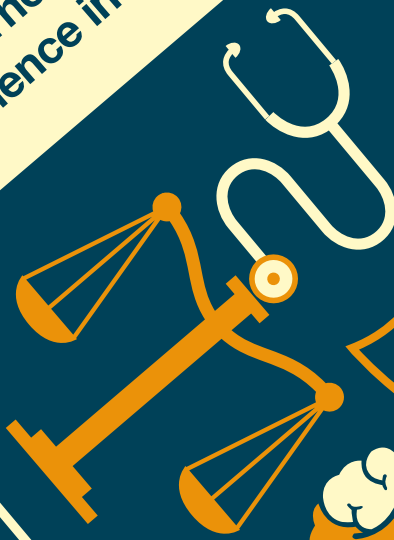


POWERING PAKISTAN FOR THE 21ST CENTURY

Volume II of III: The State of
Maths and Science in Schools



$$A^2 + B^2 = C^2$$

$$E = MC^2$$

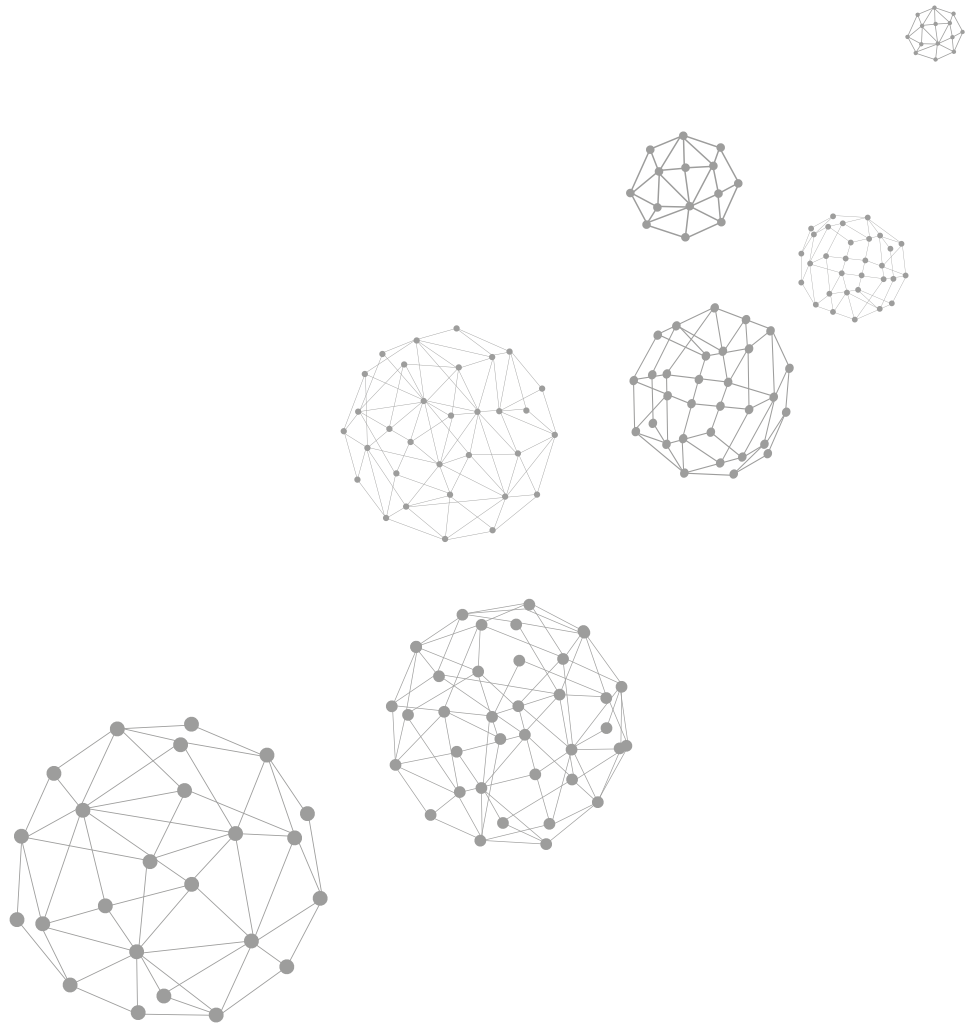


POWERING PAKISTAN FOR THE 21ST CENTURY

Volume II of III: The State of Maths & Science in Schools

Pakistan Alliance for Maths and Science
January 2017





Citation

Pakistan Alliance for Maths and Science .2017. Powering Pakistan for the 21st Century; Vol II of III: The State of Maths and Science in Schools. Islamabad. Pakistan Alliance for Maths and Science. vi-58 pp.

ISBN: 978-969-23194-0-9

Contents

Acknowledgments v
About Powering Pakistan for the 21st Century ix



1 HOW WE MEASURE MATHS AND SCIENCE EDUCATION 1

National Educational Assessment System (NEAS)	2
Punjab Examinations Commission (PEC)	3
Standardised Achievement Test (SAT)	3
Annual State of Education Report (ASER)	4
Learning outcomes data: Incomplete and incoherent	4



2 WHAT WE INVEST IN MATHS AND SCIENCE EDUCATION 7



3

THE STATE OF MATHS 11

Maths scores in ASER	11
Maths scores in NEAS	12
Maths scores in PEC	16
Maths scores in SAT	18



4

THE STATE OF SCIENCE 21

Science scores in NEAS	21
Science scores in PEC	24
Science scores in SAT	25



5

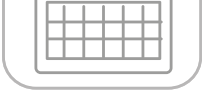
RETURN ON INVESTMENT 29



6

WHY IS THE STATE OF MATHS AND SCIENCE EDUCATION THE WAY IT IS 35

The political economy of maths and science education	36
Structural and systemic challenges	40
The quality of our schools	46
Teachers	47
The challenge of content	50



Acknowledgments

Bismillah irr Rahman irr Raheem.

The Alliance is especially grateful to the community of scientists and mathematicians that have generously contributed their time to the process of preparing this document, the previous volume and the upcoming final volume. Their feedback and consistent engagement has not only informed our analyses, but also shaped the overall structure for this effort.

The Alliance owes its thanks to the contribution of the Pakistan Innovation Foundation in particular, that designed and led the analysis of the data from NEAS, PEC and SAT, and helped establish the framework for examining the issues. Dr Pervez Hoodbhoy suggested an analysis of examinations, and a small sample of such an analysis has been included, and shows in stark terms, the limitations of the assessments system in the country. Dr Irfan Muzaffar correctly identified the need for a greater focus in the analysis on maths and science itself. An effort to do so has been made. Noreen Fatima of NFDezine has been instrumental both in proofreading both Volumes I and II and in designing and laying out the document. The document would not have been possible without the efforts of Zainab Iqbal, Maliha Umer, Zohair Zaidi, Salman Naveed Khan, Afreina Noor, Ghulam Hussain Soomro, and Aleena Khan of Alif Ailaan and Ayesha Tariq, Nida Athar, and Bisma Hayat of the Pakistan Innovation Foundation.

Finally, we would like to thank the following individuals for their various

contributions to the conceptualisation, writing, editing and review of this document:

Dr Faisal Khan, CECOS University, Peshawar

Dr Iqbal Bhangar, University of Karachi, Karachi

Abbas Rashid, Society for Advancement of Education (SAHE), Lahore

Dr Kulsoom Ghias, Aga Khan University, Karachi

Dr Manzoor H. Soomro, ECO Science Foundation, Islamabad

Dr Mukhtar Ahmed, Higher Education Commission (HEC), Islamabad

Dr Mahmood ul Hasan Butt, Higher Education Commission (HEC), Islamabad

Baela Raza Jamil, Idara-Taleem-o-Aagahi (ITA), Lahore

Sami Khan Sadozai, Islamabad

Abdullah Alam, Institute for Social and Policy Sciences (I-SAPS), Islamabad

Dr Nighat Perveen, UAE

Rizwan Mehboob, Advisor to PM on Climate Change, Islamabad

Dr Saadat Siddiqi, Khwarizmi Science Society, Lahore

Dr Sabieh Anwar, Lahore University of Management Sciences (LUMS), Lahore

Dr Ali Cheema, Lahore University of Management Sciences (LUMS), Lahore

Dr Saleem Ali, University of Delaware, USA

Dr Faisal Bari, Institute of Development and Economic Alternatives (IDEAS), Lahore

Umbreen Arif, World Bank, Islamabad

Major General Ghulam Qamar, National Defence University, Islamabad

Colonel Dr Qaim Raza Jaffry, National Defence University, Islamabad

Dr Nazir Mahmood, Islamabad

Dr Haris Aziz, University of New South Wales and Data61 - CSIRO, Australia

Dr Gulfaraz Ahmed, Former Federal Secretary, Ministry of Petroleum & Natural Resources, Islamabad

Nisar Ahmed Siddiqui, Sukkur Institute of Business Administration, Sukkur

Hasan Akhtar Rizvi, LEAD Pakistan, Islamabad

Dr Jameel-un Nabi, GIK Institute of Engineering Sciences & Technology, Topi

Dr Shaukat Hameed Khan, COMSTECH, Islamabad

Dr Monazza Aslam, University of London, UK

Zubeida Mustafa, Independent Journalist

Shamyl Bin Mansoor, School of Electrical Engineering and Computer Science (SEECs), National University of Sciences and Technology (NUST), Islamabad

Dr Ali Sarosh, College of Aeronautical Engineering, PAF Academy, Risalpur

Dr Fakhar ul Inam, COMSATS Institute of Information Technology, Islamabad

Dr Irfan Chaudhary, University of Engineering and Technology, Lahore

Dr Ishtiaq Ali, COMSATS Institute of Information Technology, Islamabad

Dr Asad Zaman, Pakistan Institute of Development of Economics (PIDE), Islamabad

Brig. (Rtd) Muhammad Amin, Balochistan University of Engineering & Technology, Khuzdar

Dr Khurshid Hasanain, COMSTECH, Islamabad



Effect on
litmus paper



About Powering Pakistan for the 21st Century

Powering Pakistan for the 21st Century is a three-volume document compiled by researchers and education activists mobilised by the Pakistan Alliance for Maths and Science (PAMS), under the patronage of a range of government and non-government organisations.

The purpose of the Powering Pakistan for the 21st Century document is to highlight the importance of maths and science education in Pakistan's classrooms, especially those in government schools, where the least privileged of this country's children study.

Volume I was titled 'How Maths and Science Power Nations'. The Prime Minister of Pakistan launched this volume on 27 January, 2016. In it we presented the case that maths and science are essential informants of a nation's progress and prosperity.

Volume II is titled, 'The State of Maths and Science in Schools'. In this volume we present a summary of the effort being invested in maths and science education, and the results being achieved with those investments. We will also explore why the state of maths and science education is as it is, and how the status quo has come about.

Volume III is titled, 'A Roadmap for Maths and Science Education'. In this volume, we will present a series of ideas and recommendations that can help Pakistan, as a state and as a society, re-orient public policy and private investment decisions, to serve a brighter, more prosperous and more secure future.

“POWERING PAKISTAN FOR THE 21ST CENTURY”

Volume I is titled “How Maths and Science Power Nations”

Volume II is titled, “The State of Maths and Science in Schools”

Volume III is titled, “A Roadmap for Maths and Science Education”

This volume takes the conversation forward by identifying the degree to which Pakistan is providing an adequate maths and science education for its children

In this volume we examine the state of maths and science education in our schools by assessing test scores data. We also explore and present the underlying factors that impact maths and science learning among children. The report argues that most Pakistani children only have access to inadequate quality of maths and science education that results from a range of factors. These factors need to be addressed in order for Pakistani children to have access to internationally acceptable standards of maths and science education. The report also acknowledges the significant improvements made in the education sector including the adoption of merit-based recruitment of teachers and increases in budgets that could contribute towards better learning reflected by improved maths and science test scores.

In this section, we set the benchmarks for maths and science achievement that can be used to measure Pakistan's performance. We use PISA and TIMSS scores to identify top-performing countries in internationally recognised maths and

science tests. If maths and science learning of our students was to be assessed on TIMSS and PISA frameworks, we are likely to find that it is at the rock bottom compared with other nations participating in these assessments. We also draw comparisons between the per capita GDP of these countries and Pakistan's. This builds on the argument about the significance of maths and science in terms of economic gains made under the 'Hanushek Distinction' in Volume I.

