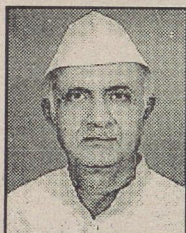


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Prof. V.V. Narlikar: A Tribute

P.C. VAIDYA

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PC VAIDYA

[This is a tribute to the memory of the late Professor V.V. Narlikar, one of the most distinguished Indian Mathematicians of the present century who passed away on April 1, 1991 at the age of 83. The author, Professor P.C. Vaidya was Professor Narlikar's student and consequently the tribute has a personal touch.]

Professor Vishnu Vasudev Narlikar who died at Pune on April 1, 1991 at the age of 83 was a great teacher of mathematics, a pioneer researcher in India on Einstein's Theory of Relativity, a popular orator on scientific topics and a warm personality.

Prof. Narlikar passed his B.Sc. examination in Mathematics from Bombay University in 1928 obtaining 96 per cent marks and went on to Cambridge for higher studies. He was awarded the prestigious Isaac Newton Studentship for 1930 and for three years 1931-34. Among his fellow students were H.J. Bhabha, S. Chandrashekhar and D.S. Kothari and his teachers included great mathematicians like Besicovitch, Cunningham, Eddington and Dirac.

In 1932 he returned to India and taught mathematics at Banaras Hindu University till 1960. After a stay of 6 years at Ajmer as Chairman of Rajasthan Public Service Commission, he became professor at the University of Poona in 1966. He retired in 1973 and spent the last 18 years in retirement with his son Dr. Jayant Narlikar.

Prof. Narlikar was a teacher-mathematician. This compound word implies something more than a teacher and a mathematician. A teacher-mathematician is one who uses teaching methods in mathematical research and research methods in mathematics teaching.

Students who had the good fortune of sitting in his class had experienced his enjoyable teaching. In the interview he gave to Dr. Mrs. A.R. Singal (Mathematical Education), he says:

"When I started teaching mathematics at Benaras, I was more self-critical and I found

that there were so many gaps and voids in my understanding of the topic I taught."

Elsewhere he points out the reasons for these gaps.

"The mathematics of the 80's is going to be different from that of the 70's just as the mathematics of the 70's was different from that of the 60's. You see the mathematics that I had learnt was of little use to me when I went to Cambridge (in 1928). Then the mathematics after October 4, 1957, when Sputnik-I went up, became a different mathematics altogether".

So a conscientious teacher of such a rapidly developing subject like mathematics will certainly find gaps and voids in his understanding of the subject. He must learn several topics by himself and that leads Professor Narlikar to say further that

"That first lesson that I learnt was: One cannot be a good teacher, a successful teacher without being always absorbed in the research topics concerned with his lectures".

The point to be noted is the last phrase of the above quotation. A researcher is absorbed in the research topics of his own speciality. The above three successive quotations of Professor Narlikar lead one to the conclusion that to be a good teacher one must be absorbed in research on topics of his lecture! Generally one teaches under graduate and / or post graduate classes and also carries out research in his speciality. But normally a teacher teaches several topics in his class which may not be topics of his research speciality. Professor Narlikar believed that a good teacher must keep contact with research in those

topics which he has to teach so that he conveys to the students no stale knowledge but the knowledge of a growing lively subject.

Professor V.V. Narlikar's mathematics classes were always enjoyable and his popular talks (on Mathematical topic) were always well appreciated because of his research oriented method of presenting a topic.

He also said, "it is necessary to intersperse lectures of a teacher with a period of silence to allow the students time to ponder". He adopted this technique even while supervising research of his Ph.D. students. He would discuss a research problem with a student and then would avoid meeting the students for a few days to give him time to ponder and arrive at his solution.

To bring into focus another trait of Prof. Narlikar's character, viz. Academic Integrity, I would now narrate my personal experience as his research student in 1942-43. He suggested to me to take up the then-outstanding problem of working out the gravitational field of a radiating star in Einstein's theory.

Both of us started working on this problem together. We enunciated the problem in the following energy manner: to calculate the gravitational field of flowing by comparing the radiation flowing out of a star with the flow of a fluid. For this comparison fluid the current belief was that if it is to represent radiation, the density should be three times the pressure. We started out work on the basis of this current understanding but we found it difficult to derive any tangible conclusion. Once during discussion I suggested that instead of assuming the pressure density relation, why not work on the basis of velocity! If the fluid is to represent the flow of radiation, the fluid velocity must be assumed to be the velocity of radiation. i.e. the velocity of light. Professor readily agreed and said, "yes, that is what we should have done!". And we started recasting our calculations to suit the new assumptions and at that very sitting Professor Narlikar derived the first tangible equation. The sitting ended with a happy note and with the hope that I shall be able to derive the other two equations.

Left with the task of working out the remaining equations of our problem, it so happened that I could not see him for 2 weeks (Normally I used to meet him twice every week) thus providing me 'time to ponder'. Well, the net result was that not only did I derive the other two equations of the problem but solved the 3 equations simultaneously and came up with the complete solution of the problem.

We wrote down the final solution in the form of a paper for publication. And Professor Narlikar put down only my name as the author of that paper. The usual practice is that the Professor who has suggested the problem becomes the first author of the paper and student's name is included as a joint author. But Professor Narlikar did not follow that routine because the main idea which provided a break through in this research was provided by me and so he gave the full credit of that research to me. Today, when I think about it, I realise that Professor Narlikar very well knew the importance of this solution and even if he had just added his name as a joint author, this solution would have been known as 'Narlikar's solution'. And that point of time I was too young to understand such points. So the solution known today as 'Vaidya Metric' could easily have been credited to his name if he had so desired. And that would have been in accordance with prevailing norms. But he preferred to stick to purer academic norms and decided that when the principal idea leading to the solution came from Vaidya, the credit of the work must go to him. What a fine example of academic integrity!

