

IUPAP
First International Conference on Women in Physics
UNESCO Headquarters, Paris, France, 7 – 9 March 2002

<http://www.if.ufrgs.br/~barbosa/conference.html>



South African Team



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Report compiled by J. Padayachee

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Report on IUPAP First International Conference on Women in Physics

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1. Introduction

There are notably fewer women than men, worldwide, in the physical sciences and engineering. Numbers also decrease markedly with each step up the career ladder, in both the academic and research (industrial and government laboratories) environments. In response to concerns about this situation, the International Union of Pure and Applied Physics (IUPAP) established a Working Group on Women in Physics in 1999 with a mandate to survey the situation of women in physics, worldwide, and suggest ways to improve it.

1.1. The IUPAP Women in Physics Working Group

Before the issues affecting women in physics could be addressed, they had to be identified. As the working group, chaired by Dr. Marcia Barbosa (Brazil), gathered information on the status of women in physics, world-wide, the complexity of the problem emerged. Firstly, there were difficulties in getting *any* information from many countries whilst others only had incomplete information. Then there was the problem of obtaining comparable data from countries with different cultures and different terminologies - language barriers in communicating the question and cultural barriers to interpreting the responses. All these problems had to be overcome before the issues could be identified. However, a common thread was that the situation of women in physics was clearly deplorable.

To highlight the under-representation of women in physics and to recommend strategies for removing the barriers they face, the Working Group decided to sponsor an International Conference on Women in Physics. The Working Group also undertook an international survey on women in physics, collecting demographic information on education, career and family.

This report presents feedback from the conference and highlights from the results of the survey that was presented at the conference.

1.2. The First International Conference on Women in Physics

The conference was held at the UNESCO Headquarters in Paris from 7 to 9 March 2002 with over 300 delegates (~15% men) from 65 countries. The three days were filled with plenary sessions, two poster sessions as well as small discussion groups covering six topics of interest.

Countries were represented by small teams of physicists with South Africa represented by Jaynie Padayachee (School of Pure and Applied, University of Natal), Elmarie Viljoen (Materials Research Group, iThemba Laboratory for Accelerator Based Sciences) and Mmantsae Diale (Department of Physics, University of Pretoria).

Each country was invited to submit a short paper and present a poster at the conference. The collected pre-conference submissions from each country were distributed at the conference. South Africa's paper can be seen in Appendix A. The papers were compiled in a document handed out at the conference.

More than 25 international organisations as well as sponsors from within individual countries in Asia, Europe, Latin America, and North America provided funding for the conference. The National Research Foundation funded two members of the South African team while the conference organisers funded the third.

1.3. Outline of this Report

This report summarises the findings of the survey and the results of the conference, from the South African team's point of view.

Chapter 2 describes the results of the survey, chapter 3 summarises the conference and chapter 4 describes the some of the problems facing physics and women in physics in South Africa, and suggested solutions.

2. Survey

The survey, conducted by the Statistical Research Centre of the American Institute of Physics, consisted of two parts: country-level data on the representation of women in physics in as many IUPAP countries as possible and an international survey of individual physicists.

The survey addressed issues of education (from secondary school to the highest degree), assessment of career evolution, marriage and children, factors that contributed to career success and suggestions for what could be done to improve the situation of women physicists in their home countries. More than 800 responses from women physicists in more than 50 countries were received.

Since the survey relied on email and personal networks among women physicists (there is no source for names and contact information for all physicists in every country), there was a bias against women who were not known or had no email. The survey also only covered women who overcame the odds and succeed in becoming physicists. Students who dropped out, women who left after an advanced degree and those presently employed in non-physics related jobs were unfortunately not included because there is often no way of contacting these women. Since the questionnaire was only available in English, people whose first language is not English could have misunderstood certain questions.

2.1. Number of Women Physicists who responded to the Survey, by Country

The table below shows the numbers of women who responded to the survey by country. 23 South African women responded to the survey.

Africa		Europe	
Cameroon	2	Armenia	8
Egypt	13	Albania	6
South Africa	23	Belgium	24
Tanzania	1	Bulgaria	3
Zimbabwe	2	Croatia	1
		Czech Republic	4
Asia		Denmark	16
China	27	Estonia	4
India	42	Finland	1
Indonesia	16	France	34
Israel	9	Germany	29
Japan	57	Greece	2
Malaysia	1	Italy	39
Pakistan	2	Ireland	11
South Korea	21	Latvia	9
Taiwan	5	Lithuania	2
Turkey	53	Netherlands	21
Uzbekistan	1	Norway	1
		Poland	4
Australia/New Zealand		Portugal	1
Australia	16	Romania	3
New Zealand	1	Russia	24
		Spain	2
North/South America		Sweden	11
Argentina	27	Switzerland	16
Brazil	32	UK	35
Canada	48	Ukraine	3
Cuba	6	Yugoslavia	20
Mexico	9		
US	80		

2.2. Highlights of the Report on the Survey

2.2.1. Education

Most of the respondents developed an interest in physics during or before secondary school. This indicates that the exposure that girls get, early on in their lives, to maths and science affects whether they choose to pursue careers in these fields. Parents play an important role in this regard and should therefore be encouraged to support their daughters' interest in science, which can help build a child's self-esteem. Teachers also play a critical role since they are responsible for teaching the subject and have the opportunity to instil excitement of the subject in girls. They also have the responsibility of ensuring that girls have confidence in their ability to study science.