In Section 1 we present an overview of major data sources used in this document to ascertain the state of maths and science education in the country. We also identify some major challenges relating to data regimes that preclude effective policymaking and implementation.

In Section 2 we discuss education budgets and the need to determine the level of existing financial investment governments make annually in maths and science. We propose a framework to parse total current and development budgets to determine the share allocated towards maths and science

education in the country.

In Sections 3 and 4, we present maths and science learning achievements among students at primary and secondary levels. We use test scores data from various sources including the National Educational Assessment System (NEAS), Punjab Examination Commission (PEC), Standardised Achievement Test (SAT), and Annual Status of Education Report (ASER) to analyse learning levels of maths and science among children.

In Section 5, we explore the returns on investments by mapping the upward trend in budgetary allocations with the change in quality of maths and science education reflected by test scores. Unfortunately, the two kinds of data needed to make an assessment that could empower better planning are not available; namely, maths and science disaggregated budget figures and standardised assessment scores from Khyber Pakhtunkhwa and Balochistan.

Finally, in Section 6, we explore why the state of maths and science education is the way it is. We divide this

section into five subsections covering political economy related challenges, structural and systemic challenges, recruitment, education and career development of teachers, challenges pertaining to the content of what is being taught in maths and science, and the overall quality of schools. This section seeks to analyse the underlying causes that contribute towards inadequate quality of maths and science education in schools and sets the context for Volume III of this document which will present a roadmap comprising of policy recommendations for better maths and science education in schools.

Setting the benchmarks

Volume I of this report made the case for greater focus on maths and science education, keeping in view Pakistan's specific contextual realities. This volume takes the conversation forward by identifying the degree to which Pakistan is providing an adequate maths and science education for its children. To assess the state of maths and science education in the country, it is important to begin with establishing what we conceive

“The Hanushek Distinction”

Cognitive capacities attained through quality education have a bigger effect on economic growth than just years of schooling

Two major benchmarking exercises are the Trends in International Mathematics and Science Study (TIMSS), and the Programme for International Student Assessment (PISA)

to be an ideal state. There are many ways that this can be explored and articulated. One measure is the self-actualisation that an education enables, and maths and science are integral to such an education. However, such a benchmark would suffer from the problem of abstraction. What is required is a standardised set of parameters that can help identify where Pakistan should be, and then use where Pakistan is to chart a path forward.

Thankfully, there are international student achievement benchmarks already in use that can help us establish these benchmarks. Comparisons with Pakistan are difficult, however, as those benchmarking exercises are not currently conducted here. The two major benchmarking exercises are the Trends in International Mathematics and Science Study (TIMSS), and the Programme for International Student Assessment (PISA).

The intention here is to present a basic diagnostic comparison between the economic statuses of countries with the best maths and science scores and that of Pakistan. While this is not an attempt to make a robust case for causation between maths and science and economic growth, the positive correlation that we are implying here follows from the evidence presented as the 'Hanushek Distinction' in Volume I. Hanushek's works identify cognitive skills, acquired through quality teaching

and reflected through performance in international tests, as having significant positive effect on national economic performance. Taking this argument forward, we plot the per capita GDP of the best performing TIMSS and PISA countries along with Pakistan's. The intent here is to show the potential economic premium to be gained in cumulative terms by the improved maths and science learning required to get there.

Trends in International Mathematics and Science Study (TIMSS)

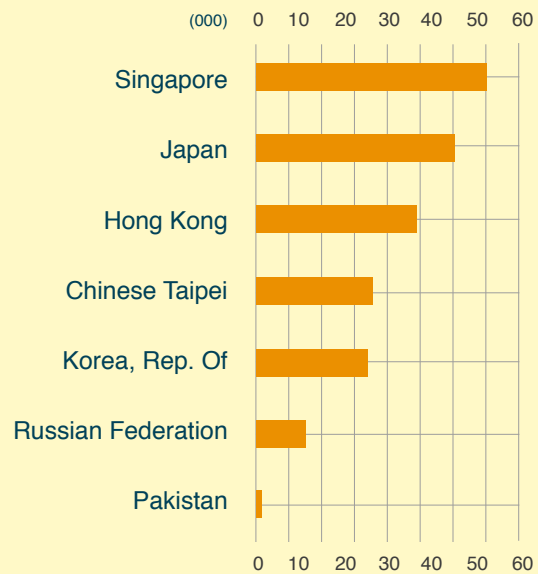
The TIMSS International Study Centre conducts international comparative assessments of student achievement in maths and science in more than 60 countries. TIMSS tests classes IV and VIII every four years. The data from TIMSS provides the participating countries with evidence about achievements as well as key deficits in the knowledge and skills of children from participating countries, identifying gaps in learning resources and opportunities, identifying areas of weakness and potential reform and measuring the impact of different educational initiatives.¹ Pakistan is poised to be a TIMSS country by 2019. The latest TIMSS scores rank the following countries as the top five performers in maths tests.

¹ <http://timssandpirls.bc.edu/about.html>

The following figure shows the GDP per capita (USD) for top performing countries on TIMSS compared to Pakistan's ²

² <http://www.tradingeconomics.com/>

GDP per capita of top performing countries in TIMSS and Pakistan



Country	Singapore	Korea	Hong Kong SAR	Chinese Taipei	Japan
TIMSS maths score	618	608	615	597	593

Similarly, top performing countries in science are:

Country	Singapore	Korea	Japan	Russian Federation	Hong Kong
TIMSS science score	590	589	569	567	557

TIMSS International Study Centre conducts international comparative assessments of student achievement in maths and science in more than 60 countries

PISA is an international survey that evaluates education systems based on students' learning levels ascertained through tests on maths, science, reading, collaborative problem solving and financial literacy.

Programme for International Student Assessment (PISA)

PISA is an international survey that evaluates education systems based on students' learning levels ascertained through tests on maths, science, reading, collaborative problem solving and financial literacy. In 2015 over half a million students from 72 countries took the internationally agreed two-hour test.² PISA tests 15 year olds in class VII or above. The latest PISA results published rank the following as the best

² <https://www.oecd.org/pisa/aboutpisa/>

The top performing countries for the maths test are:

Country	Singapore	Hong Kong	Macau	Taiwan	Japan
PISA maths score	564	548	544	542	532

The top performing countries for the science test are:

Country	Singapore	Japan	Estonia	Taiwan	Finland
PISA science score	556	538	534	532	531

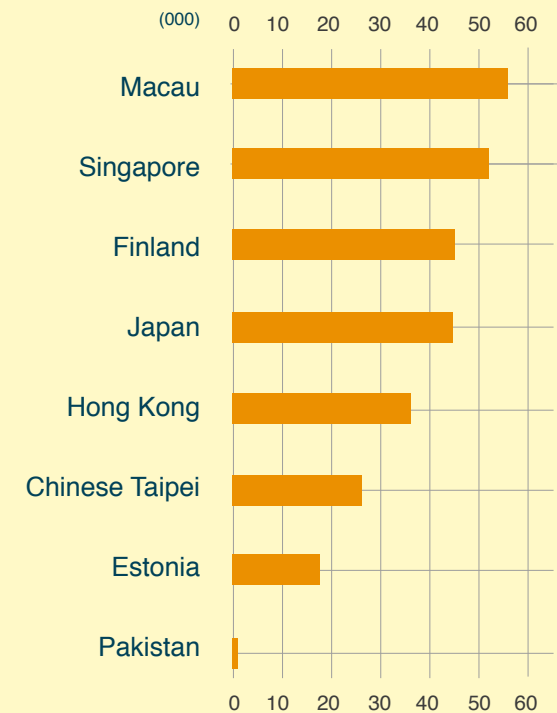
performing countries for maths:

Pakistan has a lot to gain by both becoming a country in which the TIMMS and PISA benchmarking exercises are conducted and from rapidly improving the quality of maths and science learning. Taking part in internationally standardised examinations will not only give us more robust data to analyse the learning levels in maths and science, but also inform deep-rooted analysis on trends in maths and science learning. It is all the more important since we have not had substantial policy oriented

The following figure shows the GDP per capita (USD) for top performing countries on PISA compared to Pakistan's:¹

¹ <http://www.tradingeconomics.com/>

GDP per capita of top performing countries in PISA and Pakistan



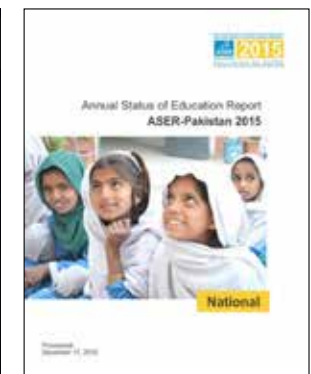
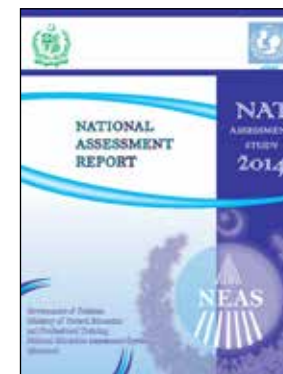
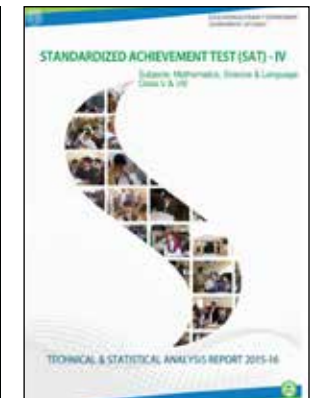
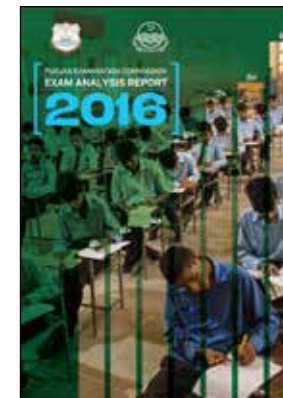


1 How we measure maths and science education?

There exists no standardised and regular national data on learning outcomes in any subject: maths, science, or any other. The annual education statistics published at the national level are derived from an annual census of school facilities. Learning outcomes data has been generated consistently through a survey conducted by a non-profit network called ASER. Literacy data is provided by the annual household survey, which has data that can be disaggregated by district only once every two years. Finally, a national survey of learning outcomes that was supposed to be an annual exercise has been conducted twice in the last nine years. Pakistan's last census, which is due every ten years, was published in 1998. In short, the conversation about how Pakistan measures maths and science education provision has to be seen within the context of the overall respect afforded to robust data, in this case, not very much. Despite these massive gaps,

small islands of experimentation and inquiry at the provincial level have generated a series of working models for how provinces can measure maths and science education provision and learning outcomes. Some major problems with data quality that preclude the government and other relevant stakeholders from fully appreciating the extent of the problems in maths and science learning are:

- Unavailability of data on maths and science achievement that could be compared with the rest of the world
- An absence of annually collected and published, nationally representative, official government data on student achievement, specifically maths and science
- The time lag from collection to analysis,





and from analysis to publication, that leaves almost no possibility of the most recent evidence being used to frame or inform policy, budgeting or resourcing decisions

- Only the Punjab and Sindh having mechanisms in place to gauge student learning at various levels and making results public; Khyber Pakhtunkhwa and Balochistan do not make the data they gather on assessment scores for quality and learning levels public.

Despite the aforementioned problems, there are some invaluable sources of data that give us the opportunity to examine various facets of the problem concerning maths and science learning among students. This section examines these data sources and synthesises relevant issues by considering different components of the problem covered under each one.

