A training session report on

Introduction to Mathematica and Algebraic Computations in General Relativity

Under STUTI program funded by DST

In association with

Indian Institute of Technology, Gandhinagar

(Project Management Unit)

Coordinated by

Prof. A.H. Hasmani

Dr. R.R. Panchal

Department of Mathematics

Sardar Patel University

Vallabh Vidyanagar Gujarat India

29th May to 4th June 2023

Acknowledgement

We convey gratitude for the encouragement and support received from multiple sources during the execution of this training since its beginning. First and foremost, we want to express our sincere appreciation to the IIT Gandhinagar (PMU) and Department of Science and Technology (DST) for entrusting us with this project. The workshop was coordinated by **Dr. Ravi Panchal (**Assistant Professor, Mathematics SPU). The workshop was conducted on the '*Introduction to Mathematica and Algebraic Computations in General Relativity*' on the instrument funded by the FIST program (Sanction No.: SR/FST/MSI-006/2002. Organizing team acknowledge the contributions of the committee, in the implementation and the execution of the program to achieve the objectives of the project.

We also acknowledge all the teaching and non-teaching staff for their contributions, without which these could not have been possible.

Dr. Ravi Panchal

Coordinator

Summary

The goal of this training session is to provide a hands-on training on Mathematica and Algebraic Computations among students, faculty, scientists and industry professionals through a week-long training workshop. The workshop was conducted in the department of Mathematics, Sardar Patel University, from **29th May to 4th June 2023** and comprised of lectures and hands-on training sessions. This initiative is funded by Department of Science & Technology under the program STUTI (Synergistic Training Program Utilizing the Scientific and Technological Infrastructure). This training program was focused on the "*developing the fundamental aspects of Mathematica software and its applications in solving algebraic equations".* Hands-on comprised of the practical training comprised of practical training to utilize simulation techniques in Mathematics.

Introduction

Department of Mathematics, Sardar Patel University conducted 7-day long hands-on training program on 'Introduction to Mathematica and Algebraic Computations in General Relativity' in its campus for participants from various backgrounds such as Post Graduates, Faculties, Scientists, Research Fellows, Ph.D. Fellows and Industry persons were invited (**Annex-1**). The following workshop's activities took place from **29th May to 4th June** 2023 (**Annex-2 & 3**). This report provides a quick overview of both the lecture and technical sessions.

- *Lecture Sessions:*

Prof. A. B. Patel (Retired Professor, Department of Mathematics, SPU) and **Dr. Bhikhabhai Patel (**Registrar, SPU) was invited as a chief guest for inauguration of the workshop. **Prof. Hasmani** (Head, Professor, SPU) gave a talk on DST-FIST grants and gave an overview on other schemes offered by DST towards popularization of S&T Infrastructure. In addition, **Dr. Hasmani** also summarized, how Mathematica is useful in calculations of complex solutions. **Dr. Ravi Panchal** (Assistant Professor, Mathematics, SPU) gave an introductory lecture on Mathematica and importance in numerical analysis. Several other aspects such as solution to differential equations, integrations, solution of ODE and PDE were also discussed by **Dr. Panchal** utilizing Mathematica as a tool. **Dr. Panchal** also gave lecture on 'Algebraic computations of various tensors in GR using Mathematica'. **Prof. A. H. Hasmani** (Head, Professor, SPU) gave lecture on 'Tensors in General Relativity' where basics and principle of tensor, metric tensor, associated metric tensor, Covariant derivatives, and geodesic equation were discussed. In this session Lecture session. In a lecture on 'Tensors in General Relativity-2' where types of tensors, like Christoffel Symbols (First and Second kind), Riemann Tensor, Ricci Tensor, Einstein Tensor, Weyl Tensor were discussed. **Prof. P. I. Andharia (**Associate Professor, Mathematics, Maharaja Krishnakumarsinhji Bhavnagar University Bhavnagar) gave a lecture on 'Numerical Methods in Mathematica,' where finding solutions from differential numerical methods such as, Matrix inversion, Eigenvalue problems, Interpolation, numerical differentiation, numerical integration

and solution of algebraic and transcendental equation and curve fitting using Mathematica was discussed.

