

## Review Article

## Role of Skill Enhancement Courses & Under-Graduate Research in Physics in Shaping the Future of Young Aspirants and Contributing to Country's Scientific Achievements, Economic Growth & Social Development



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### ABSTRACT

In the present scenario, research has become an integral part of undergraduate education, globally and India is no exception. Students can improve their bio-data by acquiring valuable skills (computational/experimental) and/or to get an experience of real situations beyond classroom and to understand the research methodology. Looking at the benefits the of under-graduate research (UGR) in global perspective, it has been inducted in the UG curriculum in the new Choice Based Credit System (CBCS) of education. The UGR can play a vital role in this regard.

This paper discusses briefly the education system of India with special focus on the CBCS system including Skill Enhancement Courses (SECs) attached to it. It examines the retention rate in physics as compared to other STEM subjects in India and found that it is the highest in context to enrolment in Ph. D. It also describes the importance of UGR at bachelor level to improve retention rate and highlights the opportunities available at various institutes of national and international repute for the outstanding students.

### KEYWORDS

Social skills | Extra-curricular activities | Student | Development

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## Introduction

Enthusiastic, energetic and innovative youth having strong passion, motivation and determination are the most valuable human resource for nurturing economic, cultural and scientific development of a nation. The energy of the youth should be utilized appropriately to bring considerable change in the society and progress to the nation. For a sustainable development, they are to be skilled and streamlined properly. Education is essential for the improvement of the economic status especially of the youngsters and therefore is one of the top priorities in the World Program of Action for Youth. Efforts are on to provide affordable and quality education for all, together with knowledge, skills and ethical values. This can bring social and economic development with good governance, tolerance and peace in the country. Gender equity in education is a must for overall development of society.

Youths are the major seekers of employments that suit to their qualification, skill and interest. Countries with higher and better levels of skilled youth adjust more effectively to the challenges and opportunities. Being one of the youngest nations in the world with an average age of 29 years and more than 60% of the population in the working age group of 15-59 years, India will have huge opportunity, in future. The potential economic gains would be realized by a country when its working age population is larger than the population that is dependent. It is predicted that around 2030, India and other South Asian countries will contribute to major work force of the world when the workforce in the developed world will be on a decline.

## Unemployment in India

Presently, India is facing problem of unemployment. According to the International Labour Organization (ILO), the unemployment rate in India is 3.5% in 2018 with 18.6 million jobless people. Unemployment rate among

educated youth in India is much higher (~16%) than the uneducated ones (~2%) and the situation worsens with increase in education level. The reason is that educated people are less likely to accept informal work even if limited number of regular, salaried jobs is available and that large number of educated youths, holding graduation degrees, lack practical knowledge, professional/communication skills. Other reason may include the less number of job creation in spite of considerable increase in India's GDP.

The past education system played major role in escalating unemployment rate in which the students were tested on the basis of the marks obtained by them in the examinations rather than testing their knowledge and capability. Preference in jobs is given to candidates with higher marks. Schools and colleges are not having adequate facilities to attract students. Privatization of education and grooming of private institutions which do not maintain standards, in spite of very high fee structures and shortage of faculty thus larger student teacher ratio are the other reasons for unemployment. Government institutions like IITs and IIMs are less in numbers to provide quality education to all, where the students are selected through entrance examinations. Some private institutions are world class but are costly and not affordable for the masses. Innovation and research are hardly part of curriculum in most of the educational institutions. Talented Indian aspirants, thus, preferred foreign institutions.

To tackle the problem of unemployment, National Skill Development Agency (NSDA) and National Skill Development Corporation (NSDC) are formed to provide/upgrade skills to the youth which can lead to self-employment as well. Other Indian government initiatives include Make in India, Digital India, and Startup India etc. Besides these, entrepreneurship and management development programmes are organized regularly to nurture the talents to train them on various aspects of industrial activity for setting up MSEs

and to improve decision making capabilities of upcoming entrepreneurs. However, most of the young graduates, seeking jobs, are unaware of these schemes. So, some more steps are required to eradicate the unemployment.

### **Need for Change in Education System**

The education plays a significant role in the building of a nation. Actually, skill without formal education and formal education without skill are both the realities of Indian system, the continuation of that for long is responsible for the over production of unemployable 'educated' youth lacking deep knowledge, confidence, motivation, and skills. Unemployment increases indiscipline, deterioration of standards and depression in them. The present alarming situation of the unemployment forces for transformation and/or redesigning of education system.