Professor Narlikar was very fond of reading and would quote from a number of sources during his talks. His popular expositions of scientific topics were a treat to hear.

Professor Narlikar's sons, Jayant and Anant are scientists in their own right. Dr. Jayant Narlikar is a well-known astrophysicist and science fiction writer in Marathi and is currently the Director of the Inter University Centre for Astronomy and Astrophysics at Pune. Dr. Anant Narlikar is a deputy director of National Physical Laboratory in Delhi.

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PROFESSOR V. V. NARLIKAR—MY TEACHER

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Vishnu Vasudev Narlikar

(1908 - 1991)

Foundation Fellow

Vishnu Vasudev Narlikar was a pioneer Relativist in India, a great teacher of mathematics, a popular orator on scientific topics and a very warm personality.

Family Background and Education :

He was born on 26th September 1908 at Kolhapur, the capital of an erstwhile princely state in Maharashtra. [The family in which he was born was a very devote and religious family. His father Vasudev Narlikar was a religious scholar and his sermons on Bhagvat Puran were heard with rapture by large audiences. This religious strain was also seen in the character of Vishnu Narlikar and in his remarkable fondness for reading Sanskrit books and books of all religions. His wife, Mrs. Sumati Narlikar is a Sanskrit Scholar.]

He had his primary and high school education at Kolhapur. In school he was known as a very bright student. At the matriculation examination (1924) of Bombay University he won the Sir Le Grand Jacob Scholarship.

[The financial position of the family was not that good, but he was able to persue higher ~~stud~~ education with the help of scholarship, he won.] He went to Bombay in 1924 and joined the Elphinston College and the Royal Institute of Science. [His college career was a great distinction.] At the B.Sc. (Hons.) examination (1928) of Bombay University, he marks in Mathematics. He went to England for higher studies. [Financially he got a loan scholarship for this from J.N.Tata Endowment and from Kolhapur State. He was also awarded Sir Mangaldas Nathubhai Travelling Fellowship of the University of Bombay.] He joined Fitzwilliam House of Cambridge University and passed the Mathematics Tripos II in 1930 and became a B* e wrangler. At this examination he stood first in Astronomy and got Tyson medal.

He began his further studies under Professor H.F.Baker and attended his lectures on "Brown's Lunar Theory". In July 1930, he began work on Liapounov's famous paper on rotating fluid bodies. [In September 1930 he gave a written review of Liapounov's method, work and achievements. Professor H.F.Baker was too busy with other work and he sent the review to Professor J.Larmor, under whose guidance Narlikar was to work further ~~On the basis of this work further.~~] On the basis of this work he was awarded Sir Isaac Newton Studentship [for one year in the first instance. A year afterwards the award was made for three more years.] He had already begun work under Prof.R.S.Eddington on Relativity and Eddington's Fundamental Theory. [The first ten items of the list of publications refer to this period at Cambridge where he was awarded a Rayleigh Prize in April 1932 for distinguished research work.]

In May 1932 he returned to India with the intention of resuming his work at Cambridge for two more years from October 1932. However in August 1932 he was offered excellent opportunities of teaching and research by the Banaras Hindu University. He accepted the offer and attended his formal education and research training and he began his professional academic career at the age of 25. He taught at B.H.U. for 28 years till 1960. After a stint at Rajasthan Public Service Commission (as its Chairman) for six years he became Lokmanya Tilak Professor of Mathematics at the University of Poona and retired in 1973.

Research Activities :

Narlikar was a pioneer relativist in India. After joining B.H.U. he had several student collaborators working with him in General Relativity, Gravitation and Cosmology. Soon this evolved into an active research school at Banaras and later at Poona. Some outstanding work carried out at this school is described below. (Figures in brackets refer to serial number of the paper in the list of publications

given at the end).

In 1947 Dr.K.R.Karmarkar had produced a number of interesting papers on the problems of equivalence of metrics but the two papers which received considerable attention were joint papers with Narlikar on the curious solution of Einstein's field equations (47) and on the fourteen scalar invariants of a general gravitational metric (58). As regards the latter, Professor A.R.Prasanna, a student of the Poona school writes :

" In 1922 the noted mathematician T.Y. Thomas had proved that in Riemannian ~~xxxxxxx~~ manifold of 4 dimension, only fourteen independent curvature invariants can be constructed. But the explicit construction of these fourteen invariants using the curvature tensor and the Weyl tensor and the metric tensor was given only in 1946 by Narlikar and his student Karmarkar. However, as this was published in the Proceedings of the Indian Academy of Sciences, it was not known outside where the credit had been given to Gehenau and Debever who did the same work in 1952. In fact I had the privilege of pointing this out to Prof.Gehenau in 1972 at the Dirac Symposium and he himself suggested that these invariants should be called Narlikar-Karmarkar invariants. One hopes that this will go into the literature and the credit due to Professor Narlikar is given".

About this time Einstein's Unifield Field theory of Gravitation and Electromagnetism was out. Dr.Ramjis Tiwari examined the nature of j_i interaction between the electromagnetic field and the gravitational. Very lengthy calculations were carried out independently by him and Professor Narlikar and several papers explaining the character of the interactions came out in 1948-49 (62,63,64).

Dr.P.C.Vaidya, while working at Banaras had obtained the relativistic solution of a non static mass ~~of~~ in 1943. A few years later Narlikar and Vaidya published some papers jointly on the electromagnetic effects of such fields (53,54). Vaidya's solution (1943) has now become famous

in general relativity.