1.1 National Educational Assessment System (NEAS)



The National Achievement Test (NAT) is administered by the National Educational Assessment System (NEAS) under the Ministry of Education and Professional Training. It is the only national-level test to measure learning outcomes across the country. So far, NEAS has published four national-level assessment reports on two classes each, across four subjects. The most recent NEAS Assessment Report was published in 2015 for a test carried out in 2014, after a hiatus of almost eight years. The National Achievement Test (NAT) 2014 was conducted by NEAS with the assistance of Provincial/Area Education Assessment Centres (PEACEs/AEACEs) on a stratified random sample of 11,200 students from 448 government schools, representing all

explicit strata (gender, location, province etc) on Probability Proportionate to Size (PPS). The students were assessed in Urdu reading, Urdu Writing and science for Class IV and English reading, English writing and maths for Class VIII. In 2014, NAT used the same scoring format and scale as international assessments like TIMSS, PIRLS and TOEFL. NAT scores were measured on a scale of 0-1000 with a standard deviation of 100 and mean score of 500. It covers only government school students.

1.2 Punjab Examinations Commission (PEC)



PUNJAB EXAMINATION COMMISSION
Government of The Punjab

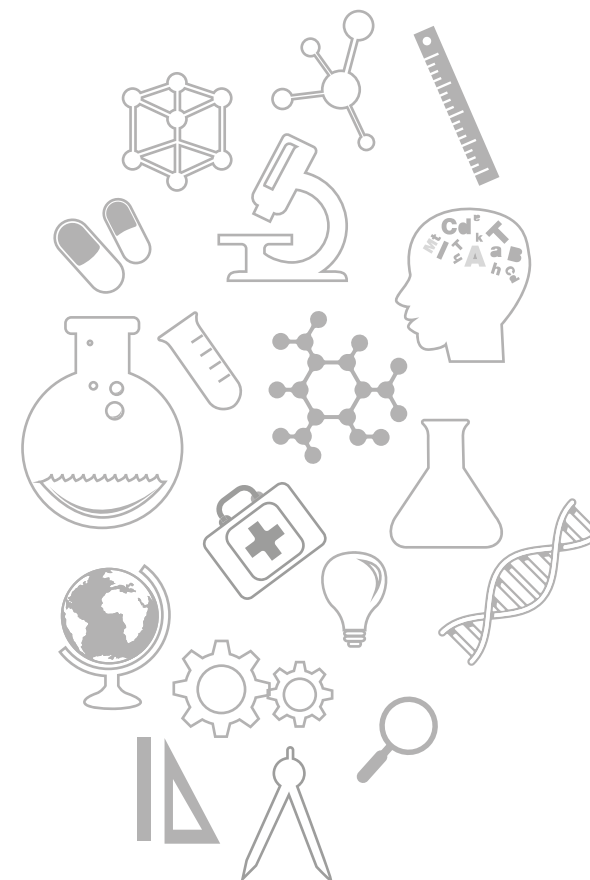
The Punjab Examinations Commission (PEC) was established by the Government of the Punjab to assess and examine student learning and achievement. The annual PEC exam is quite extensive and seeks to cover fundamental

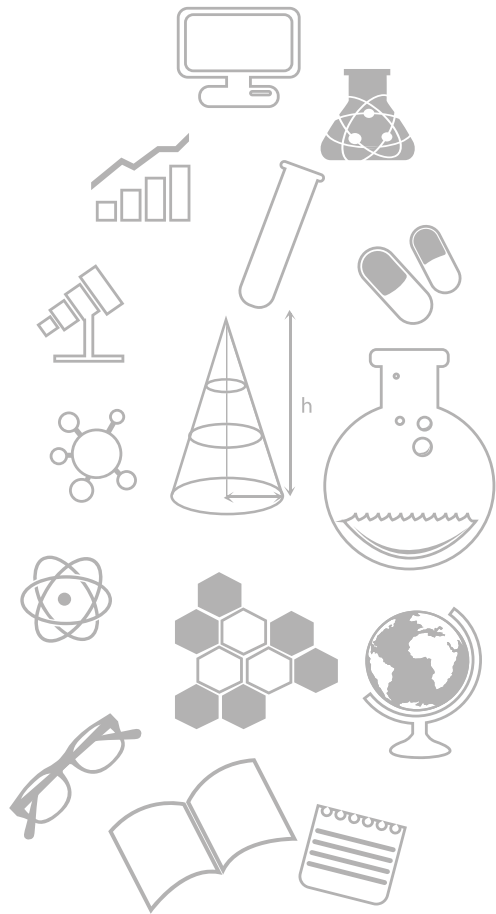
concepts and operations for both Class V and Class VIII levels. Data for PEC is available for 2015 and 2016. A total of 2,197,538 students appeared in the PEC exams in 2016. It covers both private school students and government school students.

1.3 Standardised Achievement Test (SAT)



For the last four years, the Government of Sindh has carried out an annual Standardised Achievement Test (SAT). The results from the fourth wave were published in late 2016. The SAT IV test was purposed to assess multiple dimensions of student achievement. The test focused on assessing Class V and Class VIII student achievement in three subject areas, namely language, maths, and science. Each subject is further divided into several content strands or





main content areas of learning. Data for SAT is available for 2013, 2014, 2015 and 2016. A total of 290,406 students appeared in the SAT exams in 2016. It covers only government school students.

1.4 Annual State of Education Report (ASER)



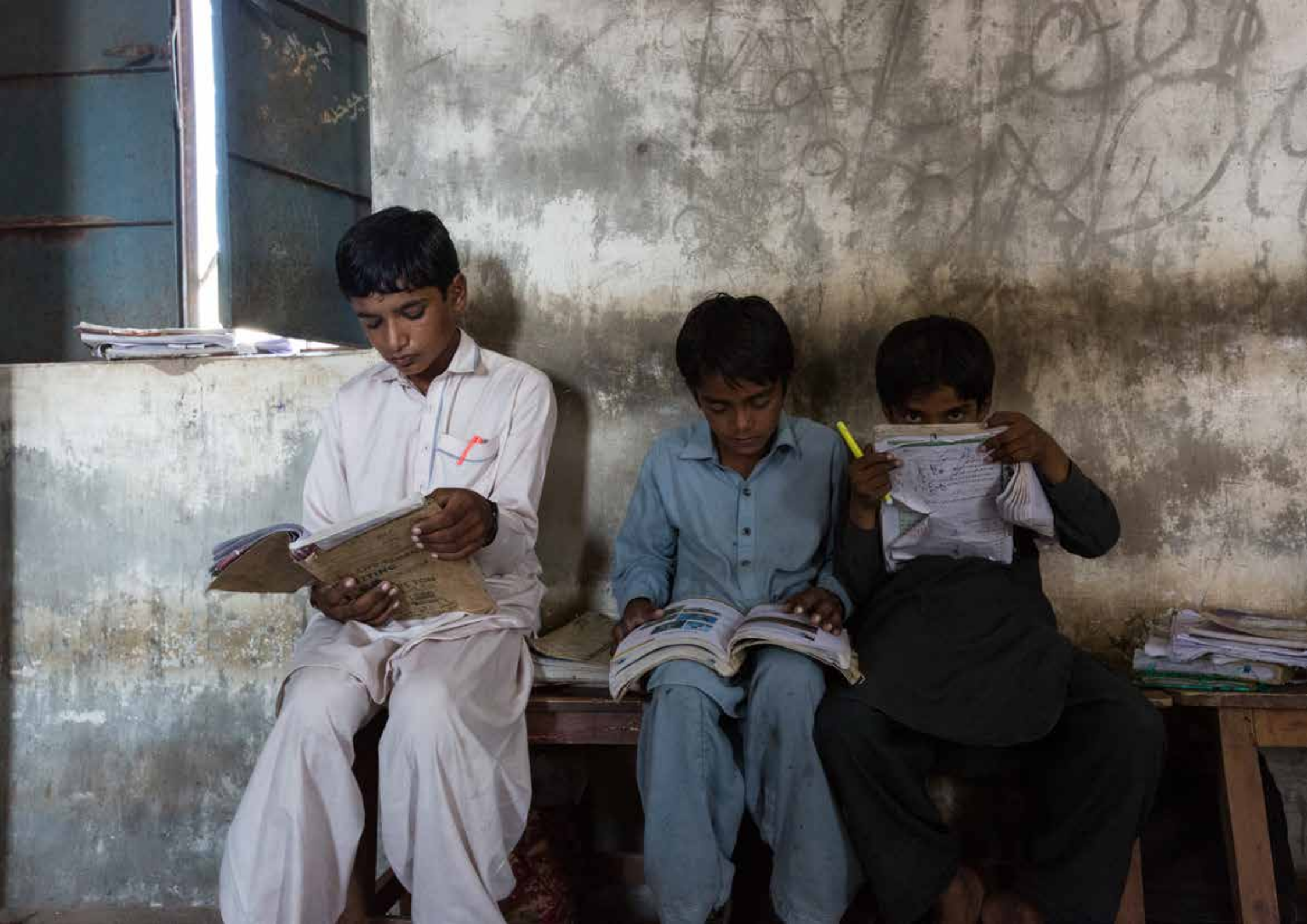
Annual Status of Education Report (ASER) has now carried out several waves of independent testing throughout Pakistan and published data in

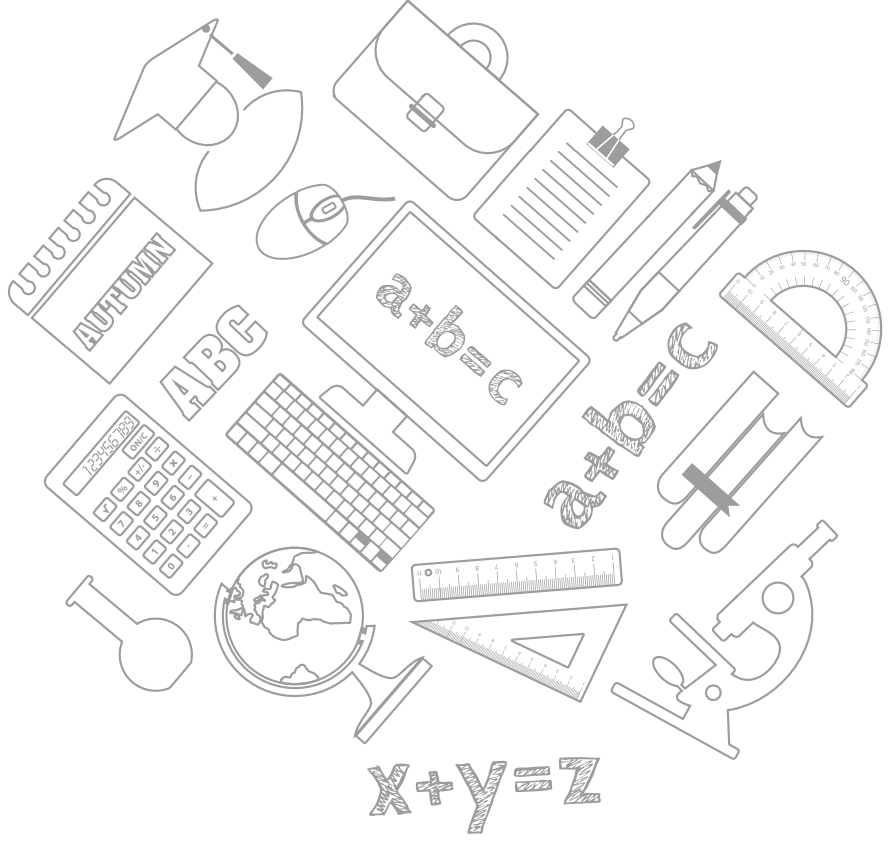
both reports as well as raw format. ASER provides locally relevant achievement scores on a yearly basis, as a result of which a time series has begun to emerge. A section of the ASER test deals with basic numeracy skills within the education system. It comes up with percentages of students, from Class I through Class X, who can conduct basic

numerical operations. Since ASER is not an official government source, albeit cited and benchmarked widely including the Economic Survey of Pakistan annually, it relies on funding from development partners and donors. This poses a risk of the process being interrupted by funding constraints. In the most recent data available, for 2015, ASER examined a total of 286,570 students. It covers students enrolled in private, government, madrassahs and non-formal schools.

1.5 Learning outcomes data: incomplete and incoherent

Pakistan does not have consolidated, standardised national-level data for maths and science education, nor indeed for any subject area. Arguably, this is a reflection of a build-first mentality in which the award of school-construction contracts has been a primary concern for decision-makers. One look at the disparate data that does exist for learning outcomes only helps confirm this suspicion.





