

Women and Physics

Bhoomika Pandya¹ and Minaxi Vinodkumar²

¹Department of Physics, Sardar Patel University, India

²Electronics Department, V.P. & R. P. T. P. Science College, India

Abstract

Almost in all aspect of a person's life, science plays an important role. Scientific approach, temperament and methodology is very important that help us to resolve the economical, social and environmental problems which make development path sustainable. Such sustainable development necessitates that science and innovation to be practiced at local, regional plus global level with equal participation of men and women. And physics plays an important role in the development of new technology that takes care of our comfort and growth. Although notable women scientists in the past contributed in a significant way in the various fields of physics, the number of female scientists in this field is negligibly small in number compared to male counterpart. So, in this paper we analyze based on the available research survey of the participation and involvement of women in physics, and try to bring out the reasons behind less women pursuing physics as career and shed the light on some possible action plans towards enhancement of women involvement in modern science and physics in particular.

Keywords: Women, Physics, Higher Education

INTRODUCTION

Physics deals with science of matter and its motion. We all are familiar with the fact that everything surrounding us is made up of matter and Physics explains such matter as combination of fundamental particles interacting through fundamental forces. Apart from the word Physics which is originated from the Greek word "Physis" means nature, and physics deals with study of nature. And our existence is closely related to nature and its sustenance. To explore its full strength towards the betterment of our life both male and female must contribute equally. But the past and present scenario shows that there is a huge difference in number of male and female participants. From the scientific aspect, lesser female participation corresponds to enormous waste of human talent for the growth of this field of science. Physics requires the more people with extraordinary analytical, communicational and technological skills with social responsibilities. Decades and century back, there were certain rigid social order that limits the participation of female in science. Many strong women withstood all the problems from the society and family and became well known in their respective fields of interest. On the other hand there were countless women physicists and astronomers who contributed very significantly but they were over looked by male dominated scientific society. Today, the situation is much better but lesser number of female participate and choose this field as their career. We illustrate this fact based on the survey available and present the ratio of female physicists working in national institutes of India as well as over the globe. We then high light the under lying reasons for the dismal participation and suggest some key ideas which can be implemented to encourage and improve the women participation in science and in physics in particular.

WOMEN IN PHYSICS - A HISTORICAL SURVEY

Looking back through the past history, it can be seen that women have been contributing significantly to physics for centuries. Vast numbers of biographies are available for recollection of the lives of women physicist. And certainly, the first name come in our mind is Marie Curie. But if you think or ask someone to name second most famous female physicist, the people can't shed light upon it. However the contribution of women in physics as well as in astronomy is noteworthy. Letting people know about remarkable contribution of women in physics is a meaningful aim, and countless websites are running to address it. Earlier, it was very hard time in which women were not allowed in higher education institutions and barred from education in university. The tutors of that time were not ready to instruct women. In such critical social order, how can hard working women achieve recognition? Before the nineteenth century and in the first half of it women were not able to do work independently or their work was suppressed by male dominating society. Even during those time there were number of brave women having love and passion about physics. As the flow of water always find its way, the legendary ladies made their way out. The only available option was to continue to work with a support of male scientists. To list few of those brave scientists, Madam Curie (1867-1934) was working with her daughter and her husband. Caroline Herschel (1750-1848), a marvelous lady astronomer was a German astronaut. She was working with her elder brother William Herschel. Her most momentous contribution to astronomy was the discoveries of numerous comets, including the periodic comet 35P/Herschel-Rigollet. But her discovery never became popular. Mileva Einsteine-Marić (1875-1948) was doing her independent research prior to marriage with Albert Einstein. Before collaborating with Otto Hahn, Lise Meitner (1878-1968) was working as unpaid assistant. The work was fruitful to the field but those lady physicists and many more like them didn't receive any recognition for their contributions. In the second half of the nineteenth century, United States and UK schools were aware of importance of women education and started educating young women in science and the classic concern was on "domestic science" or "household science" as women were engaged mainly with homemaking, cleanliness of home and being health in charge of family members [1]. Paradoxically, women were down casted for higher education and the reason was underlying fear which

was running in narrow brain that such education would create “pale, weak, neuralgic, hysterical, menorrhagic, dysmenorrhoeic girls and women” [2]. Damn horrible thinking!!! In parallel time, physics education was in progress slowly and steadily. In the last decades of nineteenth century, absence of standardization of education was felt by educators and in order to establish the standard education the “Committee of Ten” was created in 1892 [3]. The science educators and scientists were member of this committee and these people recommended the biology, chemistry and physics as a part of the high school curriculum. Hence forth the situation has improved and encouraged female counterpart to choose careers in science.