- *Technical Session*

On the day one, participants were taken for a visit to different lab facilities. On the day two, **Dr. Ravi Panchal** (Assistant Professor, Mathematics, SPU) and **Prof. Hasmani** (Head, Professor, SPU) given hands-on training to the participants using problems on Loops and conditional functions, 2D and 3D graph plotting, and Arrays and Matrices operation in Mathematica. On the third day, **Dr. Panchal** led hands-on session for the participants on a few problems of differentiation, ordinary differential equation (ODE), partial differential equation (PDE), and integration. On the fourth day, **Dr. Andharia** and **Dr. Panchal** together led hands-on session on the perspectives over different solutions of numerical methods utilizing the Mathematica software techniques. On the fifth day, **Prof. Hasmani** and **Dr. Panchal** illustrated some various kinds of tensors, like Christoffel Symbols (First and Second kind), Riemann Tensor, Ricci Tensor, Einstein Tensor, Weyl Tensor using Mathematica. On the sixth day, in this session all the participants were encouraged to share their knowledge on the utilization of Mathematica software followed by a quiz which is on the Mathematica software. On the seventh day, key points were discussed by **Dr. Panchal** and **Prof. Hasmani** followed by a valedictory session.

Outcomes of the Workshop

The STUTI workshop attracted participants from 28 different institutes (**Figure 1).** About 35 participants enrolled and attended the '*Introduction to Mathematica and Algebraic Computations in General Relativity*'. The goal of this training event was to bring together participants from many disciplines and raise awareness of the institute's research facilities. Throughout the sessions, participants asked major questions regarding theoretical and practical aspects of utilizing Mathematica as tool to solve complex numerical problems. Finally, the feedback from the participants was considered in the evaluation of the workshop (**Annex 4)**. The majority of the participants were pleased with the training session and suggested that more workshops be held in the future. Few participants suggested organizing such a workshop/training session on more troubleshooting techniques of data collection.