The National Policy on Education (NPE) is formulated by the Government of India covering elementary education to colleges in both rural and urban India. The first NPE was announced in 1968 on the basis of recommendation of Kothari Commission (1964-66) [8] and the second in 1986 with special emphasis on the removal of disparities and to equalize educational opportunity, especially for women and SC/ST communities. In the beginning of 21st century, it was realized that the Indian higher education was expanding in quantity with the large number of private institutions but compromising in quality. So, Yashpal Committee was setup in 2009 to review the various regulatory bodies like UGC, AICTE, MCI, BCI etc. linked with higher education. The committee recommended the restructuring of higher education through various reforms to make it compatible with the universities in developed nations [9].

### **Choice Based Credit System in Higher Education**

University Grants Commission (UGC) introduced the Choice Based Credit System (CBCS) to bring

equity, efficiency and academic excellence in National Higher Education System in 2015 [10] in accordance with Yashpal committee's report. It is basically a 'student-centered education system' different from traditional 'teacher oriented education system'. A uniform Credit based grading system for the assessment of the students adopted in the new system is in accordance with the global scenario. The system is designed to match students' ability and aspiration. It provides them enhanced learning opportunities with flexibility for working students to complete the program over an extended period of time along with inter-institutional transferability. This system seems to be providing the students opportunity to choose the subjects of their interest. In the CBCS system, there are more than 100 programs at bachelor level (B.A., B.Sc., B.A. Honor's & B.Sc. Honor's) with different combinations of subjects, out of which nearly 40 for B.Sc. degree. Student can chose according to his/her ability, interest, aptitude, affordability and accessibility. The courses in each of these program are categorized as core courses, ability enhancement courses (AECs), skill enhancement courses (SECs) and discipline specific elective courses (DSEs). The core courses are fixed/compulsory for the program chosen, whereas, there are a number of choices available under SECs and DSEs. The present study focuses mainly on the SECs in physics.

### **Skill Enhancement Courses in Physics in CBCS System**

In the course curriculum designed by UGC for B.Sc.(Physics, Chemistry/ Computer, Mathematics), B.Sc. with Physics, B.Sc. Honours Electronics etc., the SECs associated with physics are physics workshop skills, electrical circuits and networks, Instrumentation, technical drawing that can develop/improve the mechanical, electrical and electronic skills of the students, respectively and can give experience in handling/using various

instruments whereas the aim of “computational physics” course is to teach computer programming and numerical analysis and to apply these for solving problems in physics. The “renewable energy sources & energy harvesting” course aims to provide theoretical knowledge about the nonconventional energy sources such as solar, wind, hydro, piezoelectric, tide, geothermal, nuclear, biomass energies etc. which will be needed more in future when the conventional sources are finished. “Weather forecasting” is also an interesting SEC attached with Physics. This course can impart theoretical knowledge, awareness and understanding regarding the causes and effects of different weather phenomena and basic forecasting techniques which can directly affect the society, crops etc. In the “radiation safety” course they can learn about the various nuclear radiation producing devices, their applications in medical science (*e.g.*, MRI, radiation therapy etc.), archaeology, crime detection, mining etc. and the hazards associated with them.

However, there are problems in implementation of these SECs. The first problem is that there are no faculty appointed for teaching these SECs. Actually, the syllabi in the courses do not specifically belong to physics. For example, “mechanical drawing” is a subject of mechanical engineering. This type of SECs can be taught at university campuses or institutions having engineering departments also. At college level, the students cannot be allowed to select the SEC of his own choice, as it would require necessary infrastructure, in addition to teaching faculty and technical staff. He/she has to take whatever is available at the college. Secondly, it is well known fact that to master in any skill, one should have a practical experience of doing it repeatedly, along with the theoretical knowledge. The allotted time of 30 lectures is just not sufficient for covering the theoretical aspect as well as experiment/hand-on-mode. Also, the student will

earn only two credits for one SEC. To get real advantage of these SECs, these should be of two semesters or of one semester accompanied by summer training in industries/Government labs/Institutes in the neighborhood. Government/industry partnership with the educational institutions can play a vital role in this regard. If the above steps are taken into account, this will be going to produce skillful youth ready to be employed.