2 What we invest in maths and science education

Before we examine what results our schools are achieving in maths and science, we believe it is important to take stock of what is being invested in the effort to begin with. In this section we try to establish a framework that can help estimate the total investment of effort in maths and science education by the federal and provincial governments. Budgetary allocations in Pakistan’s federal and provincial budgets are not disaggregated by subject matter, and therefore when presenting actual figures that attempt to estimate the quantum of education budget that governments spend on maths and science is a complicated exercise. What follows is a rough framing of the challenge and opportunity for how provinces and the federal government could ascertain maths and science focused expenditure.

“We need to think about how money is spent in education. It seems to be easier to spend a billion on a large project than it is to spend hundreds of rupees on basic laboratory essentials” - Dr Sabieh Anwar, Lahore University of Management Sciences (LUMS), Lahore

The table below outlines one possible framework of analysis that could be used for budget estimations for maths and science education. The list of indicators has been developed after a thorough analysis of provincial and federal budget statements.

Framework of analysis for maths and science budget estimations 2016-17

Framework of analysis		
Budget type	Indicator	
Current/ recurrent budget	Salary budget	Salaries of maths and science teachers
		Salaries of relevant non-teaching staff (e.g. lab assistants)
	Non-salary budget	Operation and maintenance of science/computer labs
		Printing of maths and science textbooks
		Standardised maths and science tests
Development budget	Training of maths and science teachers	
	Maths and science curriculum development	
	Construction of new science/computer labs	
	Other maths and science development initiatives	

Note: All indicators have been used for primary to higher secondary school level



At present, the expenses in federal and provincial annual budget statements are neither appropriated nor presented in a manner which allows for an accurate assessment of development and non-development costs incurred on maths and science education.

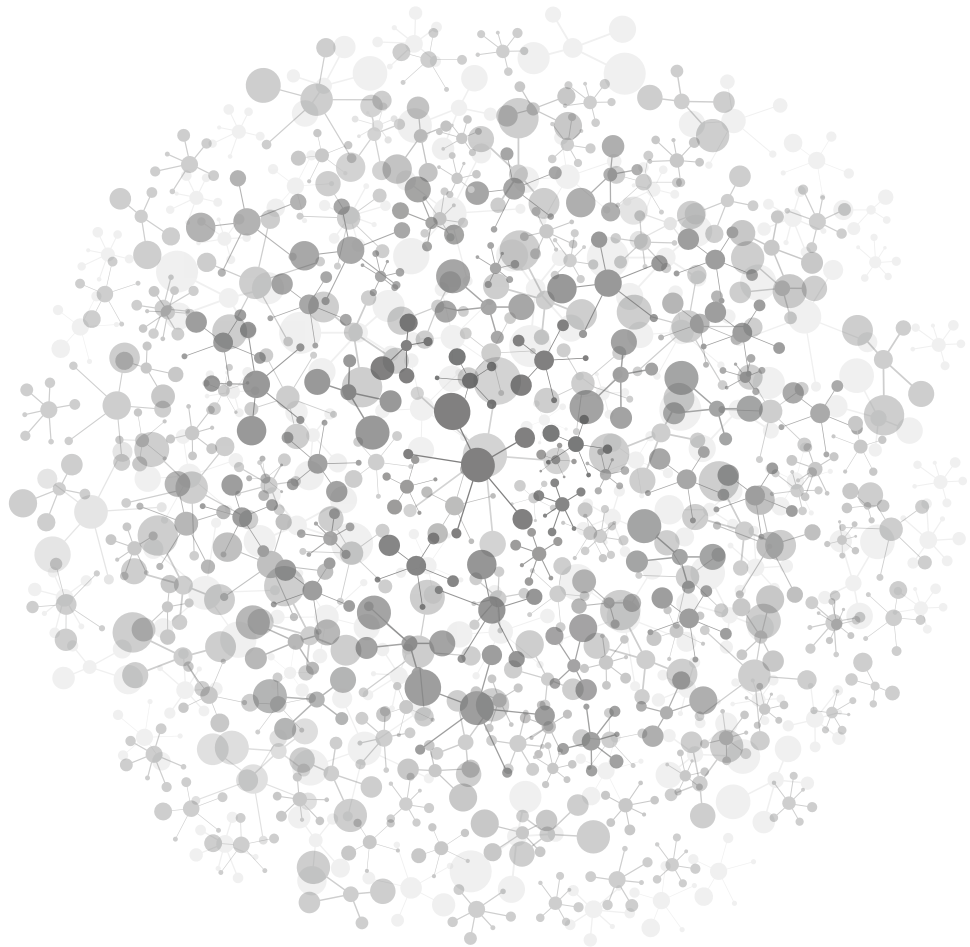
The breakdown of current budget by salary and non-salary is not available for the district allocations made by the provincial governments of the Punjab and Khyber Pakhtunkhwa. The data on the number of government school teachers, which is collected and presented in the provincial annual school census, neither provides a headcount of maths and science teachers at various levels of education nor any details on their designation, professional experience or cadre, all of which are necessary for making reasonable estimations of salary expenditure. Similarly, in the absence of the breakdown of salary budget by teaching and non-teaching staff, an estimate for each of the two categories is rendered implausible.

Furthermore the recurring expenditure incurred by the Reform Support Unit (RSU) on the SAT in Sindh and divisional boards in any of the provinces can not be accounted for, as this data is not publicly available.

The calculation of budget estimates in the presence of these overwhelming restraints necessitates a great deal of guesswork: however, the effort to establish how much taxpayers are paying into the maths and science education of the nation is incredibly important. We hope this section provides a starting point for an informed conversation on the adequacy of the state's financial commitment to the promotion of maths and science education in government schools. The exercise also highlights gaps in the existent data on budget allocations. Without the resolution of these gaps any hopes for informed policies and strategies on adequate resource allocations for maths and science education are likely to be misplaced.







3 The state of maths

This section presents test scores data from different sources to show the dismal level of maths learning among students at the primary and secondary levels. ASER data highlights the lack of ability among students to perform basic numeracy operations. NEAS, PEC and SAT data show low levels of student performance on standardized maths exams.

3.1 Maths scores in ASER

A section on the ASER survey is designed to test basic numeracy skills among children. It is important to note here that ASER tests numeracy skills in students which is only a small part of foundational maths skills that all children should have. It is important to note here that ASER tests numeracy skills in students which is only a small part of foundational maths skills that all children

ASER (Rural) Results 2015

Numerical operations	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Class X
Recognise 1-9	69.8	89.8	94.5	96.8	97.7	98.3	98.4	99.0	98.8	98.9
Recognise 10-99	36.3	70.3	73.10	92.3	95.1	96.6	97.3	98.4	98.5	98.5
Subtract: 2 Digits	7.0	21.0	45.7	67.7	81	87.5	90.5	93.8	94.9	95.8
Divide: 2 Digits	2.60	4.80	12.60	29.30	50.00	62.90	71.10	78.20	84.70	89.20
Can't perform any numerical operations	30.20	10.20	5.50	3.20	2.30	1.70	1.60	1.0	1.20	1.10

ASER (Urban) Results 2015

Numerical operations	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Class X
Recognise 1-9	85.70	94.4	97.0	98.0	97.8	99.4	98.8	99.8	99.4	99.8
Recognise 10-99	53.4	76.8	90.2	93.8	93.9	97.5	95.3	99.1	99.0	98.5
Subtract: 2 Digits	11.4	30.3	57.2	76.2	84.6	91.9	88.7	95.3	97.1	94
Divide: 2 Digits	2.60	5.40	16.90	38.00	52.40	71.80	71.80	85.40	89.50	88.70
Can't perform any numerical operations	14.30	5.70	3.00	2.00	2.20	0.70	1.00	0.20	0.60	0.20

Average score for urban students is 47 percent compared to 45 percent for rural students

Average score for male students is 47 percent compared to 45.6 percent for female students

should have. ASER results show the percentage of children from Class I to Class X, who can perform basic numerical operations such as:

- i. recognising numbers from 1-9 and 10-99
- ii. two digit subtractions
- iii. two digit divisions

The results also give a percentage of children who cannot do any of the three basic numerical operations.

The tables below show the percentage of children (rural and urban) from each class or grade-level that can perform each of the above numerical operations.

The breadth of data from ASER affords an in-depth look at which levels the learning of each of these operations takes place, as well as where and how the learning remains inadequate.

Ideally, students should learn to recognise numbers from 1-9 during Class I and 10-99 during Class II. Similarly, two digit subtractions

should be adequately taught and learnt during Class III and Class IV, followed by two digit division in Class V. Being able to do two digit divisions by Class 5 is a common standard that is often used by academics and practitioners to gauge numeracy skills at the end of formal primary education. It is evident from the above table that only around 50 percent of students enrolled in Class V within ASER's 2015 cohort were able to perform two digit divisions.

3.2 Maths scores in NEAS

The National Achievement Test (NAT) conducted by NEAS in 2014 assesses learning achievement for maths among students enrolled in Class VIII. In order to identify areas affecting overall performance, it seeks to explore students' performance on different sections of the maths curriculum including:

- i. number sense, properties and operations
- ii. measurement and geometry
- iii. information handling
- iv. algebra and functions

NEAS 2014 Mean Scores in Maths

Percentage of respondents	Mean score (out of 1000)
AJK (4 percent)	445
Balochistan (10 percent)	422
FATA (4 percent)	398
Gilgit-Baltistan (4 percent)	438
ICT (5 percent)	466
Khyber Pakhtunkhwa (17 percent)	423
Punjab (39 percent)	532
Sindh (17 percent)	416
National Mean Score	461

It also aims to assess different abilities among students that have a significant impact on maths performance. These include:

- i. conceptual understanding
- ii. procedural knowledge
- iii. problem solving

The mean scores on maths for students enrolled in Class VIII show just how much work needs to be done for our children to learn and perform better. Out of all four

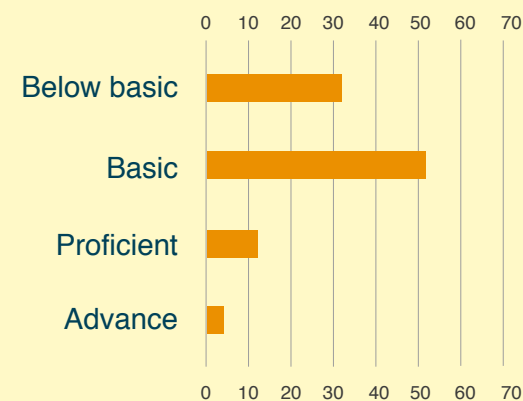
provinces and four regions, only Punjab showed an average score of over 50 percent. The table below shows the results.

NAT results also captured some variance in average scores between rural and urban as well as male and female students. The average score for urban students was 471 out of 1000 compared to 451 for rural students. Similarly, the average score for male students was 470 compared to 456 for female students. The only observation that might

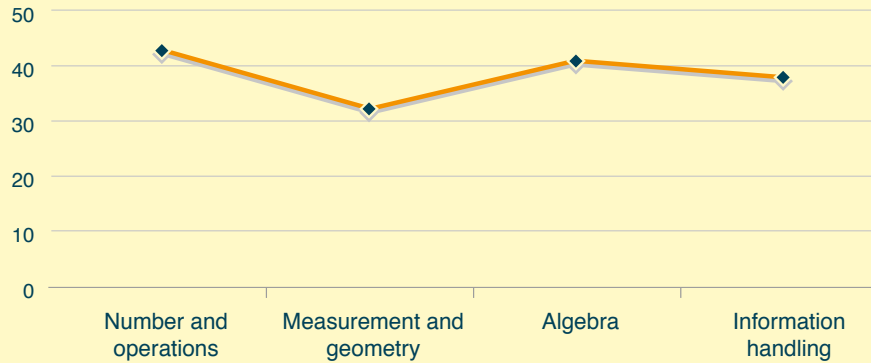
Students fared worst at doing questions that involved measurement and geometry

Among cognitive abilities, problem-solving ability seemed to be the most lacking among students

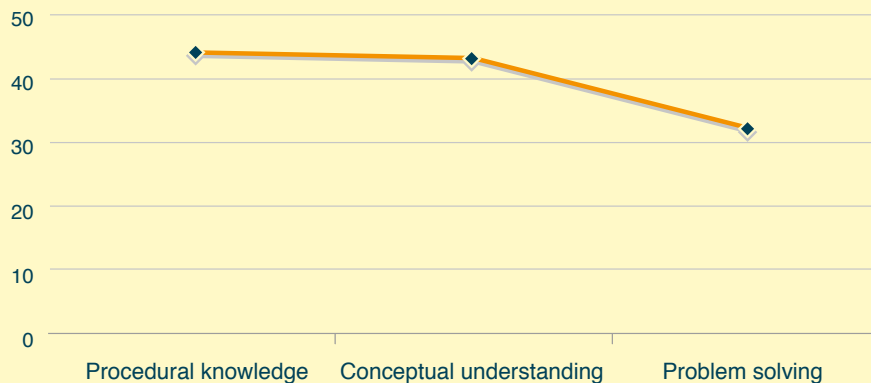
Proportion of students by level of proficiency (percent)



Scores on sections focusing on different components of the curriculum (percent)



Scores on sections focusing on different critical cognitive abilities (percent)



allow some optimism was a small increase recorded in maths scores from 2007. The national average score increased from 451 in 2007 to 461 in 2014. However it goes without saying that we need improvement at a much faster rate to ensure our children attain the quality of maths education they deserve.