After 1950, Narlikar and K.P. Singh commenced a series of joint investigations on physical significance of several metric invariants. Among several publications of this period may be mentioned ^{one} the ₁ on the role of three index symbols in general relativity (67) where an analysis is made of the indeterminateness implicit in the coordinates of general relativity and a new derivation of the inverse square law is given.

Dr. B.R. Rao, another student of Professor Narlikar at Banaras, worked on the derivation of the equations of motion from the field equations themselves. His important results have been reported in a joint paper published ~~by~~ in 1955(69). This was followed by several other papers including the one on the calculations of the *motion* of the perihelion of Mercury in 1959.

At the University of Poona (1966-1973) several students including Professor A.R. ~~Prassana~~ⁿ, Prof. N. Dadhich, Dr. R.S. Tikekar and Dr. P.P. Kale worked on problems arising out of Petrov classifications, generalised field equations, spherically symmetric metrics and their curvatures etc.

It will be seen from the above that the main research areas developed by the Banaras and Poona schools were :

- (i) Exact solutions of Einstein's equations of general relativity.
- (ii) The solutions of the unified field equations of Einstein and Schrodinger.
- (iii) Equations of motion as derived from field equations.
- (iv) The fourteen scalar differential invariants of the Riemannian metric and their physical significance.
- (v) The geometrical and physical properties of metrics satisfying Einstein's field equations.

About 20 young men were associated with him in research in these areas during 1932-1973. Most of them got doctorates, but what is more important, many of them continued their research and formed their research groups. Thus a small seedling planted by Narlikar at BHU in the early thirties has now flowered into a big banyan tree.

A Conscientious Teacher :-

At Banaras Narlikar had opportunities to learn and teach many topics in Mathematics such^{as} (1) Modern Algebra (2) Groups, characters and their applications (3) Wave Mechanics (4) Spinors and their applications (5) Hilbert's space and quantum mechanics (6) Stellar structure as it developed after 1940 etc.etc.

For his^m teaching and research were complementary. He could best be described as a teacher mathematician. A teacher-mathematician—more than a teacher and a mathematician—is one who uses teaching methods in mathematical research and research methods in mathematics-teaching. His philosophy of teaching can best be judged from his writings and lectures. At one place he has stated, 'When I started teaching mathematics at Banaras, I was more self critical and I found that there were so many gaps and voids in my understanding of the topic I taught'. Elsewhere he has pointed out the reasons for these gaps: 'Mathematics of the eighties is going to be different from that of the seventies just as the mathematics of the seventies was different from that of the sixties. The mathematics that I learnt as a student differed very much from the mathematics. I was called upon to teach'. He therefore concluded, 'The first lesson that I learnt was: one cannot be a good teacher, a successful teacher, without being always absorbed in the research topics concerned with his lectures'. His mathematics classes were always enjoyable and his popular talks on mathematical topics were always well appreciated because of his research oriented method of presenting a topic.

It was ~~mentioned~~ mentioned earlier that Narlikar used teaching methods in guiding mathematical research. To illustrate this, best way seems to be that the present author recounts his personal experience as Narlikar's research student in 1942-42. Incidentally that will bring into focus another trait of this teacher.- ~~xxxxxx~~ mathematician- his transparent academic integrity.

AV "Narlikar suggested that I should work on the problem of the gravitational field of a radiating star. We began working on the problem together. We enunciated the problem in the following manner: to calculate the gravitational field of flowing energy by comparing the radiation flowing out of a star with the flow of a fluid. For such a comparison, the current belief was that, if the fluid were to represent radiation, its density should be three times the pressure. We started our work on the basis of the understanding but found it difficult to derive any tangible conclusion. Once, during discussion, I suggested that, instead of assuming the pressure density relation, we might work on the basis of velocity; if the fluid is to represent the flow of radiation the fluid velocity must be assumed to be the velocity of the radiation. ~~i.e. the velocity of the radiation~~, i.e. the velocity of light. Professor readily agreed and said ' Yes, that is what we should have done ! We recast our calculation to suit the ^{no} ~~new~~ ^{ew} assumption and at that very sitting Narlikar derived the first tangible equation. This sitting ended on a happy note and with the hope that I would be able to derive the other two equations.

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Epilogue :-

Narlikar was the found^{er} fellow of all the three science academies in India. He was a fellow of the Royal Astronomical Society. He was president of the Calcutta Mathematical Society (1958-60) and of the Indian Mathematical Society (1981). But above all, he was revered by the present generation of Indian relativists as Grandpa Narlikar.

As mentioned earlier his wife Mrs. Sumati Narlikar is a Sanskrit scholar

A book containing lectures delivered by her in Sanskrit has been published under the title Sumati Darshanam. ~~They have~~

They have two sons, Jayant and Ananta. Dr. Jayant Narlikar is a well-known astrophysicist and science fiction writer in Marathi and is currently director of the Inter University Centre for Astronomy and Astrophysics. Dr. Anant Narlikar is a deputy director of National Physical Laboratory in Delhi.

Professor Narlikar spent his retired life with his son Jayant. He died at Pune on April 1, 1991 due to old age.

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In describing teaching methods, Professor Narlikar ~~derived~~ had once mentioned, ' it is necessary to intersperse lecture of a teacher by a period of silence to allow the students time to ponder. " He used this teaching method in my case. Left with the task of working out the remaining equations of our problem, it ~~is~~^{so} happend that I could not see him for 2 weeks, (Normally I used to meet him twice every week) thus providing me ' time to ponder '. Well, the net result was that not only did I derive the other two equations of the problem but solved the 3 equations simulteneously and came up with the complete solution of the problem. At that stage, I was over joyed because within 8 months of my joining research, I had with me a solution of an outstanding unsolved problem. It is only now that I realise how much of this was due to the teaching method of " proving time to ponder " so effectively used by Professor Narlikar.