LEAKY PIPELINE PROBLEM

Today, the fact is that there is an increase in the enrollment of female students in higher education in science stream even in the subject area of Physics (UG & PG together) but there is a slow drain of female reaching to the highest academic degree (say PhD enrollment) and in the choice of their career option in physics and other science branches. This trend is what we referred here as “LEAKY PIPELINE PROBLEM”.

JOURNEY OF PHYSICS EDUCATION

One of the major problems faced by physics education and lesser attraction of female students towards physics is the lack of inspirational good physics teachers at high school level. Many of the school teachers and faculties are themselves not very comfortable with the subject and are afraid of topics of physics and try to avoid it in their own way. Research survey clearly indicates only about 17% teachers are well qualified to teach physics [4] and rest of them are uncomfortable, poorly educated in physics and fail to induce interest among the students in the subject. This generates a fear towards the subject at the very early stages of their education. The fear transferred by teachers play a vital role in the dropout rate in physics and science in general.

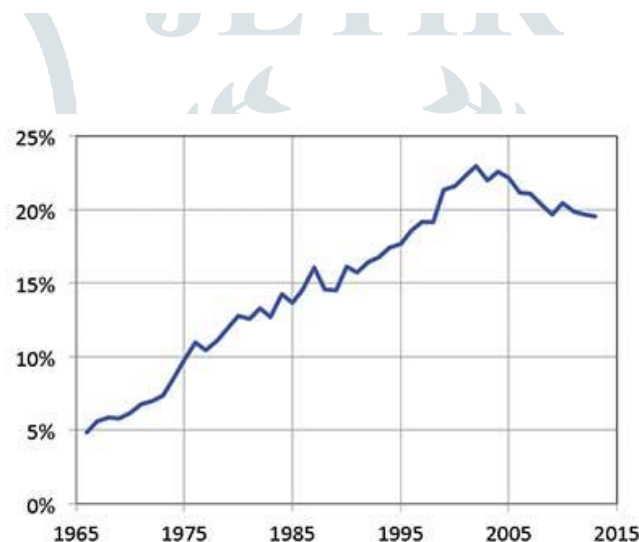


Fig. 1: Percentage of Women Owing Physics Bachelor Degree as a Function of Year [6].

Fig.1 shows the percentage of the bachelor’s degree in physics earned by female. The research is done by Hodapp and Hazari [6] in United States physics departments. And this research indicates that female students passing out bachelor’s degree is increasing by about 5% over a decade period and even this increasing trend is seen as reversed since the last decade. In their research authors have also provided a statistics on the number of female graduates continue for their higher education and successful in opting a career in academics and those who have discontinued their higher studies in the same subject.

CHOOSING A CAREER IN PHYSICS

Once a female has received a degree in Physics, what is she going to do? Whether she will choose academic line, government sector jobs or seek a job in industries? Till very recently and in cases even today, women candidates are rated lower than men candidates having identical qualifications. Many government and non-government agencies have shown reservations in the appointment of women in certain services and do not either consider or recommend them. When women scientists enter in research, it is expected that she will have the same facilities and freedom to work similar to their male counterpart. But the situations in most of the cases are not satisfactory. One of the research survey shows that women in physics are not receiving important career resources like funding, lab space, office space, equipment and travel funds etc., as a male candidate receives.

The research carried out by Lvie and Langer [7] on 15,000 physicists worldwide shown that “women physicist still do not have equal access to the career-advancing resources and opportunities enjoyed by their male colleagues”. Outcome of the

survey is listed in Table I and Table II. A simple glance into table reveals that it is true in developed nation as well as in less developed countries.

Due to this disparity between male and female, women physicists likely to have fewer students, fewer research papers, longer time to do research and lesser number of conferences etc. This leads to slower progression of women as scientists compared to male scientists. Net result is that women try to avoid the career which are male dominant or do not continue to opt such fields where their efforts and contributions do not carry sufficient attention that it requires. From the childhood women are trained by parents, family and by the society to suffer silently or satisfy with whatever they are being offered with no hesitation. This passive reactions of women lead to male domination in every front. While men go without any hesitation, demand for higher salary, large space, start-up funds and so on. Today, women workers realize its importance and started showing courage to demand for what they deserve. This has resulted into positive changes in our society.