The NAT report also included four categories of maths proficiency among students and presented the proportion of students falling under each. Alarming, 32 percent of students enrolled in the Class VIII standard have below basic proficiency. The following figure outlines the results:

The figures show average scores for questions focusing on particular sections of the curriculum and those testing specific critical cognitive abilities among students.

While scores for all sections covering different components of the curriculum are dismally low, students fared worst at doing questions that involved measurement and geometry. As for cognitive abilities, problem-solving ability seemed to be the most lacking among students.

3.2.1 Why maths scores are so low in NEAS

Average scores for all components of the curriculum and cognitive abilities are reflected by the dismal scores obtained by students. The findings also reveal the challenge of adequately measuring achievement and then devising effective policies for improving students' learning across the different themes outlined in the figures above. The NAT data is also a rich source of information from an inputs perspective, i.e. it helps us understand what leads to better performance in maths. The data reveals a few critical factors that contribute to students' performance. Some of the most salient factors are the following: students who are taught by their mothers at home tend to do better; students that are taught in Urdu perform better than those who are taught in regional languages; students who study in single grade classrooms perform considerably better than those who are taught in the multi-grade setting; students of teachers who plan their lessons daily do much better than students of teachers who plan on a weekly and monthly basis; parent-teacher interactions result in better student achievement; students perform better when there is

Students that are taught in Urdu perform better than those who are taught in regional languages

Students who study in single grade classrooms perform considerably better than those who are taught in the multi-grade setting

Students of teachers who plan their lessons daily do much better than students of teachers who plan on a weekly and monthly basis

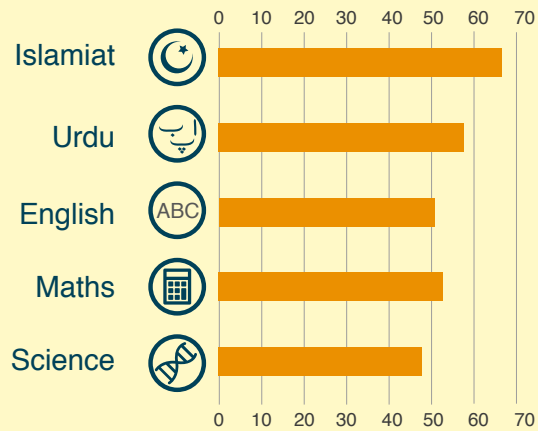
Parent-teacher interactions result in better student achievement

Students perform better when there is no corporal punishment

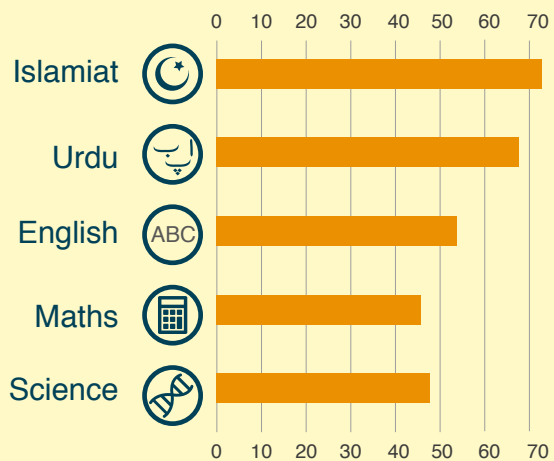
Average scores for children with homework assignments of about half an hour to an hour were higher

Students with access to a computer at home perform better than those who do not

Performance by subject for class V (percent)



Performance by subject for class VIII (percent)



no corporal punishment; average scores for children with homework assignments of about half an hour to an hour were higher; and finally, students with access to a computer at home perform better than those who do not.

Teacher characteristics are also critical for student achievement: students taught by a female teacher perform better than those taught by male teachers; students of teachers with master's degree perform better than of those with bachelor's degrees; students of teachers younger than 35 years and with 5-10 years of experience perform best.

While many factors contribute to the problem of poor learning among students, more prominent reasons have to do with the way the

political economy of education is structured, deep-rooted systemic challenges that need adequate redressal, processes governing recruitment, training and development of teachers, gaps in pedagogical system, the quality of schools, and the quality of content.

3.3 Maths scores in PEC

The maths section of the PEC exam seeks to cover fundamental mathematical concepts and operations at Class V and Class VIII levels. According to the results, students on average perform poorly on maths. For the Class V level, it is the subject with third lowest average score and for the Class VIII level it is the subject with second lowest average scores.

PEC results allow us to examine student performance on key topics from within the curriculum. Some areas and topics in maths clearly present a greater challenge for learners than others.

The PEC test also measures three domains of knowledge classified as knowing, understanding and applying. The following are simple and broad definitions used for each:

Knowing is the lowest level which can be achieved by learning or memorising facts.

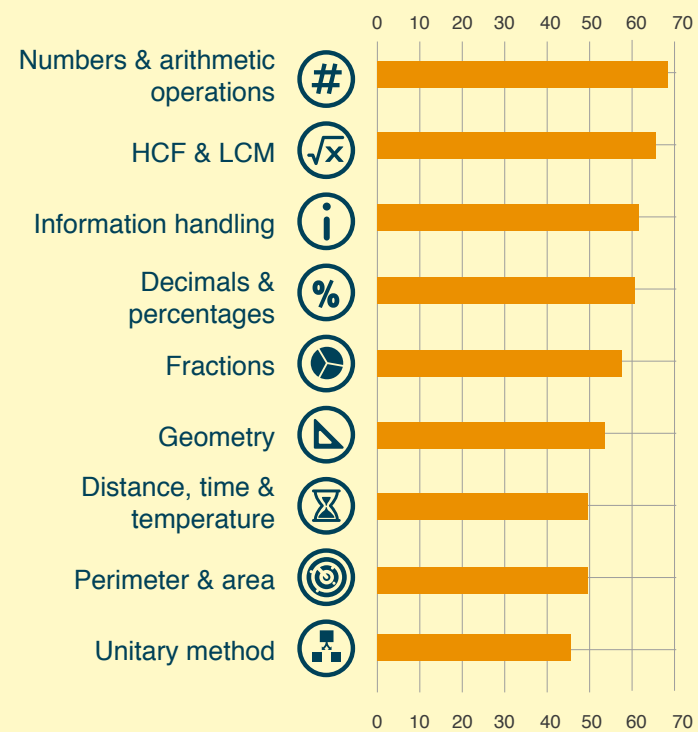
Understanding is a higher level of knowledge whereby one really knows not just the facts and what things are, but

also why things are the way they are. This depends on concepts and not just memory.

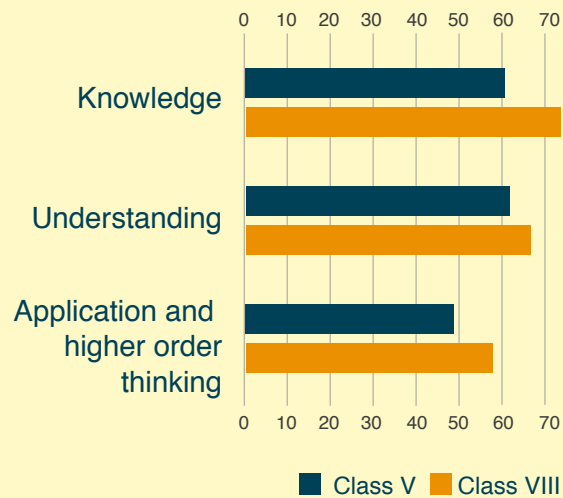
Applying is the highest level of knowledge whereby one can use what is learnt to solve a real-world problem.

Each of these three types of knowledge (or learning) is measured through a series of test questions. Looking deeper at the PEC data suggests that students performed better in questions that tested knowledge compared to ones that tested understanding or application. Scores for each cognitive domain for Class V and Class VIII allow us to see the level of overall enhancement of cognitive faculties among students, highlighting areas of focus.

Average student performance in key areas in maths – class V (percent)



Student performance across 3 cognitive domains (percent)



3.4 Maths scores in SAT

The Sindh Government has in the last four years carried out annual Standardised Achievement Tests (SAT) to measure learning achievement among students enrolled in public sector schools across the province.

Overall, maths achievement is considerably weak in the province. At the Class V level, a total of 179,157 students appeared for the exam and their mean score for maths was 24 percent, which is considerably lower than

language (33 percent) and more or less similar to science. At the Class VIII level, 11,249 students appeared for the test and their mean score for maths was 22 percent, which lower than language (38 percent) and slightly below science (23 percent).

Mean Scores for various content strands in maths are provided in the Table below. Students score highest in information-handling, followed by numbers and operations. They perform most poorly on questions related to geometry.

SAT Scores for Maths Content Strands 2016

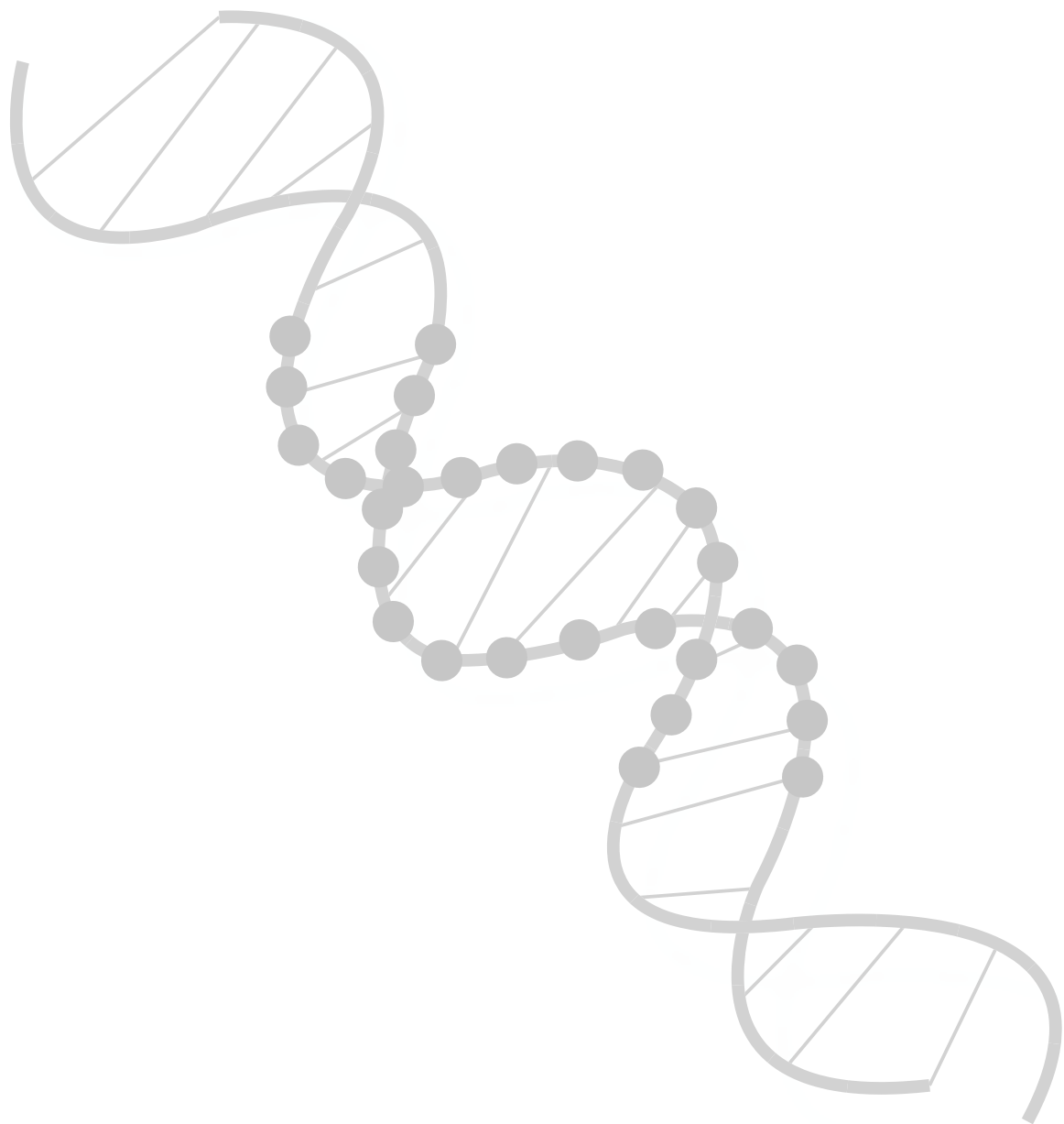
Maths content strands	Class V Score (percent)	Class VIII Score (percent)
Numbers and operations	27	25
Algebra	16	19
Measurement	34	N/A
Geometry	13	18
Information handling	37	36
Overall subject score	24	22