### **Under-Graduate Research (UGR)**

Research and innovation are the key factors for technological, economic and sustainable growth. It is now globally accepted that research should be included at under-graduation level and India is no exception. Actually, in engineering it is a tradition for quite long now that the students do some summer projects with professor at home institution or at other institutions to gain experience and simply improve the bio-data. This is considered as an extra-curricular research as it is not a part of curriculum. In some institutions, however, the last semester is for a project in industry/institution as a part of curriculum and grades are allotted for it. In the new CBCS system, the project/dissertation is included as one of the options in DSE courses for fifth or sixth semester for earning six credits as a part of curriculum. A student opting for it may have a genuine taste for research and an appropriate mentor to guide him/her so that he/she can complete the task within the time period and earn the desired credits for the award of the degree. However, a student can do project or summer training at some prestigious institution/national lab/industry. This certainly require sincerity, dedication and hard work. Even if the problem is not finished, the aptitude towards research is reflected from the efforts put by the student. By visiting, these places and working there will certainly broaden his/her understanding of the subject. In the present scenario, a person should have computational skills. Having learned these skills prior to the

project/dissertation work will be beneficial in the completion of the project.

### **Undergraduate Research in Physics**

Inclusion of research and graduation level will not only benefit the students but the teachers as well, to keep them updated with the recent technological advancement and promoting innovative teaching with the application of information technology. In the present scenario, inter-disciplinary topics/subjects/courses are designed for the benefit of society and the environment which in turn responsible for the economic growth of the country.

Recent studies have indicated that physics lags behind other STEM subjects in terms of number of students enrolled in the master's program [14]. About 80% of the graduates have no choice but to take physics, as they could not get admission in mathematics or chemistry due to low score at graduation level. Thus, only 20% of the students who are enrolled in physics are really interested in doing masters in physics and taking up physics as career. The reason behind low turnout in physics may be that the students find physics tough [15] and are unable to perform well in the exam. It is, therefore, the responsibility of the physics community to create interest for physics among students by organizing training camps and workshops. The National Graduate Physics Examination (NGPE) conducted by Indian Association of Physics Teachers (IAPT) is one such notable step. Students should be engaged in experimental activity like science exhibition and quizzes etc. Most of the students are good at problem solving in mathematics. They should be taught to apply mathematics to solve physics problems.

Summer internship programmes can play a significant role in inculcating enthusiasm and passion for physics in the young aspirants. These are available at Physical Research Laboratory (PRL), Ahmedabad; Indian Institute of Science

Education & Research (IISER), Pune; Indian Institute of Astrophysics (IIA); Bangaluru; Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore; Indian Association for Cultivation of Science (IACS), Kolkata; Indian Institute of Science (IISc), Bangalore; and many more for students pursuing B.Sc./ M.Sc. Besides these, Indian Space Research Organization (ISRO), National Centre for Radio Astrophysics of the Tata Institute of Fundamental Research (NCRA-TIFR), Pune and Raja Ramanna Centre for Advance Technology (RRCAT), Indore and several others offer project/summer training for students pursuing M.Sc. Students are also given TA and fellowship/stipend for attending these. So, the students should look for the advertisements for these and avail the opportunity. They should also remember that the selection in these internships are on the basis of their academic records. So, they should work hard and maintain a good CGPA. In these internship programmes, the project along with the necessary skills required (computational/experimental) is sometimes specified by the host institution/ mentor/ programme co-ordinator so that the student come prepared accordingly to fully utilize the opportunity.

### **Role of UGRs in promoting Physics**

The role of a teacher is important in motivating the students to accept challenges in life and inculcating moral and social values along with imparting education. Teacher should explain the importance of research and innovation to students in shaping up their own future and thus that of society as a whole. By attending summer schools and availing summer internship programs at institutes of International and national repute at bachelors level will certainly affect the number of genuine students in admission to M.Sc. / Ph.D. in Physics. Also, to get the chance for the internships, they will perform studies with full dedication and that will be reflected from their

grades in B.Sc. They will be ready for any competitive exam like GATE/NET for Ph.D. in India or abroad.

### **Students' Enrolment & Retention Rate in Higher Education in India**

According to All India Survey on Higher Education (AISHE) of 2017-18, there are 935 universities out of which 15 are exclusively for women. There are 40,923 colleges and 10,247 stand-alone institutions out of these, 36.7% colleges run postgraduate programs and only 3.6% run Ph.D. programs (all subjects). About 79.2% of the students are enrolled in UG programs whereas less than 0.5% for Ph.D. The gross Enrolment rate (GER) is 25.8% (with 26.3% for males and 25.4% for females) which is very low as compared to 85.8% of USA, 43.39% of China. In spite of the low GER, it is highly commendable for India to be at fourth position in the number of doctoral graduates (>24000) produced per year against USA on top that produces 68,000.

