# How do undergraduate students respond to early research?

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**Abstract**. Institutions of higher learning, particularly at the undergraduate level are driven by strategies used in teaching and learning. Students tends to attribute their performance on the teaching methods used in their academic terms. It is this measuring tool they use to determine their learning as exposed by their results. In the academic environment where the focus is to get an increased number of students who'll enrol for postgraduate degrees, methods of attracting students to stay longer in the system are sought out timely. In the field of Science, especially in Physics departments, where student numbers at postgraduate level are normally low, new and innovative methods are necessary to attract and retain students in the system. A study has been performed where students at the undergraduate level, were introduced to an early research environment, where the work they were exposed to is highly experimental and they had to be introduced to the fundamentals of research. At the end of the period, students were required to report back on their experiences. The second part of the study involved the analysis of scientific data obtained from our research laboratory where students had to do literature search, which also forced them to consult respective postgraduate students. In this report the responses and observations obtained from the students are reported.

## 1. Introduction

Most universities suffer from the reality of less postgraduate students which is as a result of a number of reasons. This scourge is normally prominent in the science faculty and also more so in some selected disciplines which amongst them Physics is included. Physics as a subject and a career is not famous due to the perceptions around it which includes scarcity of job opportunities' after studying as well as difficulty of the course itself. Students' experience in the field make them to quickly make up their minds about the course very early in their career. Lack of role models is one other factor that causes the reduced number of learners who gear up to postgraduate level.

As a result some interventions are a necessity if we aim to successfully deal with this national challenge. In her dissertation, Van Raden [1] states that of this list of interventions in trying to increase student numbers and to spark interest in postgraduate studies especially in Science, Technology, Engineering and Mathematics (STEM) careers, the one that was of interest was the influence of women role models. The presence of a professional woman scientists in a classroom can inform students about careers that they didn't know existed before. In some cases students can also see that anyone can be involved in research and be successful too.

Undergraduate research (UGR) is slowly becoming a vehicle for deeper, enhanced and engaged learning. In

his correspondence, Mathur [2] states that undergraduate research is something a student embarks upon of his/her own desires. The motivation for such an undertaking has a wide range from a genuine desire for research, to securing an early admission to a prestigious graduate programme, or perhaps to simply affect an improvement to the biodata. It has to be noted that most of our institutions in South Africa have scarcity or no such programs. With this observation, if these programs are established and well managed it is perceived that students will receive various opportunities for research and even internship during their undergraduate studies at institutions of higher learning. While we still explore undergraduate program, we'll continue ask questions like, what constitutes undergraduate research.

## 2. Experimental method

Within the perimeters of my daily program at the University of Johannesburg (UJ), a group of students were gathered with the aim of mentoring them with the aim of channelling them into their desired career paths. The selection of students was based on the interest of the students, as it was an open call done to students who were in their second year of their four year degree. Interested students availed themselves and were introduced to the program. Students had to learn fundamentals involved in research. These included literature search, as well as learning basic hands-on activities of experimental research. They had to take part in sample fabrication, starting from calculating masses of elements to use, weighing of respective elements (where they had to learn accuracy), cleaning (of elements, especially some rare-earths elements, where they had to learn to handle chemicals, and cleaning of apparatus). This was followed by characterization of samples (using powder X-ray diffraction), and subsequently report writing. This group of 10 students have been actively involved for 9 months prior to the survey that was done using questionnaires. Students had to spent at least 6 hours a week in the laboratory which was achieved over two allocated days in a week. The responses from some of the questions will be presented and discussed, and subsequently provide some conclusions and recommendations.

## 3. Results and discussion

The questions given in the questionnaires will be presented prior to giving students' responses which will be followed by discussions for respective questions.

*Question 1: Briefly state the level of involvement in the research so far.* **Responses: [To**
**Note:- Each bulleted response is a selected response of an individual student]**

- My involvement in the research includes:-
  - ✓ Being **hands on in basic stoichiometric calculations**, **weighing of various elements** in relation to the formation of the desired compounds and undergoing various scientific analysis - where through these analysis we shadow our mentor as she **uses numerous equipment in the low temperature laboratory**.
  - ✓ The research aids in being familiar with the general techniques of arc-melting and the usage of X-Ray Powder Diffraction instrument, electrical resistivity and magnetic susceptibility measurements by the use of relevant equipment available in the laboratory.

- The undergraduate research programme introduced me to another group of students involved in the research programme, where the actual research activities include:-
  - ✓ For now, we are still doing the basics of research. We learned about the **X-ray powder diffraction** and about the **diffraction patterns of different compounds.**

- ✓ We also **searched for publications that relate to research in Condensed Matter Physics so that we can have a better understanding of the field**. Recently we had a task to search for publications (literature search) about **gallium rich compounds which is the current research focus of our mentor.**

It is noteworthy that the activities undertaken in the program are well-known by students. Their ability to state them gives an impression that they are aware of every step undertaken in the program. Students are gradually absorbing the necessary basics, most of which are crucial in their progress.

*Question 2: Do you think you are channelled to the right direction, with regards to your desires?* Support your response?

- Yes. I always had a desire to do research at a postgraduate level. However, **I did not know which field to choose**. Through this guidance **I now know different research fields** available at UJ and I find the field of **Highly Correlated Matter** to be the most interesting.
- Yes, because **I highly value being in the field of sciences** - specifically studying Physics and Mathematics, as I enjoy working with numbers, laws and generally having to share my experience and applying my scientific knowledge to everyday problems.
- I am in a **process of finding myself**, **my strengths, my weaknesses**, **and my goals are near**, hence I believe I have channelled my studies in the right direction.