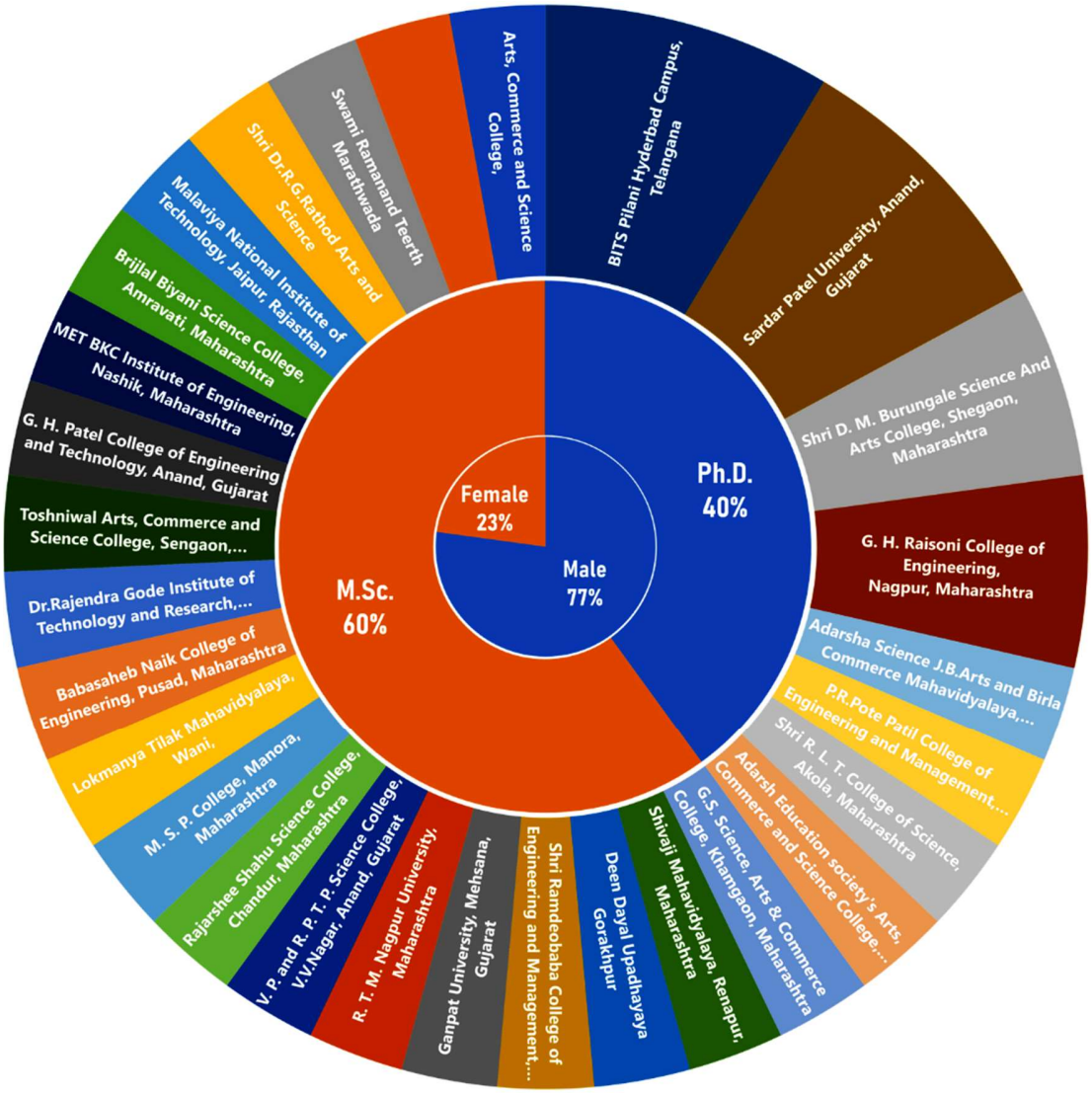


Figure 1. Participants registered workshop from different institutes.

Annexure 1: Brochure for the program.

Chief Patron

Prof. Niranjan P. Patel
Vice Chancellor (Offg.)
Sardar Patel University,
Vallabh Vidyanagar

Patron

Dr. Bhailalbhai P. Patel
Registrar
Sardar Patel University,
Vallabh Vidyanagar

Speakers

Prof. A.H. Hasmani is Professor & Head at the Department of Mathematics, Sardar Patel University, Vallabh Vidyanagar. His expertise is in the field of General Relativity and he has good expertise in working with algebraic computations in General Relativity.

Dr. P.I. Andharia is Associate Professor at the Department of Mathematics, Maharaja Krishnakumarsinhji Bhavnagar University, Bhavnagar. His expertise is in Algebraic Computations in General Relativity, Tribology, Graph Theory.

Dr. R.R. Panchal is Assistant Professor at the Department of Mathematics, Sardar Patel University, Vallabh Vidyanagar. He is working in field of General Relativity and he has experience in working with algebraic computations in general relativity.

Registration & Contact Details

Interested participants must register and only selected candidates would be invited for the workshop.

For selected candidates Registration fees, Boarding and lodging will be covered by DST.
TA will be provided as per government rules by DST.

Interested participants should register using the following link:
https://forms.gle/C5vmrYPQbq5q195PA

Registration Deadline: 18/05/2023

Shortlisted candidates will be intimated by email, latest by 22/05/2023.

Eligibility criteria:

(a) Minimum qualification:
Post Graduate (Science)

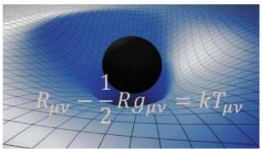
(b) Professors/Scientists/Post-Doc Fellows/ Ph.D. Fellows/Persons who are actively involved in Research in General Relativity/Cosmology

(c) Not more than 3 participants from one institute.

For more information contact:
Coordinator: Dr. R.R. Panchal
E-Mail: ravipanchal1712@spuvvn.edu

Department of Science & Technology (DST) funded

Training workshop under STUTI
(Synergistic Training Program Utilizing the Scientific and Technological Infrastructure)



7 Days National Workshop on

Introduction to Mathematica and Algebraic Computations in General Relativity

29th May, 2023 to 04th June, 2023

organized by

Department of Mathematics
Sardar Patel University
Vallabh Vidyanagar-388120
Gujarat
(NAAC ACCREDIATED 'A' GRADE UNIVERSITY)

Acknowledgements

Content of the Workshop

Day 1: Session I and II
- Introduction to Workshop
- Introduction to Computer Algebra System (CAS) Mathematica

Day 2: Session I and II
- Graphical representation in Mathematica
- Arrays, Matrices in Mathematica

Day 3: Session I and II
- Numerical Methods in Mathematica
- Differentiation, Integration, Solutions of ODE & PDE in Mathematica

Day 4: Session I and II
- Various tensors in General Relativity (GR)

Day 5: Session I and II
- Algebraic Computations of Various tensors in GR using Mathematica

Day 6: Session I and II
- NP formalism using Mathematica

Day 7: Session I and II
- Seminar presentation by participants using Mathematica

Each theory session supplemented by hands on training using individual computer.