2.2.2. Marriage and Family

Several respondents reported that the demands of a career in physics precluded them from marrying or having children. Of those respondents who were married, a significant number reported that marriage adversely affected them - a woman either spent time away from her husband and family or did not have a good career path. In some cases, the husband's career was given priority and many married respondents mentioned the difficulty of finding jobs near their husband's place of employment. However not all was bad regarding marriage since many married respondents said that the effect of their marriage was positive because they had married physicists or because they had a particularly supportive spouse.

Respondents with children were more likely to say that their careers had progressed slower compared to their colleagues than respondents without children.

2.2.3. Career

About two-thirds of the respondents were employed in academia. About one-third of respondents felt that they had progressed slower in their careers than their male colleagues.

The factors most often mentioned as barriers to career success were the problems of balancing the demands of child-care and a scientific career and discriminatory attitudes (usually assumptions of the form that women cannot do physics).

2.2.4. “What would you change?”

Three out of four respondents said that they would choose physics again.

Three out of four respondents said that the situation for women in physics in their country needed to be improved. The most frequently mentioned factor to improve the situation of women physicists was to reduce the burden that child care places on women by e.g. making child-care facilities available or more convenient, taking steps to make travel easier during the years when children are young, and having husbands who do their share of child rearing. The second most frequently mentioned way to improve matters for women physicists was to end discrimination either across society, or at least at places of employment or education.

3. The Conference: Presentations, Recommendations and Resolutions

3.1. Plenary Talks and Small Group Discussions

The plenary talks served to emphasise the poor state of women in physics in countries ranging from India, Russia and Argentina to the US and the UK as well as to highlight the success stories of those women who have made it to the top. The following issues were raised during the plenary talks (Speakers in brackets):

- The need for transparent policies during recruitment, promotion (Teresa Rees, Wales) and evaluation for funding (Claudine Hermann, France).
- The possibility that men and women learn differently and whether illustrative examples at schools are gender specific (Teresa Rees, Wales).
- The bias that exists against most women physicists because of the attitudes regarding women falling pregnant at crucial stages of projects (Egypt).
- Society must feel that physics is worth something (Elisa Baggio Saitovitch, Brazil).
- Women felt that they had to work approximately 1.5 times harder to obtain the same position as a man (Masako Bando, Japan).
- Female physicists are not recognised (e.g. Lise Meitner) and this has led to women not considering physics to be a prestigious career (I.P. Ipatova, Russia)

There were also six small group discussions on the following topics.

Attracting girls into physics
Launching a successful Physics Career
Getting women into the Physics Leadership Structure
Improving the Institutional Structure and Climate for Women in Physics
Learning from Regional Differences
Balancing Family and Career

The problems that emerged from these sessions as well as recommendations on how they can be eliminated are discussed in the following two sections.

3.2. Problems facing Physics and Women in Physics

3.2.1. Image of Physics and Physics

Physics has a poor image. It is perceived to be difficult and dull and physicists are usually male, antisocial nerds. There is therefore a lack of appropriate role models and mentors. There are higher paying jobs in other fields and society has no idea of the value of doing physics.

3.2.2. Education

The teaching of physics in schools is poor or uninspired and excitement for physics is not instilled at a young age. Physics is not taught in a context supportive for girls and if there are no laboratories (as is the case in many developing countries), girls are afraid of experiments. Older textbooks are poor and badly illustrated and there may be differences in the ways girls and boys learn.

3.2.3. Social

The social problems discussed affect women in all walks of life and are not necessarily directly responsible for women not choosing physics. They do however illustrate that there are many instances where a woman does not have her own identity because society places her in a predefined box (wife, mother, secretary).

A girl's education is taken less seriously than a boy's because she is "destined" for marriage. Many societies view marriage as the end-of-the-line for women. Women are also expected to get married and take care of children and old people at home.

Sexual harassment is a significant problem in developed countries. Issues like the compulsory use of husband's name (Belgium) and male professors refusing to supervise female students (Japan) are problems that were brought to light.

Women have a 'secretary' image.

3.2.4. Infrastructure in Country

The size of a country and its physics enterprise determines the number of people that enter the field. So, in countries where the job prospects for physicists are low, there is the perception that there is no value in doing physics. The affluence of a country also determines the amounts of funding available for equipment, mobility, etc. The lack of equipment is a serious problem for developing countries

Job security emerged as a crucial factor to increasing numbers in physics. In developed countries there are numerous jobs that pay more than a scientific career and few people consider physics.

3.2.5. Facilities

Childcare facilities at places of employment are either poor or don't exist. At universities, these facilities are often for staff but not for graduate students.

3.2.6. Career

A women's career is not perceived to be as important as her husband's and women often sacrifice their careers for their husbands'. Women also seem to have long apprenticeships and often "permanently" have temporary positions.

There exists 'boys' clubs' in places of employment where men specifically exclude women from social activities like after hour drinks and sports events. There are different evaluation criteria for men and women. For the same work, women get less pay. There are also hidden criteria for resource allocation and women are discriminated against when they take time off to have children.

Women have insufficient recognition and the perception of women in leadership positions is that if she is strong then she is perceived to be too assertive whereas if she is modest she is perceived as being weak. This is however a problem for all women in leadership positions, not just for women in physics.