Numbers 1-100

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100





4 The state of science

There is a dearth of standardised tests that look at student achievement in science. ASER, one of the most valuable national level data resources, does not contain questions on science. The only point of reference for providing a detailed national picture and some aggregate numbers is NAT, conducted by NEAS

4.1 Science scores in NEAS

The National Achievement Test (NAT) conducted by NEAS in 2014 assessed learning achievement for science among students enrolled in Class IV. In order to identify areas affecting overall performance, it seeks to explore students' performance on different sections of the content of the science curriculum including:

- i. life sciences
- ii. physical sciences
- iii. chemical sciences
- iv. earth sciences

It also aims to assess different abilities among students that have a significant impact on science performance. These include:

- i. conceptual understanding
- ii. scientific investigations
- iii. practical reasoning

The table below shows the overall average scores obtained on the science section of NAT by students enrolled in Class IV in each province and region. The scores highlight the dismal state of science learning in our schools and underline the urgent need for the state to take remedial steps. Out of four provinces and four regions, not a single one showed an average science score of over 50 percent.

The data shows that 79 percent of all students scored less than 50 percent on the test. The NAT report shows that that on average students

79 percent of all students scored less than 50 percent

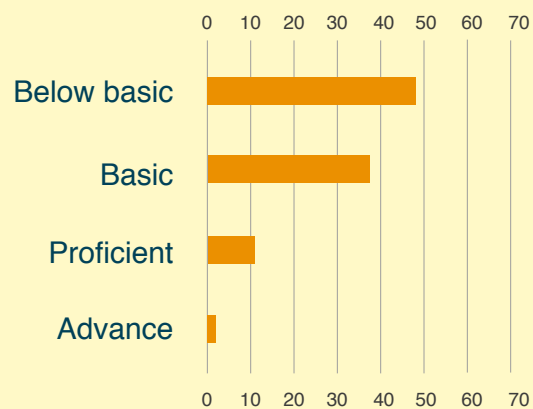
Average score for students from urban areas is 44.5 percent compared to 42.1 percent for rural students

Girls scored an average of 44.3 percent compared to 42.4 percent for boys

NEAS 2015 Mean Scores in Science

Percentage of respondents	Mean score (out of 1000)
AJK (5 percent)	418
Baluchistan (8 percent)	402
FATA (3 percent)	405
Gilgit-Baltistan (6 percent)	419
ICT (5 percent)	409
Khyber Pakhtukhwa (18 percent)	441
Punjab (44 percent)	487
Sindh (11 percent)	420
National mean score	433

Proportion of students by level of proficiency (percent)



from urban areas performed better securing an average of 445 marks than those from rural areas who secured 421 marks on average. Girls on average performed better than boys, securing an average of 443 compared to the average of 424 for boys. The average score declined from 467 in 2006 to 433 in 2014. Also the performances of students on various elements of the science content varied, though not with a big margin, starting from the highest on life sciences (39 percent) to the lowest on earth sciences (35 percent). A similar pattern was obtained with scores on key cognitive skills, namely, conceptual understanding (39 percent), practical reasoning (37 percent), and scientific investigation (38 percent).

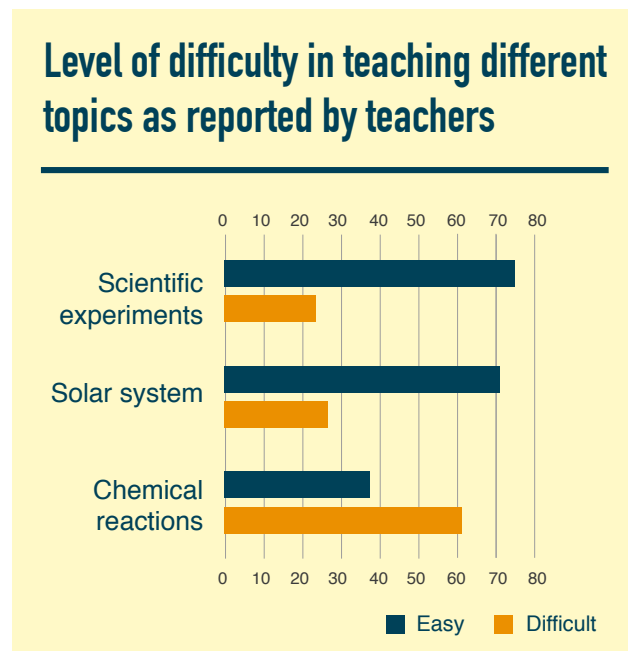
The NAT report also included four categories of science proficiency among students and presented the proportion of students falling under each. Around 49 percent of all students enrolled in Class IV who appeared for the test exhibited below basic proficiency in science. The figure below shows the results.

4.1.1 Why science scores are so low in NEAS

The NEAS data provides useful information to assess the effect of background indicators on student achievement in science. Some of the more significant factors affecting science achievement concern the quality of teaching and involvement of

parents; students perform better when they are taught by a tutor at home; students whose teachers planned their lessons performed better as well as the students whose teachers consulted other teachers about lectures; students who are guided by their teachers during class tend to perform better; students of teachers who repeated their lessons performed better and so did the students whose parents took active interest in their studies and met with their teachers on a regular basis.

The NEAS report also includes perceptions of teachers concerning the difficulty of teaching each of the three main content streams of the science curriculum. Teachers reported facing the greatest difficulty in teaching chemical reactions. The following figure outlines the results.



Students perform better when they are taught by a tutor at home

Students whose teachers planned their lessons performed better as well as the students whose teachers consulted other teachers about lectures

Students who are guided by their teachers during class tend to perform better

Students of teachers who repeated their lessons performed better

Students whose parents took active interest in their studies and met with their teachers on a regular basis performed better

4.2 Science scores in PEC

The science section of the PEC exam is quite extensive and seeks to cover fundamental scientific concepts and operations in Class V and Class VIII. A total of 1,204,339 students participated in Class V exams, while a total of 993,199 students participated in Class VIII exams with pass percentages of 75.4 and 75.9 respectively. The science exam covers a number of focus areas from the syllabus.

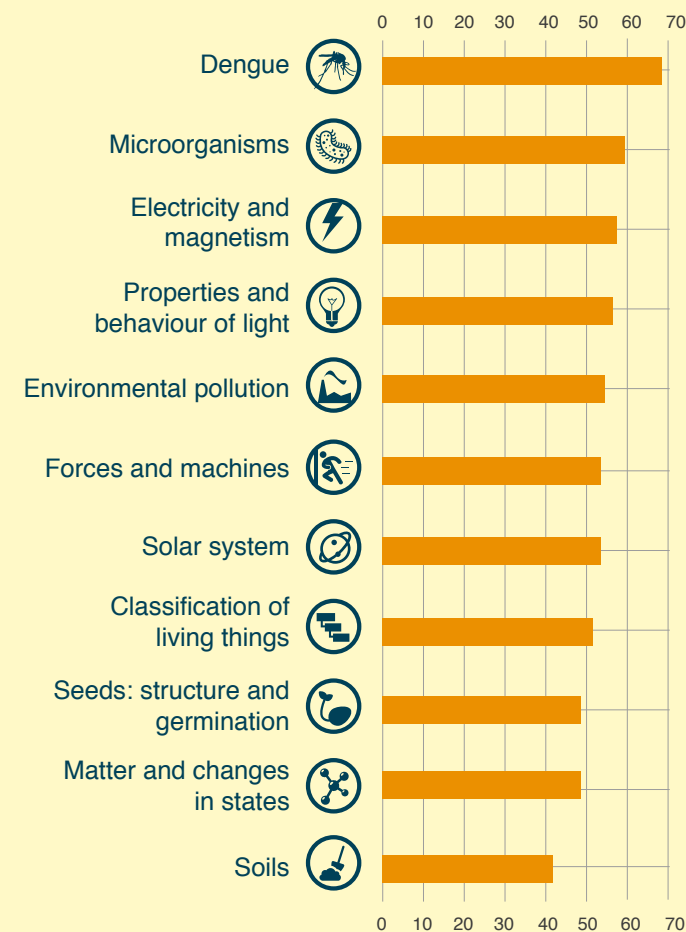
PEC 2016 Focus Areas for Science

Classification of living things	Acids, bases and salts
Electricity and magnetism	Animal Kingdom
Environmental pollution	Chemical reactions
Forces and machines	Earth and space
Matter and changes in its state	Plant kingdom
Microorganisms	Manufacture of useful products
Properties & Behavior of Light	Heredity in organisms
Seeds: Structure and germination	Properties and behaviour of light
Soils	Light pressure
Solar system	Symbol and formula

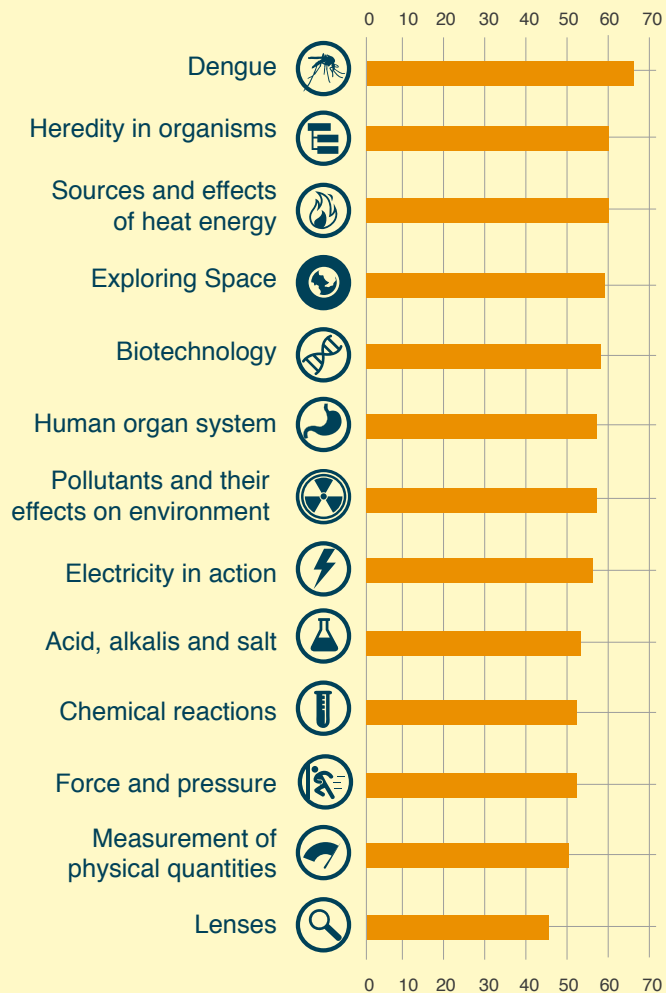
The number of questions from each of these areas varies from three to twenty. There are several sub-topics covered within each of these areas and each student is tested for knowledge, understanding and application of concepts within each area.