About University

Sardar Patel University was established by an Act of the Legislative Assembly of the then Bombay Province in December 1955 and was recognized under 2f and 12b of the UGC Act in October 1968. The university has completed 66 golden years of a fruitful existence. The university is situated in pollution-free, clean and green town Vallabh Vidyanagar. The university comprises of 27 Postgraduate Departments, a constituent college, and 148 colleges affiliated to it. There are more than 50 PG courses available in the affiliated colleges/institutions. The university has been re-accredited by NAAC in 2023 with A grade and 3.11 CGPA.

About Department

The Department is active in research specializing in General Relativity, Functional Analysis, Banach and Topological Algebras, Operator Algebras, Harmonic Analysis, Special Functions, Approximation Theory, Fluid Mechanics, Financial Mathematics. The department has a strong programme of collaborative research with mathematicians in India and abroad. The department had been recognized as a SAP Department by the UGC. Our Computer laboratory received a generous grant under DST-FIST. So far 110+ students of the department have cleared NET-JRF/SET/GATE/NBHM.

Overview of STUTI and objectives of Workshop

STUTI (Synergistic Training Program Utilizing the Scientific and Technological Infrastructure) is a DST scheme which intends to build human resource and its knowledge capacity through open access to S&T infrastructure across the country. In this program, training sessions are conducted on state of art equipment that is fully funded by DST. IIT Gandhi Nagar has been identified as Project management Unit to conduct these training sessions under the STUTI program.

The Department of Mathematics, Sardar Patel University has the privilege for being funded by DST schemes and has been selected for conducting 07 Day workshop on the said title w.e.f 29th of May, 2023 to 04th of June, 2023.

The workshop is aimed at using the computer laboratory at the department with a generous grant from Department of Science and Technology, Government of India (under their DST-FIST program). The computer facility available at our department has a fairly good number of computers and also a couple of software for efficient computations. Some of our faculty members and research scholars use this facility for numerical as well as algebraic computations. In this workshop a brief introduction to Mathematica® will be given. Also, its use for symbolic computations in General Relativity will be discussed. The workshop thus will be useful to Research Scholars working in Mathematica in general and in GR in particular.

Annexure 2: List of registered participants for the workshop.