3.3. Recommendations and Resolutions from Conference

The original recommendations and resolutions from the conference are attached as Appendix B and C respectively. These are adapted to South Africa in §4.

3.4. The Conference Website

Detailed information about the conference including follow-ups, posters and list of participants can be found on the conference web site at <http://www.if.ufrgs.br/~barbosa/conference.html>.

3.5. Summary of Conference

There are far fewer women than men in physics, with numbers decreasing drastically the higher you go up the career ladder. Those that do succeed and become professional women experience many forms of discrimination, with respect to salaries, promotions and funding. Women do not hold enough high positions at universities and their careers are discriminated against when they take time off to have children, amongst many other forms of discrimination. The resolutions adopted at the conference have highlighted those issues which need to be addressed.

4. The South African Situation

While the issues listed in **Problems facing Physics and Women in Physics** are important, they are not all relevant to the present situation in South Africa. The problems facing physics in South Africa currently focus on *attracting* people into physics.

However, the issues raised at the conference regarding how women are treated later in their careers in physics should be taken into account by the relevant institutions when decisions or policies are made. This will ensure that South African women in physics will not have to experience the problems that women in other countries are presently experiencing.

4.1. Important issues for South African Women in Physics

4.1.1. Image of Physics

Physics has a very poor profile in South Africa. This impacts on the jobs currently available for physicists, the number of people that consider physics as a serious career and on the amount of money that gets allocated for physics research because physics is not seen as an important or necessary field.

4.1.2. Education

The teaching of Maths and Science in South Africa is very poor. There are many un- or under-qualified teachers that presently teach these subjects. Therefore, the maths and science base of many young people is not strong enough for them to choose these subjects at university.

The training of maths and science teachers must be improved for the sake of the future of physics in South Africa since it is teachers that plant the first seed of a scientific career.

It is also up to teachers, parents and current physicists to ensure that more girls start enjoying physics enough to follow careers in physics, by encouraging and supporting girls' interests in science.

4.1.3. Career

One point that emerged from the survey report was that 40% of South Africa's respondents did not have PhDs. There are a few possible explanations to account for this situation: the survey did not reach older women physicists, if it did, they did not respond or that South Africa has a very young female physicist population. The final explanation can be justified by the fact that during the apartheid years, women in general were not encouraged to pursue careers in science and numbers have increased only recently.

The number of women in upper management positions in universities, research institutes and funding agencies must be increased. However since there are few women with sufficient experience to fill these positions, younger women should be given the management training to prepare them to enter these positions later in their career.

South Africa was one of few countries at the conference that had affirmative action/equal opportunity policies to address the issues of too few women in science. The NRF's Women in Research programme and related funding programmes are also firsts in terms of policy regarding the improvement of the number of women in science. This programme does not however ensure that women choose physics, it merely makes it easier later in one's career.

4.2. Recommendations for South Africa

The recommendations that emerged from the conference have been adapted to South Africa as possible methods to address some of the problems mentioned above. Most of these recommendations, when implemented, will improve physics for both men and women.

4.2.1. General Recommendations

1. Raise the profile of physics in South African society. Sell physics as a subject that affects our daily lives. Demonstrate how physics has impacted on medicine, technology, the environment, etc.
2. Encourage written rules and policies (for example an equality policy) to achieve fairness and transparency in policies, practices, and decision-making.
3. Have transparent, gender-blind processes for important decision-making. Transparency can be aided by having a requirement for decisions to be reported and explained. Important decisions include those related to recruitment, selection, salary, promotion, peer review, conference programs, allocation of space and equipment, and other issues affecting important working conditions.
4. Create, support, and encourage networks for women physicists: locally and nationally, including an e-network. Create and publicise a women in physics web site in South Africa, with links to women in physics sites in other countries. Information on successful strategies and programs should be highlighted on the site.
5. Provide Web 'index' of links to international funding sources.
6. Involve men, especially highly respected physics leaders, in improving the climate for women (and minorities) in physics.
7. Remove barriers (e.g. unisex restrooms and dormitories) that prevent full participation of girls and women in physics.
8. Adjust the reward structure at all levels to encourage desired behaviours (e.g. promotion of physics to learners, training of teachers, etc). Use the concept of academic age, rather than actual age in recruitment, selection, salary, promotion, peer review, conference programs, allocation of space and equipment promotions, funding applications, etc. This has the advantage that women can take time off for family commitments and not be penalised in their career. Age limits on grants should be removed.
9. Create opportunities for R&D employment, funding, and research equipment
10. Provide opportunities for collaboration and exchanges between regions. Provide resources for international conference travel and for physicists from developed countries to visit as lecturers in South Africa.
11. Collect data on physics demographics, including gender regularly (every one to three years) and in a consistent manner, to watch and influence trends. Request data from national and regional physical societies. Find out why women leave physics. Use the information collected to establish mechanisms that assess and improve the climate for women (and minorities) in physics.

4.2.2. Attracting Girls into Physics (childhood to university)

1. Educate parents about the opportunities for their daughters and how to support girls' interests in science.
2. Strengthen the training of science/physics teachers and include opportunities for them to do research and to interact with working scientists. Train teachers and counsellors about gender issues (girl-friendly classroom atmosphere, examples of interest to girls). Attract qualified school teachers with fair pay, respect, and working conditions.
3. Get international help and funding for schools in developing areas
4. Involve universities, research institutes, and industries to help schools and strengthen teacher training.
5. Revise educational curricula and materials to connect physics with medicine, biology, technology, the environment, etc. and to show diverse physics career paths and job prospects. Ensure that physics and maths courses, textbooks, equipment, and funding for girls' education are as good as for boys' education, and that women physicists are featured as role models.
6. Publicize physics role models who challenge the stereotypical physicist and whose stories are examples of career success and leadership positions.
7. Help smart girls form networks e.g. clubs that provide enrichment opportunities and encouragement.