Table 1: Percentage of Respondents with Access to Key Resources [7]

	Less developed countries		Very highly developed countries	
	Women	Men	Women	Men
Funding	34	51	52	60
Office Space	64	74	72	77
Lab Space	42	47	46	52
Equipment	42	49	58	64
Travel Fund	31	47	57	64
Clerical Support	22	38	30	43
Students	42	53	33	43

Table 2: Percentage of Respondents With Career Advancing Experiences [7]

	Less developed countries		Very highly developed countries	
	Women	Men	Women	Men
Gave a talk at a conference as an invited speaker	51	67	58	73
Served on committees for grant agencies	22	37	26	36
Conducted research abroad	54	71	61	69
Served as editor of journal	16	24	11	19
Advised graduate students	63	77	58	70
Served on thesis or dissertation committees (not as an advisor)	52	66	37	52
Attended a conference abroad	75	81	83	87
Advised undergraduate students	82	84	69	74

Fig. 2 shows the percentage of women participating in physics at various academia stages, including high school to tenured associate professor in United States universities. At the high school level, unlike the other levels, more than 45% young women enroll and rests are male. So there is a little disparity in science class enrollment. But if we look at the college entrance stage, bachelor degree and Ph.D., participation differences between men and women are very high. There is more than 80% participation of males and female participation is just 20%. At the Ph.D. level this difference will further increase. The similar trend we can see for the assistant professor and associate professor level. The bar on associate professor indicates the expected percentage based on assistant professor levels 6 years prior; statistically this difference between expected and actual number is not significant enough. Compared to male associate professors, the female associates are only about 14%. This data shows that starting from equal numbers at high school stage, it drops to 20% or below at the college level and beyond. This fall is very serious and at this stage from high school to college entrance, more efforts required to change the scenario for women participation in higher education. Here the college entrance means first year student's intent to major in field.

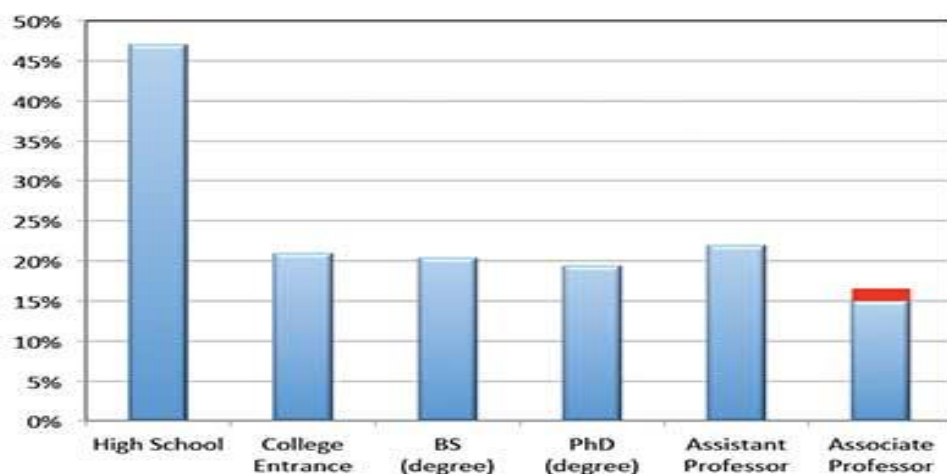


Fig. 2: Percentage of Women Participating in Physics at various Academic Stages [6].

LEADERSHIP

Culturally, the mental status of women is warm, soft, nurturing and communal. When a woman deviates a little out of the social or family expectations, they are looked down negatively and face severe criticism within the society and family. Such social norms also affect or restrict on the freedom of their choices and aspirations towards what they would like to be based on their taste and interest. Such things make the road to leadership difficult for women. It is evident from the data that only very few women are heading their respective departments.

FAMILY AND WORK BALANCING

Being a female, a lady has certain expectations from family members. Society believes that for a lady having fulfillment in life, motherhood is a key component. In addition to that child bearing and nurturing also slow down women's career growth. The criteria for a lady to have overall success in life is to achieve domestic perfection with professional accomplishment. In order to have a TAG of complete woman, a lady scientist must also manage their family expectations like marriage at right age, have offspring, manage to cook and feed, maintain home cleanliness etc. In so many cases women scientists pause or end her career just in support to her husband and family.

REVIEW ON THE DRAINING OUT OF WOMEN FROM THEIR PROFESSIONAL FIELD

The draining out of women professionals is due to social norms which compel them to leave their profession. One excellent review article on the women and science literature by Blickenstaff [5] outlines some of the major reasons on why women do not pursue science, engineering and technology. Some of the major issues are highlighted below.

1. Biological difference between men and women.
2. Lack of positive experiences with science in childhood.
3. The absence of female scientists/engineer as role model.
4. The pedagogy of science classes disfavors female students.
5. Science curricula are irrelevant to many girls.
6. Cultural pressure on girls/women to conform to traditional gender roles.
7. An inherent masculine worldview in scientific epistemology.