Sr. No.	Candidate Name	Gender	Educational Qualification	Email address	University/Institute
1	Akshay Pawan Jenekar	Male	M.Sc. (Mathematics)	apjenekar@gmail.com	Arts, Commerce and Science College, Maregaon, Maharashtra
2	Alfred Yusuf Shaikh	Male	Ph.D. (Mathematics)	shaikh_2324ay@yahoo.com	Indira Gandhi Kala Mahavidyalaya, Ralegaon, Maharashtra
3	Amrut Prabhakarrao Nirwal	Male	Ph.D. (Mathematics)	amrutnirwal47@gmail.com	Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra
4	Anil Shankarrao Nimkar	Male	Ph.D. (Mathematics)	anilnimkar@gmail.com	Shri Dr.R.G.Rathod Arts and Science College, Maharashtra
5	Ankita Jangid	Female	M.Sc.(Physics)	2020rpy9068@mnit.ac.in	Malaviya National Institute of Technology, Jaipur, Rajasthan
6	Ankush Nile	Male	M.Sc. (Mathematics)	ankushnile15@gmail.com	Brijlal Biyani Science College, Amravati, Maharashtra
7	Archana Satish Shirsat	Female	M.Sc. (Mathematics)	archanashirsat1990@gmail.com	MET BKC Institute of Engineering, Nashik, Maharashtra
8	Bhagwat Thakran	Male	M.Sc. (Mathematics)	bhagwat.thakran@raisoni.net	G. H. Raisoni College of Engineering, Nagpur, Maharashtra
9	Rita Mate	Female	M.Sc. (Mathematics)	ritamate03@gmail.com	
10	Bhavyata N Patel	Female	Ph.D. (Mathematics)	bhavyatapatel@gcet.ac.in	G. H. Patel College of Engineering and Technology, Anand, Gujarat
11	Burhan Safi	Male	M.Sc. (Mathematics)	burhansafi2@gmail.com	Sardar Patel University, Anand, Gujarat
12	Prashantkumar Patel	Male	Ph.D. (Mathematics)	prashant225@gmail.com	
13	Sagar V. Soni	Male	M.Sc. (Mathematics)	sagar.soni7878@spuvvn.edu	
14	Debasmita Mohanty	Female	M.Sc. (Mathematics)	newdebasmita@gmail.com	BITS Pilani Hyderbad Campus, Telangana
15	Gaurav Narayanrao Gadbail	Male	M.Sc. (Mathematics)	gauravgadbail6@gmail.com	
16	Sai Swagat Mishra	Male	M.Sc. (Mathematics)	saiswagat009@gmail.com	
17	Dnyaneshwar Pralhad Tadas	Male	M.Sc. (Mathematics)	dtadas144@rediffmail.com	Toshniwal Arts, Commerce and Science College, Sengaon, Maharashtra
18	Harshal Ashokrao Nimkar	Male	M.Sc. (Mathematics)	harshalnimkar53@gmail.com	Dr.Rajendra Gode Institute of Technology and Research, Amravati, Maharashtra
19	Kailas Raghunath Borgade	Male	Ph.D. (Mathematics)	borgadek@gmail.com	Babasaheb Naik College of Engineering, Pusad, Maharashtra
20	Kailas Ramkrushna Mule	Male	Ph.D. (Mathematics)	drkailasmule@gmail.com	Shri D. M. Burungale Science And Arts College, Shegaon, Maharashtra
21	Nitesh Gangadharrao Ghungarwar	Male	M.Sc. (Mathematics)	nghungarwar31@gmail.com	
22	Mahadeo Ganeshrao Bhujade	Male	M.Sc. (Mathematics)	mgbhujade20@gmail.com	Lokmanya Tilak Mahavidyalaya, Wani, Maharashtra
23	Mahaveer Dhabe	Male	M.Sc. (Mathematics)	mahaveer.dhabe@gmail.com	M. S. P. College, Manora, Maharashtra
24	Mamta Suresh Palaspagar	Female	M.Sc. (Mathematics)	mamta.palaspagar@rssc.edu.in	Rajarshee Shahu Science College, Chandur, Maharashtra
25	Neha Bharatbhai Rathod	Female	Ph.D. (Mathematics)	rathodneha005@gmail.com	V. P. and R. P. T. P. Science College, V.V.Nagar, Anand, Gujarat
26	Parimal Wamanrao Gaidhane	Male	M.Sc. (Mathematics)	parimalgaidhane95@gmail.com	R. T. M. Nagpur University, Maharashtra
27	Parth Patel	Male	M.Sc. (Mathematics)	parthpatel444.pp4@gmail.com	Ganpat University, Mehsana, Gujarat
28	Pratik Lepse	Male	Ph.D. (Mathematics)	pratiklepse124@gmail.com	Shri Ramdeobaba College of Engineering and Management, Nagpur, Maharashtra
29	Ram Bharosha Tiwari	Male	M.Sc. (Mathematics)	rambharoshatiwari@gmail.com	Deen Dayal Upadhayaya Gorakhpur University, Uttar Pradesh
30	Raut Dnyaneshwar Kundlik	Male	Ph.D. (Mathematics)	dkraut1983@gmail.com	Shivaji Mahavidyalaya, Renapur, Maharashtra
31	Sachin Madan Shihnge	Male	M.Sc. (Mathematics)	smshingne131@gmail.com	G.S. Science, Arts & Commerce College, Khamgaon, Maharashtra
32	Sachin Pralhadrao Hatkar	Male	Ph.D. (Mathematics)	schnhatkar@gmail.com	Adarsh Education society's Arts, Com. & Sci. College, Maharashtra
33	Samadhan L. Munde	Male	Ph.D. (Mathematics)	samadhan.munde86@gmail.com	Shri R. L. T. College of Sci, Maharashtra
34	Sarika Prakash Shahare	Female	Ph.D. (Mathematics)	spshahare@prpotepatilengg.ac.in	P.R.Pote Patil College of Engineering and Management, Amravati, Maharashtra
35	Sudhir Narayanrao Bayaskar	Male	Ph.D. (Mathematics)	bayaskaramv@gmail.com	Adarsha Science J.B.Arts and Birla Commerce, Maharashtra