8. Attract more girls to compete in physics/science competitions e.g. the National Science Olympiad.
9. Raise boys to share family responsibilities and to expect women to have professions, i.e. sensitise them to gender issues.
10. Raise/teach boys to respect girls and their choices.

4.2.3. Launching a Successful Career (University to Mid-Career)

1. Have flexible entry and graduation requirements for physics majors, and provide early opportunities for students to participate in research.
2. Train/sensitise faculty and supervisors to gender issues (female-friendly atmosphere, respectful and collegial treatment).
3. Provide enlightened and supportive mentors and supervisors for women physicists. These people should find funding, teach the women the rules of the game and how to write successful proposals, introduce them to important professional contacts, give them challenging assignments and opportunities, provide constructive feedback on unsuccessful proposals or interviews, give them credit, and advocate them in the physics community.
4. Provide training for women physicists in presentation of results, paper writing, grant applications, etc.
5. Have open evaluation criteria for resource allocation

4.2.4. Balancing Family and Career

1. Respect and value family obligations (convenient, quality child care at workplace, during collaborative visits and at conferences, flexible working hours).
2. Pause 'career clock' and have flexible age limits and rules for grants and fellowships, to not disadvantage people who take time off for family responsibilities. (Accord career interruptions for family service the same respect as for military service.)
3. Provide funding sources to help people return to physics after a career pause.
4. Solve the dual-career couple problem by facilitating geographically co-located job opportunities and creative solutions, such as shared positions.

4.2.5. Getting Women into Physics Leadership

1. Appoint women physicists to leadership positions (not just as tokens) and include them on important committees in their institutions, countries and professional societies.
2. Involve more people in leadership. Consider innovative approaches, such as shared positions, term appointments, and novel structures.

4.3. Resolutions for South Africa

The ideas in these resolutions are aimed at bringing more women into the mainstream and leadership of physics. They were unanimously approved by the delegates at the conference.

4.3.1. Resolution Directed at Schools, the Department of Education and the Department of Arts, Culture, Science and Technology

Girls should be given the same opportunities and encouragement as boys to learn physics in schools. When parents and teachers encourage girls, it strengthens their self-confidence and helps them advance. Methods and textbooks used in teaching physics should include those that have been shown to interest girls in physics and foster their success. Studies show that young girls have a strong desire to help improve people's lives, and therefore it is important that they have the opportunity to see ways that physics has a positive impact on society.

4.3.2. Resolutions Directed at Universities

Students

Universities should examine their policies and procedures to ensure that female students are given an opportunity for success that equals that of male students. All policies that perpetuate discrimination should be abolished, and policies that promote inclusion should be adopted. This may involve adopting such practices as: using a broad interdisciplinary approach to physics; providing flexible entry criteria to the physics major; allowing early participation in research; providing mentoring; and exposing students to the important contributions physics makes to other sciences, medicine, industry and the quality of daily life. Adopting these practices will have an especially positive effect on young women, who often feel isolated and unwelcome in physics.

Staff

Recent studies have shown that, even at top research institutions, women scientists have not been treated fairly with respect to their male colleagues. This is not only very harmful to women in science but in the long run will be harmful to science as well. Universities must examine and communicate their policies and practices to make sure that they promote equity; it is of key importance that universities guarantee transparent and fair mechanisms of recruitment and promotion. Additional important elements for success are access to research funding and facilities and sufficient time for research.

Having a family should not be allowed to impede women's participation in scientific careers. A family-friendly environment that provides such things as child-care facilities, flexible working schedules and employment opportunities for dual career families will enable career success.

University governance has been found to be dominated by men. Women need to be included in university and physics department governance, particularly on key policy committees. Women must have input into those policies that control their own destinies. It is important for the development of young women physicists to see successful women active in research, teaching and leadership.

4.3.3. Resolution Directed at Research Institutes

Research institutes will benefit from policies that allow women scientists to be successful. Institute directors should make sure that policies that promote gender equity in recruitment and promotion are adopted and enforced. Too often what has been termed a "glass ceiling" is allowed to stop the advance of women's careers.

Institute directors should take an active part in ensuring that family-friendly practices such as child-care facilities and flexible working schedules are available to all. Surveys repeatedly show that a leading concern of women is balancing career and family life; having a family should not be allowed to impede successful participation in scientific research.

4.3.4. Resolution Directed at Industrial Laboratories

Industrial laboratories will benefit from policies that allow women scientists to be successful. Industrial managers and research directors should make sure that policies that promote gender equity in recruitment and promotion are adopted and enforced. Too often what has been termed a "glass ceiling" is allowed to stop the advance of women's careers.

Industrial managers should take an active part in ensuring that family-friendly practices such as child-care facilities and flexible working schedules are available to all. Surveys repeatedly show that a leading concern for women is balancing career and family life; having a family should not be allowed to impede successful participation in scientific research.