The experience of early involvement in undergraduate research seem to have given insight and encouragement to some students. Many times in scarce skills, which include STEM, and more so a career in Physics, see a huge negativity from students. These sources of negativity range from, the difficulty of the course, lack of exposure and role models and lack of facilities. While students struggle with the course, challenges related to lack of exposure dampen interest and they end up not considering postgraduate studies. It is evident that most of them get to universities not sure of what to do after their junior degrees, as one response alludes to the fact that he is still finding himself, in terms of strengths and weaknesses. Studies performed by other undergraduate student researchers, state that students' research experience clarified their career interests and increased their understanding and confidence in their major courses. Close to 70 percent of those surveyed said their interest in a STEM career increased due to their prior undergraduate experience, and 29 percent of students who had never considered getting a Doctorate degree now expected to. There appeared to be a positive effect of the duration of the research experience on how students viewed the experience [2].

*Question 3: How is this involvement affecting your overall studies?* **Responses:**

- This involvement in research **motivates me to work hard on my academics**. This is because our mentor monitors our progress and we are required to get good results to continue with the program. Furthermore, we are given time to work on our school work so our involvement in research doesn't have any bad effects on our academics.
- Actually **it supports my studies**, as it **elevates my interests** and supports my understanding of other courses.
- The research is helping **me improve on my scientific perspective of life itself**, the **methodology used in research helps me think critically** and respond to situation with a **proactive manner**.

Responses from students informs that they get motivated to even perform better in other courses in their curriculum. Students develop a scientific unction and they begin to develop different problem solving skills to even apply in their everyday life. An involvement of a mentor was seen as a crucial part, especially in guidance and approval of what they do. In their work Shellito at al [4] state that the amount of time a mentor and mentee are together is an important determinant of satisfaction. The most satisfied students spent 2.5 hours a week with their mentors, while those that were somewhat satisfied reported only spending 1.1 hours a week in contact with their mentors. Of the three models of mentors (project, career, and individual), 54 percent of the students felt the ideal mentor would emphasize project guidance, while 34 percent felt the ideal mentor would provide individual guidance. At this stage of inception of UGR, while students are encouraged to be involved in research, they were mostly pushed to perform well in their courses.
It is during the time spent with mentees that a mentor develops well defined projects, recognizing students' constraints outside of the laboratory. He/She will also be in a position to see needs and gaps and can make sure that, students have ample supplies of apparatus and good working equipment and whether they understand all that is communicated to them. Over and above these, spending time with and becoming acquainted with students, gives positive constructive feedback, being approachable, respecting students, progress toward student independence, encouraging reporting back, offering career advice timely, and providing continued mentorship [4] are crucial for their growth.

*Question 4: Is the program of early research involvement recommended for undergraduate students?* **Responses:**

- **Yes, it motivates students by stimulating interest and enjoyment**. It enhances the learning of scientific knowledge.
- Yes, it makes us **work on our own**. It makes **us explore** and find more information.
- Yes, because **undergraduate students get the opportunity to have hands-on experience** of what their careers will entail and to relate other knowledge to what we meet on a daily basis - as well as to have an **insight into the work involved in the Honours and Masters programs** offered.
- I do not know of any other research programs such as this one. In fact, I am convinced that it is the only undergrad research program in South Africa. **It is a good program** to be part of, we learn a lot and it **helps us prepare for postgraduate studies**. Therefore, I would recommend it to other undergrad students.

Students report enthusiasm about the program, as it also allows them opportunities that other students don't have, opportunities like, being in research lab, interacting with postgraduate students early in their curriculum, a certain level of freedom and independence, knowledge and various research options. Amongst other reported learning gains, were their confidence in their ability to do research and working like a scientist, as they spoke of hands-on experience. Gains were also reported in other skills (i.e., communication as they also wrote a scientific report as well as computer skills gained from writing and data manipulation), clarification of career goals, enhanced career preparation, and changes in attitudes [5].

*Question 5: Is undergraduate research program a better tool for learning? Support your answer.*
**Responses:**

- **Yes,** because with that experience, you learn how other students, including postgraduate students in the group, work and thus you follow their footsteps. At the same time research helps us to learn individually.
- **Yes**, it motivate students by stimulating interest and enjoyment. It enhance the learning of scientific knowledge.
- **Yes** it is a better tool for learning as the mentor gives guidance now and then, we are never in the dark.

Exposure to working with others in a group motivated students as they observe each other's commitment levels. Idling students also realised that there's no room for mediocre and they went on to do their part in making sure that they are at the same level of expectation. While students explore and learn new learning skills, it is important that the mentor monitors the whole process of learning and research.

## 4. Conclusions and Recommendations

The program UGR has been established with the aim of encouraging students to stay longer in the curriculum and subsequently get to PhD level. However, at this early stage, it is learnt that there are other goals that are being achieved over and above sparking interest and development of a deeper learning culture. Students get motivated as they also see their peers excelling in their work, that is, it creates positive competition amongst them.

It is recommended that a curriculum UGR project be made part of at least the students' laboratory activity, while more search continues on a broader scale and also on more students. This will help establish whether it can be taken or adopted as a requirement for the university syllabus of an UG (Bachelor) degree. It is believed that, we can solve most of our national challenges where we are faced with less numbers of students enrolment in STEM careers.

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