Annexure 3: Schedule date and activities during the workshop

Sardar Patel University

Department of Mathematics

Workshop on Introduction to Mathematica and Algebraic Computations in General Relativity

29/05/2023 to 04/06/2023

Schedule

Day 1 (29-05-2023)		**Day 2 (30-05-2023)**		**Day 3 (31-05-2023)**	
09:15	Registration	08:30	Breakfast	08:30	Breakfast
10:00	Inauguration	09:30	Session 2A	09:30	Session 3A
10:30	Session 1A	11:00	Tea Break	11:00	Tea Break
11:20	Tea Break	11:30	Lab Session 2A	11:30	Session 3B
11:30	Session 1B	13:00	Lunch Break	13:00	Lunch Break
13:00	Lunch Break	14:30	Session 2B	14:30	Lab Session 3
14:30	Lab Session 1	16:00	Lab Session 2B	17:30	Tea Break
17:30	Tea Break	17:30	Tea Break	19:00	Dinner
19:00	Dinner	19:00	Dinner		

Day 4 (01-06-2023)		**Day 5 (02-06-2023)**		**Day 6 (03-06-2023)**		**Day 7 (04-06-2023)**	
08:30	Breakfast	08:30	Breakfast	08:30	Breakfast	08:30	Breakfast
09:30	Session 4A	09:30	Session 5A	09:30	Session 6A	09:30	Session 7A
11:00	Tea Break	11:00	Tea Break	11:00	Tea Break	11:00	Tea Break
11:30	Session 4B	11:30	Session 5B	11:30	Session 6B	11:30	Session 7B
13:00	Lunch Break	13:00	Lunch Break	13:00	Lunch Break	13:00	Lunch Break
14:30	Lab Session 4	14:30	Lab Session 5	14:30	Lab Session 6	14:30	Feedback & Valedictory
17:30	Tea Break	17:30	Tea Break	17:30	Tea Break		
19:00	Dinner	19:00	Dinner	19:00	Dinner		

Content of the Workshop

Session 1A	About the Workshop	AHH
Session 1B	Basic Functions and Introduction to Mathematica	RRP
Session 2A	Graphical representation in Mathematica	RRP
Session 2B	Arrays, Matrices in Mathematica	AHH
Session 3A	Differentiation, Integration, Solutions of ODE & PDE in Mathematica	RRP
Session 3B	Various tensors in General Relativity (GR)	AHH
Session 4A	Various tensors in General Relativity (GR)	RRP
Session 4B	Numerical Methods in Mathematica	PIA
Session 5A	Algebraic Computations of Various tensors in GR using Mathematica	RRP
Session 5B	Algebraic Computations of General Observer Quantities	AHH
Session 6A	NP formalism using Mathematica	AHH
Session 6B	NP formalism using Mathematica	RRP
Session 7AB	Seminar presentation by participants using Mathematica	AHH+RRP

AHH: A.H. Hasmani

PIA: P.I. Andharia

RRP: R.R. Panchal

Annexure 4: Feedback summary

S.No.	Content	Rating
1	Overall grading of the Programme with reference to relevance of course, module/content etc.	99% rated above 8 points
2	Overall grading of the facilities provided by the institute, i.e., Hostel, Mess, Class Rooms, Transport/infrastructure etc.	99% rated above 8 points
3	Overall grading of the faculty members conducting the training	97% rated above 8 points
4	How do you rate the overall training methodology	98% rated above 8 points
5	How far the field visit is relevant and related to your research study	88% rated above 8 points
6	Usefulness of this training in your current role	89% rated above 8 points
7	Usefulness of this training in future work/job you may handle	92% rated above 8 points
8	How far have you benefitted from interaction with the fellow participants of the training	98% rated above 8 points
9	How far the course material supplied relevant and related to the training curriculum	88% rated above 8 points
10	Overall grading of the process of training	97% rated above 8 points
11	Your recommendation to your peers/ colleagues for the training Programme	96% rated above 8 points