice” of UG research, the student usually learns from the mentor’s expertise and works collaboratively with the research PI and PI’s research group to carry out the research project. Thus the student gets an opportunity to carry out

original and authentic research, while taking the primary responsibility for the project and to provide substantial input into its direction thus encouraging independent and critical thinking skills of the UG student (Hunter et al., 2007). Research based learning has been reported to be beneficial not only for students, but also for the faculty members as well as research institutions. In 1998, United States' research universities were challenged by the Boyer Commission Report and strongly recommended by funding agencies to integrate hands-on research-based learning in students' college education which will consequently provide greater opportunities for authentic, interdisciplinary, and student-centered learning where the role of the faculty is a "facilitator" of learning (Hunter et al., 2007).

The follow-up surveys of UG research experience carried out by Lopatto et al (Lopatto, 2007) indicated that the students reported that they gained independence and intrinsic motivation to learn, and showed active participation in courses taken after their experience in UG research. Thus Research education, or training is attracting a lot of attention and scrutiny moreover because research itself holds great importance in the global knowledge economy and societal benefits (Pearson and Brew, 2002).

European Commission report, Assessing Europe's University Based Research (in Hicks et al (Hicks, 2012)) argues about global competitiveness and reports that university research performance is widely considered as an important player and a major factor in economic performance, because of its role in education, research, and innovation, and therefore universities are regarded key to the success of global and knowledge-based economy (Hicks, 2012).

International or global developments have prompted a phenomenon like industry–university collaboration, which is an aspiring yardstick to further modernize and develop new knowledge gained from various research activities, and its translation into new technologies and products and its commercialisation. Thus interactions between public and private science will shape the future path of research which will further strengthen universities ties with industry and the international community

Moreover PIs research publication record can also result in academic-industrial collaborations, which could also potentially result in establishing a spinoff company where innovative products can be further developed to the commercial stage, which can eventually result in creation of jobs for the society. Much of the new knowledge

produced, organised and transmitted as a result of the increased research activity with the university via government and private funding are most likely to dramatically transform higher education systems profoundly (Bleiklie and Powell, 2005).

5.3 Strengths and Weakness of the project

Strengths:

1. Based on the feedback received, this project provided research lab based training to organisations UG student and enabled them to learn a wide range of transferable skill-set such as working independently as well as part of a team, decision making, presentation skills which will enhance their employability after graduation. This project also added a new perspective to their learning in the current on-going UG studies as well as potentially provided future career directions.
2. The research group hosting the UG student gained from the return set of data which can potentially culminate into a research publication and/or form part of a PhD student's thesis.
3. This was an opportunity for the research group to gain experience as a co-supervisor of an UG student, which will help in confidence building and becoming an independent principal investigator (PI), thus an opportunity to critically engage with significant and emergent issues in their own field of scientific research

Weakness:

The UG student chooses the research project from a list of projects made available to them, as opposed to the PI having an opportunity to interview in order to choose from a list of interested candidates. Consequently, there would always be some concerns regarding the future recruited UG students, particularly in relation to their willingness and enthusiasm to apply their training precisely so that the data generated if of good quality and robust.

5.4 Recommendations

The time-frame of the UG research projects if increased from 6 weeks to 8-10 weeks will give more time to the student to learn and apply their research knowledge,

further their research project which can potentially encourage and allow the UG student to develop their scientific identity and bonding to the fellow researchers.

5.5 Summary and Conclusion

Results from this project show that articulating the change initiative, involving relevant stakeholders at all the levels, collaborating with them and addressing their resistance is vital for the implementation and success of the change initiative. Results and the feedback showed that stakeholders initially showed resistance, however, after the initiation and implementation of the project showed engagement with the project and embodied the change. The UG student also showed enthusiasm for the project and actively supported the research group. This project demonstrated that recruiting organisations UG student in the PI group for the research project was advantageous for nurturing of new and transferrable skills of the UG student, and was also advantageous for the research group in terms of the help with generating the data and co-supervisory experience. This is also in line with the organisations vision and mission statement about development of the organisations undergraduates and research performance.

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7.0 APPENDICES

Appendix I: Gantt chart map of the project plan

	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16
Initiation (SSC student project)							
Task 1: Design Research Project x 2							
Task 2: Stakeholder Analysis							
Task 3: PESTLE analysis							
Task 4: Submit Project Plan (x2) to SSC project co-ordinators which will be made available to the student for selection							
Task 5: Readiness of the lab to host the student for their project							
Implementation (SSC student project)							
Task 1: Brief student about their project who will carry out literature review – a measure students enthusiasm and understanding of the research project (Week 1)				Student I	Student II		
Task 2: Train student in basic and advanced research skills (Week 2)					Student II		
Task 3: Student applies the training acquired in order to carry out the SSC project as per the project plan under close supervision – measurement of students acquired research skills (Week 3)						Student II	Student II
Task 4: Student starts working with minimal supervision, and presents the dataset generated during weekly review meetings (Week 4-6)						Student II	Student II
Task 5: The student writes and submits their project at the end of 6-weeks						Student II	Student II
Task 6: SSC student project feedback from student & the group						Student II	Student II

Appendix II Standards & Criteria of research project of the group

Area of study	Type of Study	Goal	Drug Carriers	Molecule	Model (In-vitro)
Inflammatory bowel disease (IBD)	Inflammation	Drug delivery to treat inflammation	Nanoparticles	Biotechnology	Epithelial cells (Caco-2) & Caco-2/macrophages (Healthy & Inflamed)

Appendix III Consumables/Materials required to start the study

Goal	**Materials/consumables required**
Prepare nanoparticles	Polymers, solvents, tween, syringe, needle
Establish in-vitro cell culture model (Healthy and Inflamed)	Cell lines, transwells, cell culture growth medium
Inflammatory mediators	LPS (3 types), TNF,

Appendix IV: Feedback from the UG students

Questions
1. Students enthusiasm before the start of the project
2. Students enthusiasm during the project
3. How research project has helped the student with the development of their skills; a. Fundamental and advanced research skills b. Personal and professional skills such as their critical thinking and analytical skills as well as ability to work independently a well as part of a team
4. Whether this research project has helped the student in their current studies and motivated them towards any future career directions?