PEC results allow us to examine student performance on key topics from within the curriculum. Some areas and topics from the science curriculum clearly present a greater challenge for learners than others. The following figure outlines the findings.

Average student performance on different topics - class V (percent)



Average student performance on different topics – class VIII (percent)



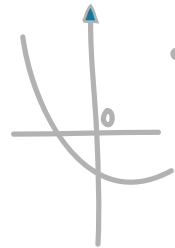
4.3 Science scores in SAT

The mean score for science achieved by students from Class V was 24 percent, which is considerably lower than language (32 percent). At the Class VIII level the mean score for science was 23 percent, which is considerably lower than language (38 percent).

Mean scores for various content strands in science are provided below. Students score highest in life sciences in both Class V and Class VIII. They are weakest in physical science at both class-levels.

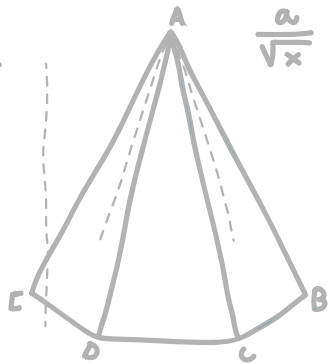
SAT Scores for Science Content Strands 2016

Science Content Strands	Class V score (percent)	Class VIII score (percent)
Life science	31	25
Physical science	17	22
Earth & space science	36	23
Overall subject score	24	23

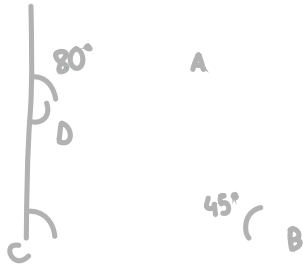


$$ax^2 + bx + c = 0$$

$$x \left(\frac{2\pi}{a} - b \right)$$



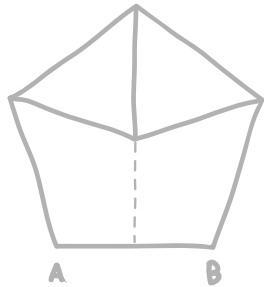
$$\frac{a}{\sqrt{x}}$$



$$A + B + C + D = 360^\circ$$

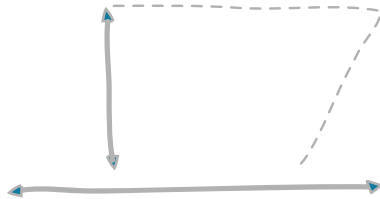


$$y = \left(\frac{bx+a}{2} \right) - h$$

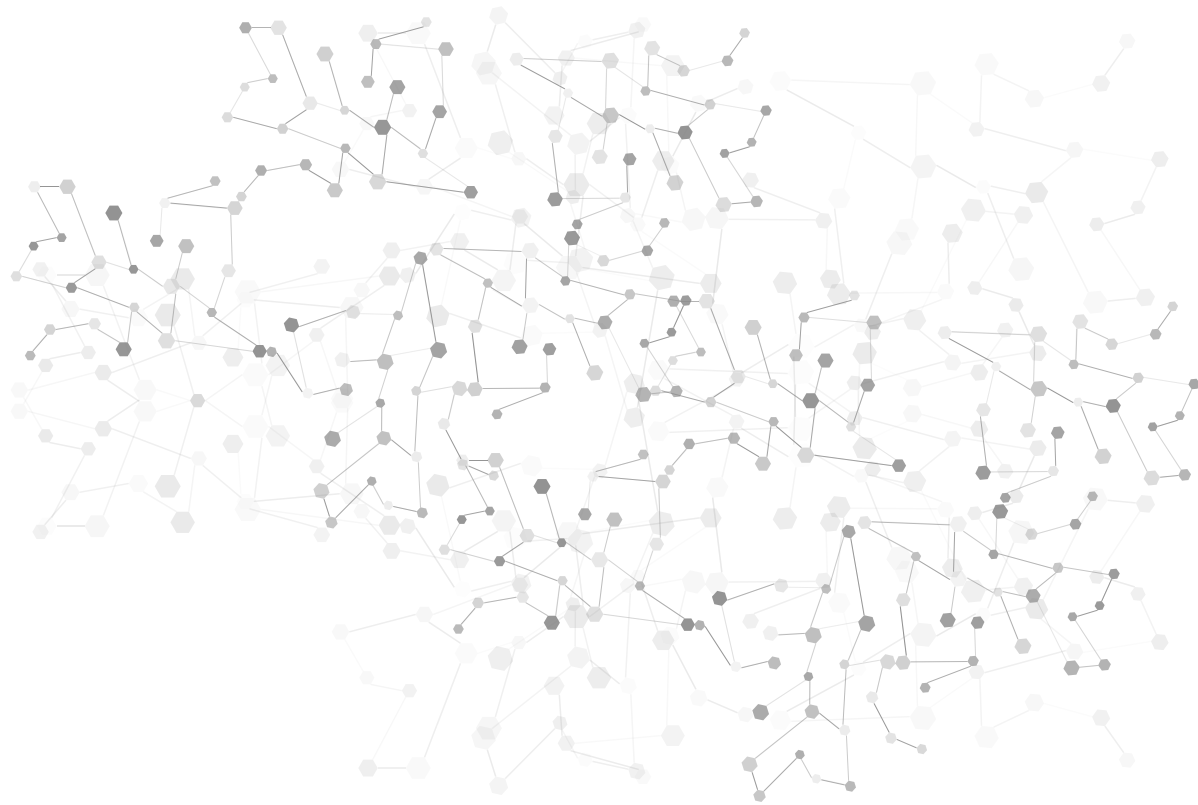


$$y(-a) + \left(\frac{2}{2} - a \right)$$

$$a = x^2$$







5 Return on investment

One important measure to determine the quality and success of existing spending on maths and science education, is to see what kinds of improvement in scores results from increased spending. However, a fair assessment of the return on investment in education, and specifically maths and science education is not possible without more robust data, both in terms of public financial management systems and outlays, and in terms of assessments and scores that are standardised year on year, within provinces, and across provinces and regions at the national level. Nevertheless, we present

below, some trends that should provoke governments across the country to establish key performance indicators in the realm of returns on investment in maths and science. The theory of change here would be that such analysis will help government officials target public spending on education in a direction that yields, over time, constantly improving learning outcomes.

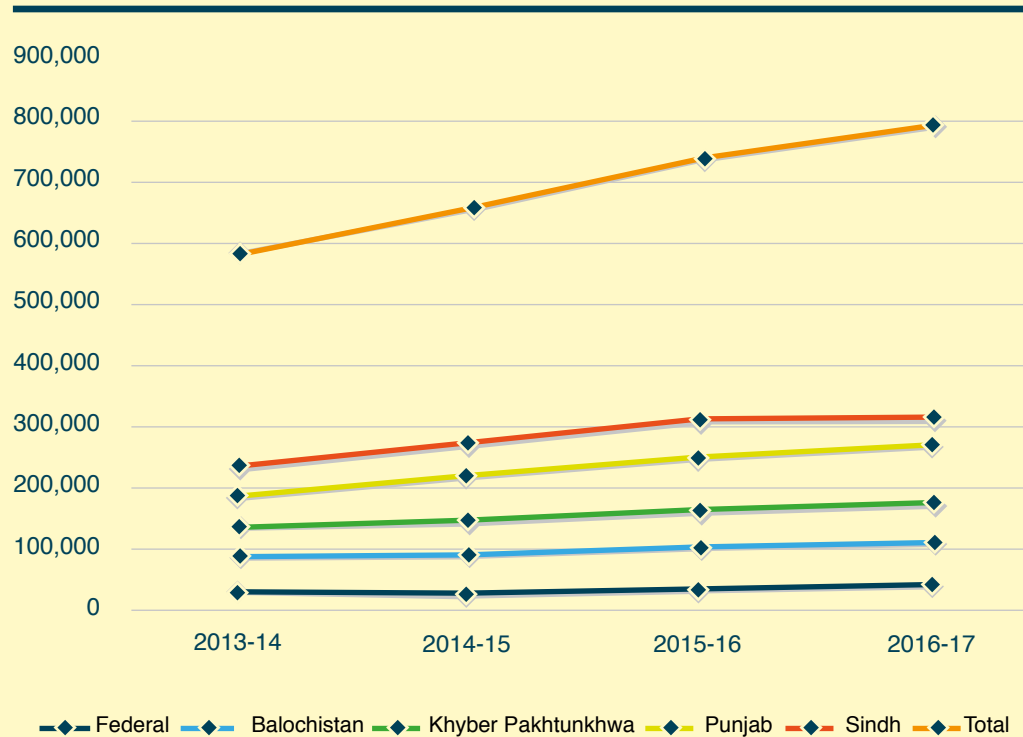
Federal and provincial governments have been increasing yearly allocations to education budgets. The total quantum of increase in allocations at the federal level,

Total National and Provincial Budget Allocations (Millions of Rupees)

Province	2013-14	2014-15	2015-16	2016-17
Federal	80,398	86,400	97,880	108,971
Balochistan	34,898	40,674	48,524	49,112
Khyber Pakhtunkhwa	96,407	111,300	119,720	143,436
Punjab	232,566	273,000	310,200	312,800
Sindh	135,546	145,020	157,517	176,385
Total	579,815	656,394	733,841	790,704

The total quantum of increase in allocations at the federal level, from 2013-2014 to 2016-2017 is roughly 36 percent. For the Punjab, the increase is about 34 percent. For Khyber Pakhtunkhwa it is 49 percent. In Sindh it is 30 percent and in Balochistan it is 41 percent

Total National and Provincial Budget Allocations (Millions of Rupees)



from 2013-2014 to 2016-2017 is roughly 36 percent. For the Punjab, the increase is about 34 percent. For Khyber Pakhtunkhwa it is 49 percent. In Sindh it is 30 percent and in Balochistan it is 41 percent .

As noted in the figure, the governments' increasing commitment towards education is reflected through welcome increases in the education budgets. However, in order for us to appreciate the returns on this investment in terms of quality of education measured through student test scores, the first step is to see if the trend in increasing budgets is matched by a similar trend in improvements in standardised test scores.