4.3.5. Resolution Directed at Scientific Societies (South African Institute of Physics, South African Women in Science and Engineering)

Scientific and professional societies can and should play a major role in increasing the number and success of women in physics. Each society should have a committee or working group that is responsible for such issues and that makes recommendations to the society as a whole. At a minimum societies should do the following things: work with other organizations to collect and make available statistical data on the participation of women in physics at all levels; identify women physicists and publicize them as role models; include women on program committees and as invited speakers for society-sponsored meetings and conferences; and include women on editorial boards of society journals.

4.3.6. Resolution Directed at National Governments

Physics plays a key role in understanding the world we live in, and physicists contribute strongly to the economic and cultural development and welfare of nations. It is therefore in every nation's self-interest to provide strong physics education for all its citizens and to support advanced education and research. Governments must ensure that women have the same access and chance for success in research and education as men. National planning and review committees should include women, and awards of government funds should only be made to organizations and institutions that make gender equity a part of their policies.

4.3.7. Resolution Directed at the National Research Foundation

Agencies that make funding available for scientific research play a key role in promoting the success of individual scientists as well as science as a whole. Past studies have shown evidence for gender bias in the review process. Therefore, to ensure that women have the same access to research funding as men, all competitions for funding should be transparent and widely publicized; the criteria for obtaining funds should be clear; and women should be included on all review and decision making committees. Limits on age of eligibility or grant structure and duration that seriously disadvantage applicants taking family leave should be reconsidered. Granting agencies should maintain and make available statistical data by gender, including such information as the proportion and qualifications of women and men who apply for funding and who obtain funding.

5. Conclusions

An issue raised at the conference was: "How do other professional women manage? What is special about women in physics?" Perhaps if these questions are answered, the solution to improving the status of women in physics will be closer. However, implementing the resolutions and recommendations will surely be the first steps to improving the situation for physics, physicists and women in physics in South Africa.

The advice that should be given to young people interested in a career in physics must include:

- Be prepared for foreign experience
- Be flexible early in your career
- Be prepared to be single
- Plan own career path, including your private life
- Use networking

while advice for older people must be to:

- Support younger people if you have them.

6. Acknowledgements

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Appendix A: South Africa's Paper

South Africa: The Rainbow Nation, Women and Physics

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A brief history of South Africa

Apartheid: a word that ruled South Africa since 1961; a word that has since become synonymous with South Africa; a word that meant that there was limited opportunity, often none for non-whites. It officially ended on 27 April 1994, a momentous day in history that will go down as South Africa's first democratic election. More importantly it will go down as the day South Africans took the first steps to restore the balance that had been upset by apartheid. As a result, South Africa is presently in the midst of great social restructuring with South Africans being more open to change. This is therefore the perfect time to highlight the problems of women, physics and women in physics since there is great hope for change.

South Africa is unlike most countries in Africa. It has a large developed-world infrastructure merged with all the problems that are typical of a developing-world country. High rates of poverty, illiteracy (results of the 1996 census showed that 36% of the population over the age of 20 was illiterate, 55% of which were women), unemployment, crime, HIV/AIDS and related issues are South Africa's major social problems. This in turn affects the country's economic stability. South Africa needs the economic growth that comes from technological development to pave the road to the future. Since scientific thinking drives technological development, South Africa desperately needs scientifically literate people. However, in a country where the need to survive comes first, scientific literacy is not given much priority.

After the 1994 elections, affirmative action policies were implemented across the country, in all walks of life, to give preference to previously disadvantaged or under-represented groups, which include non-whites and women. This has helped get women into careers where there were none before.

Physics in a Slump

Physics in South Africa is in a slump at the moment. This can be seen in schools, at the undergraduate level and at the research level.

Prior to 1994, 90% of the country's Education funds went to 20% of the population (White). Blacks were largely excluded from an education in science and mathematics. Although 10 years of education is now compulsory and free for all South Africans, improving science and mathematics education is extremely difficult due to lack of infrastructure and teachers. In 2000, 60% of South African schools had electricity, 64% had access to telephones and 12% had access to computers. Many South African schools do not have access to books or laboratory equipment to perform the most basic of experiments. South Africa also has 11 official languages and while English is often the language of instruction, a Black language is the language of understanding. There are also many un- and under-qualified teachers presently teaching science. The South African government has released a document entitled "National Strategy for Mathematics, Science and Technology Education in General and Further Education and Training" [1] which describes the problems being faced and outlines a plan for increasing the number of teachers and improving the standard of science education. There are also plans for all schools to have electricity and telephone access within the next three years.

At universities, students see an uncertain, low-paying career in physics research and opt for the safer, high profile jobs offered by engineering, IT and the finance sector. There are also fewer bursaries offered to study physics at universities and while most physics students used to be White, these are now leaving the country. There are non-whites interested in physics but they are often unprepared for university physics. This has generally resulted in a steep decline in the numbers of students choosing physics at university. There are however certain Physics Departments (e.g. University of Natal-Pietermaritzburg) that have experienced an increase in the number of students because of (amongst others) programmes to help unprepared students.

At the research level funding has in general not been increased by government over the past few years. Companies that employ physicists have in many cases undergone some form of restructuring, forcing many of the physicists who lost jobs to leave the country.

Women, Society and Physics

The average South Africa woman faces many hardships in her daily life, with violence against women being a dominant problem. The government has done a great deal to empower women, as can be seen by the

number of women now in high-profile positions but it is difficult to improve the quality of life of all women in the country.