Table 3:No. of Female Scientists (Physics Department) in Known National Research Institute of India

Name of National institute	Place	Total No. of Scientist	Total no. of female Scientist	% of women Scientist
Indian Institute of Science	Bangalore	53	3	05.66%
National Physical Laboratory	Delhi	552	102	18.47%
Institute of Physics	Bhubaneswar	26	4	15.38%
Tata Institute of Fundamental Research	Mumbai	20	0	00.00%
Inter- university Centre for Astronomy and Astrophysics	Pune	22	0	00.00%
National Center Radio Astrophysics	Pune	17	5	29.41%
Physical Research Laboratory	Ahmedabad	9	1	11.11%
Space Physics Laboratory	Thiruvananthapuram	54	6	11.11%
Harish Chandra Institute of Mathematics and Physics	Allahabad	20	3	15.00%
S N Bose National Centre for Basic Sciences	Kolkata	12	1	08.33%
Institute of Plasma Research	Gandhinagar	8	1	12.50%
Inter-University Consortium for DAE Facilities	Indore	21	1	4.76%
Indian Institute of Astrophysics	Banglore	43	7	16.27%

Here a humble effort has been made to survey the status of women scientist in well-known research institutes of India. In Table III, name of the institutes with the number of total scientists, numbers of female scientists along with percentage of women scientist with reference to total number of scientists are presented. It can be seen clearly from the table that there are very less number of females in well-known leading research institute of India. Their percentage is less than 30%. And even in some institutes, there is no female faculty. Similar survey done for few leading universities of Gujarat at the master level physics course analyzed here shows a very blink situation wherein in five post graduate departments have no female faculty members. Sardar Patel University and Gujarat University Physics departments have one or two female faculty members only. This shows a large gender imbalance in higher education.

Table 4: No. of Female Faculties (In Physics Department) in Known Universities of Gujarat

Name of University	Place	Total No. of Faculties	Total no. of female Faculties	% of women Faculties
Sardar Patel University	Vallabh Vidyanagar	9	2	22.22%
Gujarat University	Ahmedabad	9	2	22.22%
The Maharaja Saiyajirao University (Pure Physics)	Baroda	23	1	04.34%
The Maharaja Saiyajirao University (Applied Physics)	Baroda	15	0	00.00%
Saurashtra University	Rajkot	9	0	00.00%
Maharaja Krishnakumarsinhji Bhavnagar University	Bhavnagar	2	0	00.00%
Veer Narmad South Gujarat University	Surat	7	0	00.00%
Hemchandracharya North Gujarat University	Patan	2	0	00.00%

SOME TIPS TO IMPROVE THE SITUATION

In this section we discuss some action plans and useful tips to improve the number of female participations in science particularly in physics at the higher education.

- Attracting girls into physics starting from school education.
- Launching a successful career in physics for females.
- Getting women into the physics leadership structure nationally as well internationally.
- Improving the institutional climate for women in physics.
- Learning from regional differences.
- Balancing family and career aspirations through government schemes.

Encouragement schemes through professional organizations working for the growth of physics both in the academic and industrial perspectives must be launched. Such professional organizations not only constitutes national level committees focused on women participation in physics but have programs specially designed to help women to choose their career in physics. Such an attempt is an important step in the development of the nation.

Women being almost 50% of our population, for the growth and development of a nation cannot afford to keep them away. We must encourage young girls and women to participate and take part in scientific schemes and goals of the nation. These activities will have very positive impact on improving the esteem of highly educated women and will help to build up the national spirit. For a working female the working environment must be very conducive and gender sensitive. Mindset of the society must be evolved to adapt for the changing scenario and recognize women professionals as important and equal to male counterpart. As far as the career growth is concerned, equal professional opportunities must be made available with no bias with reference to their cultural or social order in society. Special training programs for parents of girl child may be arranged to highlight all the schemes meant for girl child only. All such attempts ultimately contribute to change the social order, "Females as potential careerists and not just homemakers".

EXISTING EFFORTS

Here we highlight some of the steps made by different organizations and institutions in India to support women professionals.

- DST and DBT Schemes for women to come back to science after break.
- DBT, INSA and NASI special awards for women.
- Establishment of the Task Force for Women in Science by DST.
- Support of women entrepreneurs by DST, DBT and other organizations.
- Mentorship and awareness programs run by different agencies and groups: DST-NASI, IASc, NIAS and DST.

CONCLUSION

As there is no magic bullet for chronic shortage of women in physics but the situation is quite improving due to the various steps taken by society, government organizations and by women herself. As with any problem, the initial stage towards seeking a solution is acknowledging that the problem exists. To excel in any discipline, one must have commitment and interest. Man and women have equal role to play on the sustainable scientific growth of a nation. We must look forward to have a civilized society wherein disparity between men and women are totally removed and they participate towards the betterment of our society and build the nation with a new social order with equality for all. Here the scientific temperament and scientific principles can play a major role.

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