We wrote down the final solution in the form of a paper for publication. And Professor Narlikar put down only my name as the author of that paper. The usual practice is that the Professor who suggested the problem becomes the first author of the paper and student's name is included as a joint author. But ~~the~~ Professor Narlikar did not follow that routine because the main idea which ^{gave} ~~divided~~ a break through in this research was provided by me and so he gave the full credit of that research to me. Today, when I think about it, I realise that Professor Narlikar very well knew the importance of this solution and even if he had just added his name as a joint author, the solution would have been known as 'Narlikar's solution'. And at ^{at} the point of time I was too young to understand such points. So the solution known to-day as 'Vaidya metric' could easily have been credited to his ~~xxxxxxx~~ name if he had so desired. And that would have been in accordance with prevailing norms. But he preferred to stick to purer academic norms and decided that when the principal idea leading to the solution came from Vaidya the credit of the work must go to him. What a fine example of academic integrity !

Professor Narlikar was very fond of reading and would quote from a number of sources during his talks. His popular expositions of scientific topics were a treat to hear.

He was the President of the Calcutta Mathematical
Society (1958-60) and President of the ~~mathematics~~
mathematics section of the Science Congress (1953).



Dr. Harbikan

VISHNU VASUDEV NARLIKAR

(1908 - 1991)

Foundation Fellow

VISHNU VASUDEV NARLIKAR was a pioneer Relativist in India, a great teacher of mathematics, a popular orator on scientific topics and a very warm personality.

FAMILY BACKGROUND AND EDUCATION

He was born on 26th September 1908 at Kolhapur, the capital of an erstwhile princely state in Maharashtra. The family in which he was born was a very devout and religious family. His father Vasudev Narlikar was a religious scholar and his sermons on Bhagvat Puran were heard with rapture by large audiences. This religious strain was also seen in the character of Vishnu Narlikar and in his remarkable fondness for reading Sanskrit books and books of all religions. His wife, Mrs Sumati Narlikar is a Sanskrit Scholar.

He had his primary and high school education at Kolhapur. In school he was known as a very bright student. At the matriculation examination (1924) of Bombay University he won the Sir Le Grand Jacob Scholarship. The financial position of the family was not that good, but he was able to persue higher education with the help of scholarships he won. He went to Bombay in 1924 and joined the Elphinston College and the Royal Institute of Science. His college career was of great distinction. At the BSc (Hons) examination (1928) of Bombay University, he stood first class first with record breaking marks in mathematics. He went to England for higher studies. Financially he got a loan scholarship for this from JN Tata Endowment and from Kolhapur State. He was also awarded Sir Mangaldas Nathubhai Travelling Fellowship of the University of Bombay. He joined Fitzwilliam House of Cambridge University and passed the Mathematics Tripos II in 1930 and became a B* Wrangler. At this examination he stood first in Astronomy and got Tyson Medal.

He began his further studies under Professor HF Baker and attended his lectures on "Brown's Lunar Theory". In July 1930, he began work on Liapounov's famous paper on rotating fluid bodies. In September 1930 he gave a written review of Liapounov's

method, work and achievements. Professor HF Baker was too busy with other work and he sent the review to Professor J. Larmor, under whose guidance Narlikar was to work further. On the basis of this work he was awarded Sir Isaac Newton Studentship for one year in the first instance. A year afterwards the award was made for three more years. He had already begun work under Prof AS Eddington on Relativity and Eddington's Fundamental Theory. The first ten items of the list of publications refer to this period at Cambridge where he was awarded a Rayleigh Prize in April 1932 for distinguished research work.

In May 1932 he returned to India with the intention of resuming his work at Cambridge for two more years from October 1932. However in August 1932 he was offered excellent opportunities of teaching and research by the Banaras Hindu University. He accepted the offer and then ended his formal education and research training and he began his professional academic career at the age of 25. He taught at BHU for 28 years till 1960. After a stint at Rajasthan Public Service Commission (as its Chairman) for six years he became Lokmanya Tilak Professor of Mathematics at the University of Poona and retired in 1973.

RESEARCH ACTIVITIES

Narlikar was a pioneer relativist in India. After joining BHU he had several student collaborators working with him in General Relativity, Gravitation and Cosmology. Soon this evolved into an active research school at Banaras and later at Poona. Some outstanding work was carried out at his school is described below. (Figures in brackets refer to serial number of the paper in the list of publications given at the end.)

In 1947 Dr KR Karmarkar had produced a number of interesting papers on the problems of equivalence of metrics but the two papers which received considerable attention were joint papers with Narlikar on the curious solution of Einstein's field equations (47) and on the fourteen scalar invariants of a general gravitational metric (58). As regards the latter, Professor AR Prasanna, a student of the Poona school writes.

"In 1922 the noted mathematician TY Thomas had proved that in Riemannian manifold of 4 dimensions only fourteen independent curvature invariants can be constructed. But the explicit construction of these fourteen invariants using the curvature tensor and the Weyl tensor and the metric tensor was given only in 1946 by Narlikar and his student Karmarkar. However, as this was published in the *Proceedings of the Indian Academy of Sciences*, it was not known outside where the credit had been given to Gehenau and Debever who did the same work in 1952. In fact I had the privilege of pointing this out to Prof Gehenau in 1972 at the Dirac Symposium and he himself suggested that these invariants should be called Narlikar-Karmarkar invariants. One hopes that this will go into the literature and the credit due to Professor Narlikar is given".