As a result of apartheid, South Africa's physics research environment was dominated by white (Afrikaans speaking) males, and it is taking time to balance things out. Women who choose a career in physics have problems of their own. They are discouraged from an early age by parents and teachers not to study physics, do not fit into the male-dominated research environment, have to work harder for promotions, funding, respect and find it difficult to be taken seriously by male colleagues. Women in the work-place are often treated as outsiders and many feel unwelcome. Most white men in South Africa have no idea what it feels like to be an outsider in a work place - how it eats at one's confidence and drives one to look for other jobs or turn down potential employment.

On the lighter side, it has emerged that female physicists have experienced a greater success than their male counterparts with getting technicians to help them out!

Physics: Out of the Lab!

The traditional idea is that choosing physics means choosing academia and research. What needs to be emphasised to society is that choosing physics means being trained to solve problems. A result of the abstract nature of physics as a subject is that students learn to handle abstract problems and are then better equipped to tackle problems of any nature from any sector. While most physicists choose academia and research, there is a small percentage of physicists in South Africa that have chosen to go into sectors ranging from business to industry to finance.

As was concluded [2] at the 2000 IUPAP Conference on Physics and Industrial Development (COPID 2000), for physics to thrive in the developing world there has to be greater alignment between physics, industry and the developmental needs of the country. While physicists working in industry in the developed world have made significant contributions to innovation, this technological wave is yet to pass through the developing world [2]. It is these accomplishments that must be used as selling points to prospective physics students, not only academia and research. This will raise the profile of physics, hopefully attracting more women to the field, as well.

Pot of Gold at the End of the Rainbow?

There is a pot of gold for the Rainbow Nation and it all starts now, in the midst of this period of transition. The starting point is taking physics out to the people, de-mystifying it and de-Einsteinizing it. Physics must not be sold as a "genius" subject. Children should not be told (as they often are!) that they are not smart enough to do physics. Girls must be encouraged to explore the beauty of Nature from the Physical Science's point of view. The encouragement for girls to pursue physics should come from those women who have already done so. This means that female physicists must be made more visible to society by, for example, visiting schools to expose young girls to physics. These visits must be coupled with a science-awareness programme for their parents and teachers to encourage girls to choose science.

Women in physics in South Africa should also band together and use their resources around the country to try to raise the profile of women in physics in the country. At present there is no network for South African women physicists and a way to address this problem would be to create one.

Lending a helping hand

There are organisations currently working on improving the status and working conditions of women in science. There is strong support from the National Research Foundation, the South African science funding entity, encouraging established researchers to take on female students. There is also pressure from top levels at universities to employ women but there has sadly been little response to advertisements for these posts.

A "Women-in-Research" programme (<http://www.nrf.ac.za/wir/>) has been established by the National Research Foundation. The programme seeks to stimulate discussion, and address key issues that affect women researchers. Of particular concern is the serious under-representation of women among senior researchers, heads of departments, senior management and among those who access resources from funding agencies and organisations, which has resulted in their limited participation in national discourses and research agendas. The programme aims to:

- Support women, especially non-white women, to develop and strengthen their research skills
- Increase the number of women in postgraduate studies, academia, research and in leadership positions at South African tertiary and research institutions.

The Association of South African Women in Science and Engineering (SAWISE) has a membership drawn from all fields of science and engineering. SAWISE has carried out many awareness activities in order to raise the profile of women scientists in South Africa. They often organise trips for young girls to promote science as a career. They also provide a bursary for honours study in Science and Engineering fields.

The Foundation for Education, Science and Technology started hosting Science Summer Camps for girls in 2000. Each camp focuses on a different scientific theme and promises to be a regular event.

The South African Institute of Physics (SAIP) is the only professional body for physicists in the country. Unfortunately the SAIP has been dominated for most of its existence by white, Afrikaans-speaking, men, thereby alienating many (even male) physicists. Fortunately, the composition of the SAIP has been changing over the past few years and the Institute is presently involved in a transformation process to bring it in-line with the current needs of physics and physicists in South Africa. At present change can be seen in the structure of the Council of the SAIP since there are now three women on the Council of 10. 2001 also saw the first woman elected to the presidency of the SAIP in its 46-year history. Having a woman in this position can only be a good thing for the future of increasing the number of women physicists in the country.

Over the Rainbow

At the annual Conference of the SAIP in 2001, the Vice-Chancellor of the University of Natal pointed out to the physicists present that the future of physics lies in the hands of the physicists. Perhaps as women in physics, we should take the initiative to improve the future for women in physics and work together to increase our numbers.

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Appendix B: Recommendations from Conference

These are the original recommendations from the Conference.

Introduction

Many specific recommendations emerged during the conference. Not all will be applicable to all countries or situations. They should be reviewed by each country team, which should translate the applicable ones and work to implement them in their country. The recommendations are grouped into categories, but many are likely to have impact in other categories, too. Note that most of these recommendations, when implemented, will improve physics for both men and women.