Promoting Women's Education has been a priority in India over the years. "Beti Bachao, Beti Padhao" campaign is also a step in this direction. The women are doing better than or equally good to men in every field. In undergraduate science programs, the number of male and female students are nearly equal but at Master's level female dominance is at the highest ever according to the findings of the AISHE (2017-18). Not only more women are enrolling in pure sciences, but are completing their degree.

It also shows that the students enrolment in Physics for M.Sc., M.Phil. and Ph.D. are 75,114 [31695Males(M) & 43415Females(F)], 1299 [421(M) & 878(F)] and 5932 [3805(M) & 2127(F)], respectively, that for mathematics are 1,55,239 [62698(M) & 92541(F)], 1299 [674(M) & 2081(F)] and 3894 [2143(M) & 1751(F)], respectively and that for chemistry are 125805 [53684(M) & 72121(F)], 1150 [323(M) &

8827(F)] and 7562[4479(M) & 3083(F)], respectively. A comparison of these data shows that the enrolments in M.Sc. and M.Phil. are the highest in mathematics among the three main science stream subjects with more number of females than males. This is due to the fact that are more number of seats available in mathematics approximately double of that in Physics at every college/university as it is basically a theoretical subject and does not require any lab setting etc. except some computers. Physics lab is the costliest so have least number of seats available in M.Sc. Physics. However, the situation is reversed in case of enrolment for Ph.D. i.e. for mathematics, it is the lowest and for physics, the highest in terms of percentage of the students who pass M.Sc. and enroll for Ph.D., might be due to less opportunities available for an M.Sc.(Physics). The retention rate is found to be maximum for physics as compared to mathematics and chemistry in India which is in contrast to that pointed. But the female retention rate is much lower to that of male when the enrolment for Ph.D. in physics is considered. Similar trend is reported by Barthelemy *et al.*, (2015). Due to lesser course duration, the female retention rate in M. Phil. courses are higher than that for males in all the three subjects considered. In spite of large number of graduating women, India stands at 121st position among 131 countries with the working women percentage only 27% and is decreasing continuously. This may be due to family responsibility and/or working atmosphere and social constraints. The need of the hour is to increase the working women population through policies promoting female-friendly sectors to improve India's status in the global perspective.

### **Other Government Initiatives for Promotion of Science & Research in Higher Education**

Government of India has launched Rashtriya Uchchatar Shiksha Abhiyan (RUSA) in 2013 to improve the overall quality of state institutions by providing funding to promote research and

innovations to improve equity and by making accreditation mandatory for them. DST sponsored "Innovation in Science Pursuit for Inspired Research (INSPIRE)" is an excellent programme to attract talents towards studying science by offering 10,000 scholarships (@ Rs.80,000 pm) per year pursuing B.Sc./M.Sc. SWAYAM, a digital platform of distance learning is provided where prestigious educational institutes offer best quality content as video lectures, downloadable reading materials, self-assessment tests and online discussion forum for students from school to post-graduation, free of cost.

India is established as one of the super powers in space technology. Remarkable work is also going on in astronomy and astrophysics as evident from the contributions of Indian scientists in the gravitational wave detection in 2015. It is to be noted that the Nobel Prize in Physics (2017) was awarded to Rainer Weiss, Barry Barish and Kip Thorne for decisive contributions to the LIGO detector and gravitational waves detection. A LIGO detector is to be installed in India by 2025 [22]. For quality research and to motivate young talents, government should increase the budget for research which is <1% of India's GDP, well below the world average of 2.25%.

### Conclusion

If the CBCS system is properly implemented with necessary modifications, the students graduating will be accomplished in one or the other skill. They can take up the teaching/technical job in any teaching institution as well. Taking up research projects at graduation level is a valuable step for whom; those are planning for a career in teaching and research. It is true for any subject/field including physics.

The present study shows that overall retention rate is maximum for physics as compared to mathematics and chemistry in India for Ph.D. in contrast to the earlier studies but the female retention rate is much lower than their

counterparts. The retention rate of females in M. Phil. courses, however, are higher than males in all the three subjects considered in the present study.

A skilled person with good academic record is highly placed, thus contributing to country's GDP and economic growth. Although the qualified and skilled persons have global market, they must be encouraged to serve the country. The Prime Minister's Fellowship Scheme for doctoral research in science and technology is an excellent scheme to keep the talent within the country with a fellowship of Rs 75000/- pm. In case, a student goes abroad for higher studies, the environment in the country should be such that he is willing to come back and his expertise be utilized for the welfare of the country.

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