About this time Einstein's Unified Field theory of Gravitation and Electromagnetism was out. Dr Ramji Tiwari examined the nature of interaction between the electromagnetic field and the gravitational. Very lengthy calculations were carried out independently by him and Professor Narlikar and several papers explaining the character of the interaction came out in 1948-49 (62, 63, 64).

Dr PC Vaidya, while working at Banaras had obtained the relativistic solution of a non static mass in 1943. A few years later Narlikar and Vaidya published some papers jointly on the electromagnetic effects of such fields (53, 54). Vaidya's solution (1943) has now become famous in general relativity.

After 1950, Narlikar and KP Singh commenced a series of joint investigations on physical significance of several metric invariants. Among several publications of this period may be mentioned the one on the role of three index symbols in general relativity (67) where an analysis is made of the indeterminateness implicit in the coordinates of general relativity and a new derivation of the inverse square law is given.

Dr BR Rao, another student of Professor Narlikar at Banaras, worked on the derivation of the equations of motion from the field equations themselves. His important results have been reported in a joint paper published in 1955 (69). This was followed by several other papers including the one on the calculations of the motion of the perihelion of Mercury in 1959.

At the University of Poona (1966-1973) several students including Professor AR Prasanna, Prof N Dadhich, Dr RS Tikekar and Dr PP Kale worked on problems arising out of Petrov classifications, generalised field equations, spherically symmetric metrics and their curvatures etc.

It will be seen from the above that the main research areas developed by the Banaras and Poona schools were :

- (i) Exact solutions of Einstein's equations of general relativity.
- (ii) The solutions of the unified field equations of Einstein and Schrodinger.
- (iii) Equations of motion as derived from field equations.
- (iv) The fourteen scalar differential invariants of the Riemannian metric and their physical significance.
- (v) The geometrical and physical properties of metrics satisfying Einstein's field equations.

About 20 young men were associated with him in research in these areas during 1932-1973. Most of them got doctorates, but what is more important, many of them continued their research and formed their research groups. Thus a small seedling planted by Narlikar at BHU in the early thirties has now flowered into a big banyan tree.

A Conscencious Teacher :

At Banaras Narlikar had opportunities to learn and teach many topics in mathematics such as (1) Modern Algebra (2) Groups, characters and their applications (3) Wave Mechanics (4) Spinors and their applications (5) Hilbert's space and quantum mechanics (6) Stellar structure as it developed after 1940 etc.

For him teaching and research were complementary. He could best be described as a teacher mathematician. A teacher-mathematician-more than a teacher and a mathematician-is one who uses teaching methods in mathematical research and research methods in mathematics teaching. His philosophy of teaching can best be judged from his writings and lectures. At one place he has stated, 'When I started teaching mathematics at Banaras, I was more self critical and I found that there were so many gaps and voids in my understanding of the topic I taught'. Elsewhere he has pointed out the reasons for these gaps, 'Mathematics of the eighties is going to be different from that of the seventies just as the mathematics of the seventies was different from that of the sixties. The mathematics that I learnt as a student differed very much from the mathematics, I was called upon to teach'. He therefore concluded. 'The first lesson that I learnt was, one cannot be a good teacher, a successful teacher, without being always absorbed in the research topics concerned with his lectures'. His mathematics classes were always enjoyable and his popular talks on mathematical topics were always well appreciated because of his research oriented method of presenting a topic.

It was mentioned earlier that Narlikar used teaching methods in guiding mathematical research. To illustrate this, the best way seems to be that the present author recounts his personal experience as Narlikar's research student in 1942-43. Incidentally that will bring into focus another trait of this teacher- mathematician - his transparent academic integrity.

"Narlikar suggested that I should work on the problem of the gravitational field of a radiating star. We began working on the problem together. We enunciated the problem in the following manner, to calculate the gravitational field of flowing energy by comparing the radiation flowing out of a star with the flow of a fluid. For such a comparison, the current belief was that, if the fluid were to represent radiation, its density should be three times the pressure. We started our work on the basis of this understanding but found it difficult to derive any tangible conclusion. Once, during discussion, I suggested that, instead of assuming the pressure density relation, we might work on the basis of velocity; if the fluid is to represent the flow of radiation the fluid velocity must be assumed to be the velocity of the radiation. i.e. the velocity of light. Professor readily agreed and said, Yes, that is what we should have done!' We recast our calculations to suit the new assumption and at that very sitting Narlikar derived the first tangible equation. This sitting ended on a happy note and with the hope that I would be able to derive the other two equations.

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We wrote down the final solution in the form of a paper for publication. Narlikar put down only my name as the author of the paper. The usual practice is that the professor who suggests the problem becomes the first author of the paper and the student's name is included as a joint author. But Narlikar did not follow that routine because the main idea which provided a breakthrough in the work was provided by me and so he gave full credit to me. Today, when I think about it, I realize that Narlikar very well knew the importance of this solution, and even if he had just added his name as a joint author, the solution would have been known as 'Narlikar's solution'. At that point of time I was too young to understand such things. The solution known today as 'Vaidya metric' could easily have been credited to his name if he had so desired and that would have been in accordance with prevailing norms. But Narlikar preferred to stick to purer academic norms and decided that when the principal idea leading to the solution came from Vaidya the credit of the work must go to him. What a fine example of academic integrity.

Epilogue :

Narlikar was the founder fellow of all the three science academies in India. He was a fellow of the Royal Astronomical Society. He was president of the Calcutta Mathematical Society (1958-60) and of the Indian Mathematical Society (1981). But above all, he was revered by the present generation of Indian relativists as Grandpa Narlikar.