General Recommendations

1. Coordinate data collection and access internationally on physics demographics, including gender, to watch and influence trends. Collect data regularly (every one to three years) and in a consistent way, to watch and influence trends. Request data from national and regional physical societies. Find out also why women leave physics.
2. Create, support, and encourage networks for women physicists: local, national, international, including a world-wide e-network. Create women-in-physics web pages in each country, with links to each other and to information on successful strategies and programs. Provide a well publicized international web presence for Women in Physics.
3. Involve men, especially highly respected physics leaders, in improving the climate for women (and minorities) in physics.
4. Have transparent, gender-blind processes for important decisionmaking. Transparency can be aided by having a requirement for decisions to be reported and explained. Important decisions include those related to recruitment, selection, salary, promotion, peer review, conference programs, allocation of space and equipment, and other issues affecting important working conditions.
5. Establish mechanisms to assess and improve the climate for women (and minorities) in physics. Proven approaches include creating special committees for women in physics and focusing resources and attention on this issue. Examples include having a source of matching funds for initial years of a tenure-track position filled by a woman, and committees that visit universities, research institutes, and other physics employers to advise on their climate for women.
6. Encourage written rules and policies (for example an equality policy) to achieve fairness and transparency in policies, practices, and decision making.
7. Provide Web 'index' of links to international funding sources.
8. Remove barriers to full participation of girls and women (restrooms, dormitories, etc).
9. Adjust the reward structure at all levels to encourage desired behaviors.

Attracting Girls into Physics (childhood to university)

1. Revise educational curricula and materials to connect physics with medicine, biology, technology, the environment, etc. and to show diverse physics career paths and job prospects. Ensure physics courses, math courses, textbooks, equipment, and funding for girls' education are as good as for boys' education, and feature women physicists as role models.
2. Strengthen the training of science/physics teachers and include opportunities for them to do research and to interact with working scientists. Train teachers and counsellors about gender issues (girl-friendly classroom atmosphere, examples of interest to girls). Attract qualified school teachers with fair pay, respect, and working conditions.
3. Publicize physics role models who counteract the stereotypes and whose stories are examples of career success and leadership positions.
4. Educate parents about opportunities for daughters and how to encourage them.
5. Help smart girls network (clubs, enrichment opportunities, and encouragement).
6. Attract more girls to compete in prestigious physics competitions.

7. Raise boys to share family responsibilities and to expect women to have professions.
8. Get international help and funding for schools in developing countries
9. Involve universities, research institutes, and industries to help schools and strengthen teacher training.

Launching a Successful Career (University to Mid-Career)

1. Have flexible entry and graduation requirements for physics majors, and provide early opportunities for students to participate in research.
2. Train/sensitize faculty and supervisors to gender issues (female-friendly atmosphere, respectful and collegial treatment).
3. Provide enlightened and supportive mentors and supervisors for women physicists. These people should find funding, teach the women the « rules of the game » and how to write successful proposals, introduce them to important professional contacts, give them challenging assignments and opportunities, provide constructive feedback on unsuccessful proposals or interviews, give them credit, and advocate them in the physics community. .
4. Provide training for women physicists in presentation of results, paper writing, grant applications, etc.
5. Shorten the post-post-doc phase with its inherent insecurity and relocation requirements.

Balancing Family and Career

1. Respect and value family obligations (quality child care convenient to workplace and at conferences, flexible working hours).
2. Pause 'career clock' and have flexible age limits and rules for grants and fellowships, to not disadvantage people who take time for family responsibilities. (Accord career interruptions for "family service" the same respect as for "military service")
3. Provide funding sources to help people return to physics after a career pause.
4. Solve the dual-career couple problem by facilitating geographically co-located job opportunities and creative solutions, such as shared positions.

Getting Women into Physics Leadership

1. Appoint women physicists to leadership positions and include them on important committees in their institutions, countries, professional societies, and IUPAP.
2. Involve more people in leadership. Consider innovative approaches, such as shared positions, term appointments, and novel structures.

International Aspects

1. Create opportunities for R&D employment, funding, and research equipment in developing countries (not just factories employing cheap labor).
2. Provide opportunities for collaboration and exchanges between regions and countries. Provide resources for conference travel for physicists from developing countries, and for physicists from developed countries to be visiting lecturers in developing countries.
3. Establish and sponsor international speaker program(s) for women physicists: web-accessible data base of names and topics; source of travel support.
4. Sponsor prestigious, topical international physics summer schools with female and male speakers, organizers, and participants.

Appendix C: Resolutions from Conference

These are the original resolutions from the Conference. They were unanimously approved by the delegates at the conference.

Introduction

Physics plays a key role in understanding the world we live in, and physicists contribute strongly to the welfare and economic development of nations. The knowledge and problem-solving skills of physicists are essential in many professions and industries and to society at large. To thrive in today's fast-changing, technological world, every country must achieve a highly educated population of women and men, fully engaged in making decisions important to their well being.

Thus a knowledge of physics is an important part of general literacy for every citizen. In addition, advancing physics understanding is an exciting intellectual challenge that benefits from the diverse and complementary approaches taken by both women and men from many cultures. Currently women can and do contribute to this quest and, through physics, to the welfare of humankind, but only in small numbers: women are an underutilized "intellectual reserve." Only when women participate fully as researchers in the laboratory, as scientific leaders and teachers, and as policy makers will they feel equal partners in a technological society.

The ideas in these resolutions are aimed at bringing more women into the mainstream and leadership of physics. They were unanimously approved by over 300 physicists from 65 countries attending the first International Conference on Women in Physics, held in Paris, France, 7-9 March 2002.

Each country is different. Thus the conference participants are translating these resolutions into their own languages. In the translation, the ideas in the resolutions will be appropriately phrased and directed to the responsible entities in each country.

1. Resolution Directed at Schools and Their Government Sponsors

Girls should be given the same opportunities and encouragement as boys to learn physics in schools. When parents and teachers encourage girls, it strengthens their self-confidence and helps them advance. Methods and textbooks used in teaching physics should include those that have been shown to interest girls in physics and foster their success. Studies show that young girls have a strong desire to help improve people's lives, and therefore it is important that they have the opportunity to see ways that physics has a positive impact on society.

2. Resolutions Directed at Universities

2.1 Students

Universities should examine their policies and procedures to ensure that female students are given an opportunity for success that equals that of male students. All policies that perpetuate discrimination should be abolished, and policies that promote inclusion should be adopted. This may involve adopting such practices as: using a broad interdisciplinary approach to physics; providing flexible entry criteria to the physics major; allowing early participation in research; providing mentoring; and exposing students to the important contributions physics makes to other sciences, medicine, industry and the quality of daily life. Adopting these practices will have an especially positive effect on young women, who often feel isolated and unwelcome in physics.

2.2 Faculty and Researchers

Recent studies have shown that, even at top research institutions, women scientists have not been treated fairly with respect to their male colleagues. This is not only very harmful to women in science but in the long run will be harmful to science as well. Universities must examine and communicate their policies and practices to make sure that they promote equity; it is of key importance that universities guarantee transparent and fair mechanisms of recruitment and promotion. Additional important elements for success are access to research funding and facilities and sufficient time for research.

Having a family should not be allowed to impede women's participation in scientific careers. A family-friendly environment that provides such things as child-care facilities, flexible working schedules and employment opportunities for dual career families will enable career success.

University governance has been found to be dominated by men. Women need to be included in university and physics department governance, particularly on key policy committees. Women must have input into

those policies that control their own destinies. It is important for the development of young women physicists to see successful women active in research, teaching and leadership.

3. Resolution Directed at Research Institutes

Research institutes will benefit from policies that allow women scientists to be successful. Institute directors should make sure that policies that promote gender equity in recruitment and promotion are adopted and enforced. Too often what has been termed a "glass ceiling" is allowed to stop the advance of women's careers.

Institute directors should take an active part in ensuring that family-friendly practices such as child-care facilities and flexible working schedules are available to all. Surveys repeatedly show that a leading concern of women is balancing career and family life; having a family should not be allowed to impede successful participation in scientific research.

4. Resolution Directed at Industries

Industries will benefit from policies that allow women scientists to be successful. Industrial managers and research directors should make sure that policies that promote gender equity in recruitment and promotion are adopted and enforced. Too often what has been termed a "glass ceiling" is allowed to stop the advance of women's careers.

Industrial managers should take an active part in ensuring that family-friendly practices such as child-care facilities and flexible working schedules are available to all. Surveys repeatedly show that a leading concern for women is balancing career and family life; having a family should not be allowed to impede successful participation in scientific research.

5. Resolution Directed at Scientific Societies

Scientific and professional societies can and should play a major role in increasing the number and success of women in physics. Each society should have a committee or working group that is responsible for such issues and that makes recommendations to the society as a whole. At a minimum societies should do the following things: work with other organizations to collect and make available statistical data on the participation of women in physics at all levels; identify women physicists and publicize them as role models; include women on program committees and as invited speakers for society-sponsored meetings and conferences; and include women on editorial boards of society journals.

6. Resolution Directed at National Governments

Physics plays a key role in understanding the world we live in, and physicists contribute strongly to the economic and cultural development and welfare of nations. It is therefore in every nation's self-interest to provide strong physics education for all its citizens and to support advanced education and research. Governments must ensure that women have the same access and chance for success in research and education as men. National planning and review committees should include women, and awards of government funds should only be made to organizations and institutions that make gender equity a part of their policies.

7. Resolution Directed at Granting Agencies

Agencies that make funding available for scientific research play a key role in promoting the success of individual scientists as well as science as a whole. Past studies have shown evidence for gender bias in the review process. Therefore, to ensure that women have the same access to research funding as men, all competitions for funding should be transparent and widely publicized; the criteria for obtaining funds should be clear; and women should be included on all review and decision making committees. Limits on age of eligibility or grant structure and duration that seriously disadvantage applicants taking family leave should be reconsidered. Granting agencies should maintain and make available statistical data by gender, including such information as the proportion and qualifications of women and men who apply for funding and who obtain funding.

8. Resolution Directed at IUPAP

IUPAP is the international organization of physicists and as such exerts considerable influence on the physics community through its statements and activities. IUPAP should both endorse the above resolutions aimed at other groups and also examine its own actions to make sure that they contribute to increasing the number and success of women in physics. It will also be valuable for IUPAP to communicate the results of this conference to international scientific organizations in other fields. In the election of IUPAP's Executive Council and Commission members, procedures should be instituted to ensure the full inclusion of women.

IUPAP sponsors major international conferences; a criterion for such sponsorship should be the demonstration that women are included on the International Advisory Committees and Program Committees. IUPAP should require conference organizers to report gender distribution of invited speakers. IUPAP should encourage all of its national Liaison committees to include women among their members. Liaison committees should also advocate these resolutions in their countries. IUPAP should continue its Working Group on Women Physics and empower it to establish an international advisory committee with a member in as many countries as possible. Finally, this group will form the basis of a network that can continue the work of increasing the number and success of women in physics