As mentioned earlier his wife Mrs. Sumati Narlikar is a Sanskrit scholar. A book containing lectures delivered by her in Sanskrit has been published under the title Sumati Darshanam.

They have two sons, Jayant and Anant. Dr Jayant Narlikar is a well-known astrophysicist and science fiction writer in Marathi and is currently director of the Inter University Centre for Astronomy and Astrophysics. Dr Anant Narlikar is a deputy director of National Physical Laboratory in Delhi.

Professor Narlikar spent his retired life with his son Jayant. He died at Pune on April 1, 1991 due to old age.

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Obituary

Vishnu Vasudev Narlikar was born at Kolhapur on 26 September 1908. He had his school education at Kolhapur and College education at the Elphinstone College and Royal Institute of Science, Bombay. After passing his B.Sc. (^h Honours) examination of Bombay University in 1928 with 96 per cent marks in mathematics, ^h He went on to Cambridge for higher studies. There in 1930 he passed Mathematics Tripos winning B* distinction. His research career began with studying Liapounov's famous paper on rotating fluid bodies. On the basis of a written review of Liapounov's method and achievement, ^E he was awarded Isaac Newton Studentship in Oct. 1930. In 1932 he returned to India.

In that year, when he was a young man, ^{of} twentyfour the late Pandit Madam Mohan Malviya persuaded him to join Banaras Hindu University as the head of the department of mathematics. He taught mathematics at B.H.U. for 28 years till 1960. After a stint with Rajasthan Public Service Commission (as its chairman) for six years, ^{by} he became Lokmanya Tilak Professor of Mathematics at the University of Poona in 1966. He retired in 1973. Since then he spends ^E last 18 years in retirement with his son Prof. Jayant Narlikar.

For him teaching and research were complementary. He could best be described as a teacher-mathematician. This compound word implies some thing more than a " Teacher and a Mathematician. A teacher mathematician is one who uses teaching method in mathematical research and research methods in mathematics teaching.

At Banaras, in addition to General Relativity and Riemannian Geometry, he used to teach several other topics like (1) Modern Algebra (2) Groups, characters and applications (3) Wave Mechanics (4) Spinors and their applications (5) Hilbert's space and Quantum mechanics (6) Stellar structure etc.etc. His philosophy of teaching

Elsewhere he has pointed out the reasons for these gaps,

-2-

can best be judged from his writing and lectures. At one place he has stated

" When I started teaching mathematics at Banaras, I was more self critical and I found that there were so many gaps and voids in my understanding of the topic I taught ".

" Mathematics of the 80's is going to be different from that of the 70's just as the mathematics of the 70's was different from that of the 60's . The mathematics that I learnt as a student differed very much from the mathematics I was called upon to teach ".

He therefore has concluded :

Lesson
" The first that I learnt was : One can not be a good teacher, a successful teacher without being always absorbed in the research topics concerned with his lectures ".

His mathematics classes were always enjoyable and his popular talks on the mathematical topics were always well appreciated because of his research oriented method of presenting a topic .

Professor V.V.Narlikar was a pioneer relativist in India. After joining B.H.U. he had ^{several} student collaborators working with him in relativity. Soon this evolved into an active research school at Benares and later at Poona. The main research areas cultivated at this school were:

- (1) Exact solutions of Einstein's equations of General Relativity.
- (2) The solutions of the unified field equations of Einstein and of Schrodinger.
- (3) Equations of motion as derived from field equations.
- (4) The fourteen scalar differential invariants of the Riemannian metric and their physical significance.

- (5) The geometrical and physical properties of metrics satisfying Einstein's field equations.

About 20 young men were associated with him in the research problems in the above areas during 1932 to 1973. Most of them got their doctorate, but what is more important, many of them continued their research work and formed their own research groups. Thus a small seedling planted by him at Benares in early thirties (and by Prof.N.R.Sen at Calcutta in late twenties) has now flowered into a big banyan tree.

It was mentioned earlier that Professor Narlikar used teaching methods in mathematical research. To illustrate this I shall recount my personal experience as his research student in 1942-43. Incidentally this will bring into focus another trait of this teacher- mathematician - his transparent academic integrity.

Professor Narlikar suggested that I should work on the problem of the gravitational field of a radiating star.

Both of us started working on this problem together. We enunciated the problem in the following manner : to calculate the gravitational field of flowing energy by comparing the radiation flowing out of a star with the flow of a fluid. For this comparison fluid the current belief was that if it is to represent radiation, the density should be three times the pressure. We started our work on the basis of this current understanding but we found it difficult to derive any tangible conclusion. Once during discussion I suggested that instead of assuming the pressure density relation, why not work on the basis of velocity ! If the fluid is to represent the flow of radiation

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He was one of the founding fellows of the academy. He was President of the Calcutta Mathematical Society (1958-60) and of the Indian Mathematical Society (1981). But above all, he was revered by the present generation of Indian relativists as grandpa Narlikar

He died on 1 April 1991 at Pune due to old age.

P.C.Vaidya

Professor V.V.Narlikar: A Teacher - Mathematician

x Let us clarify one or two points regarding the title of this essay. We have all heard about Dr. Jayant Narlikar and let us not confuse the Professor mentioned in the title with Dr. Jayant Narlikar. As a matter of fact, Professor V.V. Narlikar is the father of Dr. Jayant V. Narlikar. x

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After a brilliant career at Cambridge, Professor V.V. Narlikar worked as Professor of mathematics for 28 years at Banaras Hindu University (1932 - 1960) and later at Poona University (1966 - 1973). So he has been a teacher of mathematics. He has carried out some important research work in Mathematical Theory of Relativity and so he is also a mathematician. But the compound word Teacher-Mathematician mentioned in the title implies something more than a "Teacher and a Mathematician". A teacher-mathematician is one who uses teaching methods in mathematical research and uses research methods in mathematics teaching. I have the good fortune of knowing Professor Narlikar as a teacher-mathematician and in this essay I would like to share with others my reminences of the happy days I spent about an year at Banaras learning ABC of mathematical research from this eminent teacher-mathematician.

2. Research methods in Teaching

As mentioned earlier I was a research student of Professor Narlikar and again I was with him during the turbulent days of Quit India Movement of 1942, when Banaras University was closed and almost 'occupied' by the army. So I had no opportunity of learning mathematics in his class and therefore I have no first hand experience of Narlikar's way of using research methods while teaching a class. However, I have heard him on several occasions talking about teaching and learning of mathematics. I would therefore freely quote from memory his experiences as a mathematics teacher. He has said,

"When I started teaching mathematics at Benaras, I was more self critical and I found that there were so many gaps and voids in my understanding of the topics I taught".

Elsewhere he points out the reasons for these gaps.

"The mathematics of the 80's is going to be different from that of the 70's just as the mathematics of the 70's was different from that of the 60's. You see the mathematics that I had learnt was of little use to me when I went to Cambridge (in 1928). Then the mathematics after October 4, 1957, when Sputnik I went up, became a different mathematics altogether".

So a conscientious teacher of such a rapidly developing subject like mathematics will certainly find gaps and voids in his understanding of the subject. He must learn several topics by himself and that leads Professor Narlikar to say further that,

"The first lesson that I learnt was: One cannot be a good teacher, a successful teacher without being always absorbed in the research topics concerned with his lectures"

The point to be noted is the last phrase of the above quotation. A researcher is absorbed in the research topics of his own speciality. The above three successive quotations of Professor Narlikar lead one to the conclusion that to be a good teacher one must be absorbed in research on topics of his lecture! Generally one teaches under-graduate and/or post-graduate classes and also carries out research in his speciality. But then normally a teacher teaches several topics in his class which may not be topics of his research speciality. Professor Narlikar believes that a good teacher must keep contact with research in those topics which he has to teach so that he conveys to the students no stale knowledge but the knowledge of a growing lively subject.

Professor V.V. Narlikar's mathematics classes were always enjoyable and his popular talks (on Mathematical topics) were always well-appreciated because of his research oriented method of presenting a topic. In this connection let me narrate a personal experience here.

In 1937 Professor Narlikar was invited by Bombay University to deliver a course of lectures on General Theory of Relativity. I was a young undergraduate student and with some of my friends I attended those lectures. Not that I followed all that he talked about, but even at that young age I carried the impression that Relativity throws out a big challenge for mathematical research. The research oriented method of presenting his topics to the audience had captivated at least one young mind and when at the M.Sc. stage occasion arose for me to choose an area of mathematics in which to specialise. I opted for Relativity. And later in an hour of crisis when the Ahimsak Vyayan Sangh (not an institute of mathematics, but a Gandhian institute of Constructive Work) where I was working had to be closed down in May 1942 I remembered the magnetic effect of those research oriented semi popular lectures of Professor Narlikar. I wrote to him requesting him to take me as a research student. Pat came his reply by return of post and on 28th June 1942 I reached Banaras to learn ABC of mathematical research under him.

3. Teaching Methods in Mathematical Research

In order to touch the aspect of teaching methods in mathematical research I shall quickly go over some details of the research work I carried out during the year 1942 - 43 at Banaras. The same details will also bring into focus another important trait of a Teacher-Scientist - his transparent academic integrity.

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As mentioned earlier I had attended Professor Narlikar's Bombay University lecture during my college-days. In these lectures he had mentioned two outstanding (hitherto - i.e. upto 1937) unsolved problems in Einstein's theory of relativity. During my work at Banaras, when Professor Narlikar thought that I had reached a stage where I could try my hand at a research problem, he referred to these unsolved problems and suggested that I should pick up the first of the two problems and attempt to solve it. The problem was to work out the gravitational field of a radiating star in Einstein's theory.

Both of us started working on this problem together. We enunciated the problem in the following manner: to calculate the gravitational field of flowing energy by comparing the radiation flowing out of a star with the flow of a fluid. For this comparison-fluid the current belief was that if it is to represent radiation, the density should be three times the pressure. We started our work on the basis of this current understanding but we found it difficult to derive any tangible conclusion. Once during discussion I suggested that instead of assuming the pressure-density relation, why not work on the basis of velocity! If the fluid is to represent the flow of radiation, the fluid velocity must be assumed to be the velocity of radiation, i.e. the velocity of light. Professor readily agreed and said, "yes, that is what we should have done!" And we started recasting our calculations to suit the new assumption and at that very sitting Professor Narlikar derived the first tangible equation. The sitting ended with a happy note and with the hope that I shall be able to derive the other two equations.

In describing teaching methods, Professor Narlikar had once mentioned, 'it is necessary to intersperse lectures of a teacher by a period of silence to allow the students time to ponder.' He used this teaching method in my case. Left with the task of working out the remaining equations of our problem, it so happened that I could not see him for 2 weeks, (Normally I used to meet him twice every week) thus providing me 'time to ponder'. Well, the net result was that not only did I derive the other two equations of the problem but solved the 3 equations simultaneously and came up with the complete solution of the problem. At that stage, I was overjoyed because within 8 months of my joining research, I had with me a solution of an outstanding unsolved problem. It is only now (1988) that I realise how much of this was due to the teaching method of "providing time to ponder" so effectively used by Professor Narlikar.

4. Academic Integrity

We wrote down the final solution in the form of a paper for publication. And Professor Narlikar put down only my name as the author of that paper. The usual practice is that the professor who has suggested the problem becomes the first author of the paper and student's name is included as a joint author. But Professor Narlikar did not follow that routine because the main

idea which provided a break-through in this research was provided by me and so he gave the full credit of that research to me. Today, when I think about it, I realise that Professor Narlikar very well knew the importance of this solution and even if he had just added his name as a joint author, this solution would have been known as 'Narlikar's solution'. And at that point of time I was too young to understand such points. So the solution known today as 'Vaidya metric' could easily have been credited to his name if he had so desired. And that would have been in accordance with prevailing norms. But he preferred to stick to purer academic norms and decided that when the principal idea leading to the solution came from Vaidya, the credit of the work must go to him. What a fine example of academic integrity!

Professor V.V. Narlikar completed 80 years of age last September, and I thought this was an occasion to share with others my experiences of studying under him, of researching with him and ultimately of being a friend of this great Teacher-Mathematician - the Sandipani of 20th Century.

*and expired on ... I thought one way to lighten
the heavy burden of this deep sense of
bereavement was*

For Mr. ...

Prof. V. V. Narlikar

Professor Vishu Vasudev Narlikar who died at Pune on April 1, 1991 at the age of 83 was a great teacher of mathematics, a pioneer researcher in India on Einstein's Theory of Relativity, a popular orator on scientific topics and a warm personality.

Prof. Narlikar passed his B.Sc. examination in Mathematics from Bombay University in 1928 obtaining 96 per cent marks and went on to Cambridge for higher studies. He was awarded the prestigious Isaac Newton Studentship for 1930 and for three years 1931-34. Among his fellow students were H. J. Bhabha, S. Chandrasekhar and D. S. Kothari and his teachers included great mathematicians like Besicovitch, Cunningham, Eddington and Dirac.

In 1931 he returned to India and taught mathematics at Banaras Hindu University till 1960. After a stay of 6 years at Ajmer as Chairman of Rajasthan Public Service Commission, he became professor at the University of Poona in 1966. He retired in 1973 and spent the last 18 years in retirement with his son Dr. Jayant Narlikar.

Prof. Narlikar was a teacher-mathematician. This compound word implies something more than ~~teacher~~^a teacher and a mathematician. A teacher-mathematician is one who uses teaching methods in mathematical research and research methods in mathematical teaching.

Students who had the good fortune of sitting in his class had experienced his enjoyable teaching. In the interview he gave to Dr. Mrs. A. R. Singal (Mathematical Education), he

he said

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Professor V.V.Narlikar's mathematics classes were always enjoyable and his popular talks (on Mathematical topics) were always well appreciated because of his research oriented method of presenting a topic.

He also said, " it is necessary to intersperse lectures of a teacher with a period of silence to allow the students time to ponder". He adopted this technique even while supervising research of his Ph.D. students. He would discuss a research problem with a student and then would avoid meeting the students for a few days to give him time to ponder and arrive at his solution.

To bring into focus another trait of Prof.Narlikar's character, viz, Academic Integrity, I would now narrate my personal experience as his research student in 1942-43. He suggested to me to take up the then- outstanding problem of working out the gravitational field of a radiating star in Einstein 's theory.

Both of us started working on this problem together. We enunciated the problem in the following manner: to calculate the gravitational field of flowing energy by comparing the radiation flowing out of a star with the flow of a fluid. For this comparison fluid the current belief was that if it is to represent radiation, the density should be three times the pressure. We started out work on the basis of this current understanding but we found it difficult to derive any tangible conclusion. Once during discussion I suggested that instead of assuming the pressure density relation, why not work on the basis of velocity ! If the fluid is to represent the flow of radiation, the fluid velocity must be assumed to be the velocity of radiation. i.e. the velocity of light.

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Left with the task of working out the remaining equations of our problem, it so happened that I could not see him for ² weeks (Normally I used to meet him twice every week) thus providing me 'time to ponder'. Well , the net result was that not only did I derive the other two equations of the problem but solved the 3 equations simultaneously and came up with the complete solution of the problem.

We wrote down the final solution in the form of a paper for publication. And Professor Narlikar put down only my name as the author of that paper. The usual practice is that the Professor who has suggested the problem becomes the first author of the paper and student's name is included as a joint author. But Professor Narlikar did not follow that routine because the main idea which proved ^{to be} a break through in this research was provided by me and so he gave the full credit of that research to me. Today, when I think about it, I realise that Professor Narlikar very well knew the importance of this solution and even if he had just added his name as a joint author, this solution ~~and~~ would have been known as ' Narlikar's solution '. And ^{at} that point of time I was too young to understand such points. So the solution known today as ' Vaidya Metric ' could easily have been credited to his name if he had so desired. And that

would have been in accordance with prevailing norms. But he preferred to stick to purer academic norms and decided that when the principal idea leading to the solution came from Vaidya, the credit of the work must go to him. What a fine example of academic integrity !

Professor Narlikar was very fond of reading and would quote from a number of sources during his talks. His popular expositions of scientific topics were a treat to hear.

Professor Narlikar's sons, Jayant and Anant are scientists in their own right. Dr. Jayant Narlikar is a well-known astrophysicist and science fiction writer in Marathi and is currently the Director of the Inter University Centre for Astronomy and Astrophysics at Pune. Dr. Anant Narlikar is a deputy director of National Physical Laboratory in Delhi.

P.C.Vaidya