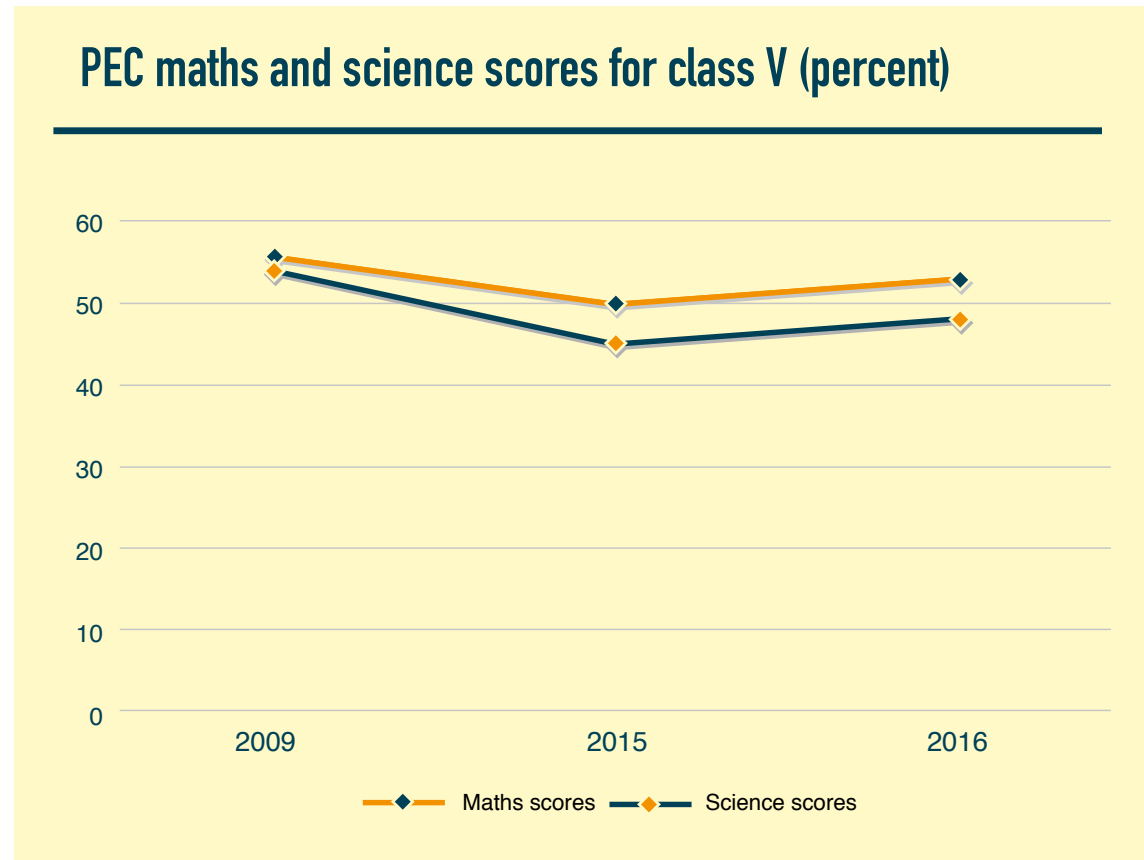
Unfortunately, availability of data is the greatest impediment followed by lack of standardised methodologies for assessments and grading in formulating a robust analysis. Data on student achievement from Khyber Pakhtunkhwa and Balochistan is not available and hence we are left with scores from Punjab and Sindh. In Punjab, the published PEC report does not follow the same structure used before 2015. We used data from PEC reports from 2009, 2015 and 2016 to make a point about changes in student achievement in maths and science. For Sindh, we used SAT reports from 2013, 2014, 2015 and 2016 to make a similar point.

5.1.1 PEC

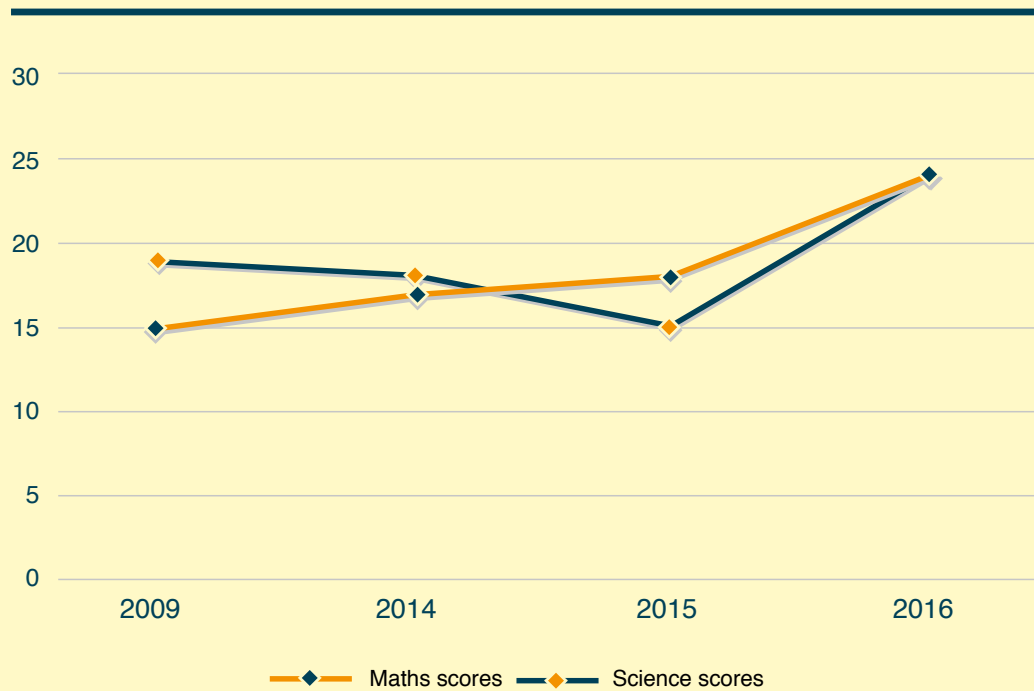
The data shows that student test scores in maths and science reported in 2016 are lower than in 2009. While just three data points are not enough for a deep rooted examination of the problem, it is however apparent that vast volumes of money invested in the education sector have not yet yielded adequate results in terms of student achievement. It is however important to note that a lack of adequate standardisation in methodologies and testing techniques means that year-on-year data from PEC is not as robustly comparable, for year-on-year comparisons as it could be. In order for there to be robust analysis of year on year trends mapping the changes in levels of student achievement, testing methodologies need to be more streamlined and more standardised.

5.1.2 SAT

Maths and science scores have shown some improvement in Sindh over the last four years. There has been an increase of 26 percent in science scores and an increase of 60 percent in maths scores. While any improvement is appreciable it is apparent that a much faster rate of improvement is required across the province.



SAT maths and science scores for 2016 (percent)



It is likely that there may be a lag between additional investments being made in education and their impact being visible in test scores. However, it is also possible that the investments being made are not in a manner that could result in immediate and direct bearing on maths and science achievement.

GOVT. BOYS HIGH SCHOOL MALANHORE VEENA

SCHOOL IS A LIGHT

TO THE SOCIETY

ER TO LEARN

FOR TO SERVE



6 Why the state of maths and science education is the way it is

Both at the national level and at the provincial level, various kinds of tests across different time periods demonstrate the low levels of learning in maths and science. The diagnostic exercises conducted in the Punjab and Sindh over the last few years have added a layer of depth and complexity to our understanding of the challenge of quality maths and science teaching and learning, but the added knowledge of how bad things are is relatively meaningless without a robust and honest exploration of why the state of maths and science education is as it is. In this section, we explore five distinct but inter-related reasons that we believe are at the heart of low levels of maths and science learning and the resulting low stock of cognitive skills that Pakistan suffers from. These are:

- A political economy in which the odds are stacked against maths and science education
- Government structures and systems, at both the policy level and the administrative level that privilege inputs and those delivering them, and therefore prevent a greater focus on children and on learning outcomes, especially in maths and science
- The standard of education in government schools being so low that they are the least preferred option
- A national stock of teachers that, although improving in recent years, has been historically so bad that it has produced an intergenerational problem of low quality teaching in today's classrooms, perpetuating low quality teaching endured by teachers when they were students
- The challenge of low quality content being taught in maths and science, and how the assessments and examinations systems are reinforcing poor learning outcomes; in addition to the quality of content, how material is taught is also a significant challenge. Pedagogical improvement is another area that needs attention.



We explore each of these causes of the poor learning outcomes in maths and science below.

6.1 The political economy of maths and science education

“The political leadership can play a key role in budgetary allocation, in reinforcing the importance of science and mobilising public opinion, in making science and technology a priority for their government/party manifesto” - Dr Faisal Khan, CECOS University, Peshawar



Poor and unacceptably low maths and science learning outcomes are ultimately a reflection of the failure that occurs in Pakistan’s classrooms. The interaction in those classrooms between teachers that don’t have the adequate skills, students that don’t have the adequate levels of nutrition and home-level support, and schools that are ill-

equipped to provide a conducive environment is what leads to the breakdown in the teaching-learning process that produces poor learning outcomes in maths and science.

One approach to trying to solve the problem of poor learning outcomes in maths and science is to address the problem of the classroom interactions that constitute this breakdown. Some of the policy instruments that have traditionally been used to address this include teacher training, improved classroom facilities, improved school infrastructure and school feeding programs that boost student nutrition. All of these are useful instruments in the quest to improve learning outcomes, particularly in maths and science. However it is also important to explore and examine how things got to where they are and what is the origin of the various factors whose confluence in the classroom produces these low quality maths and science learning outcomes. In other words, instead of trying to fix a teacher that lacks the motivation, incentives, and capabilities to deliver better

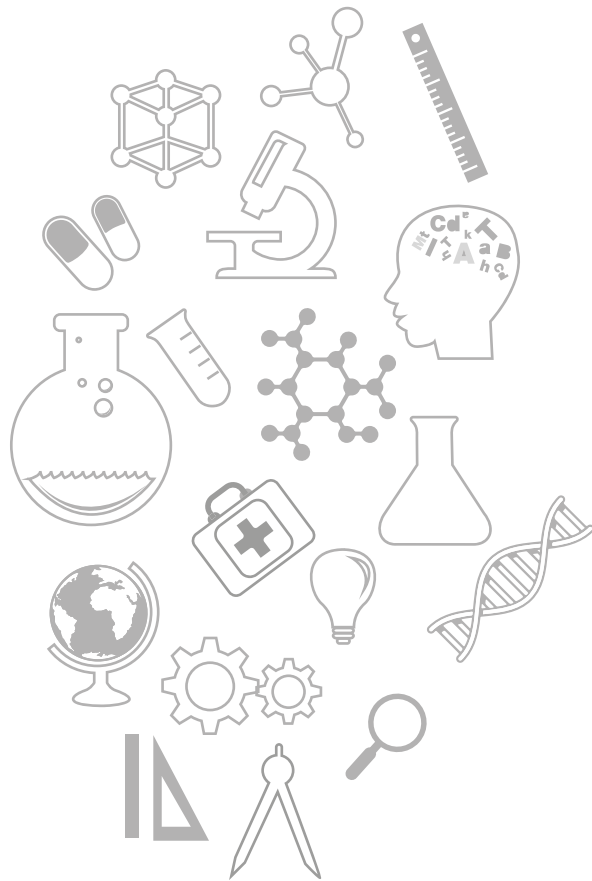
instruction in maths and/or science, there is value in understanding how that teacher got there in the first place. Similarly, instead of trying to fix a school without boundary walls by building those walls, there is value in understanding how that school got built without walls, or perhaps more aptly, how the walls came down, and did not automatically get rebuilt immediately. Similarly, instead of trying to bring out-of-school children to schools that those children don't want to attend, there is value in understanding the dynamic that generates high out-of-school numbers across the country, concurrent to historic high enrolment levels in private schools. A political economy approach to maths and science education can help us do exactly this.

6.1.1 Maths and science as a cultural failure

Consistently low maths and science scores across all four provinces, and across time, suggests not only a single failure but a

series of failures to which neither state, nor society has reacted adequately. Low learning outcomes are well known and have been for a long period of time. Yet there has been no systematic response to this failure, either by civil society, state actors, or the private sector. Many observers note the rapid and mushrooming growth of private schools as evidence that the market has adequately responded to the problem of low quality education. This is true if the world is restricted to the housing authorities and gated communities of the rich and almost-rich in Pakistan. However given the massive number of out of school children, the market has chosen very carefully to include one kind of problem (the problem that can afford a solution), whilst excluding another kind of problem (the problem that cannot afford a solution). One possible explanation for this failure is that the overarching culture, within which social and state priorities are identified and established, has excluded maths and science education as a worthy constituent of the national agenda. This could be posited





not only for maths and science alone but for education at large, although the substantially better scores in some of the standardised tests at the provincial level in other subjects suggest that maths and science do represent unique challenges. It is important to note here that lack of agency concerning maths and science is evident from the relative lack of work exploring reasons for the current state of maths and science education in the country. On the contrary, there are various examples of in-depth works on the subject in other countries. In countries that consistently have high scores in maths and science there is an explicit premium that is associated with maths and science in the public discourse: political leaders, civil society and the market itself work to demonstrate the benefits of investing in maths and science. The absence of a culture in which maths and science enjoys a privileged status helps explain the absence of a social or state-based response to the crisis of maths and science education.

6.1.2 Maths and science as a market failure

Excellence in maths and science, unless manifested through an associated profession, has not traditionally been rewarded by the job market in Pakistan. This is a distinct and stark contrast from places where there are consistently good learning outcomes in maths and science, such as Finland and Israel, where the job market for young people rewards excellence in maths and science with the best jobs.

A growing body of work, such as the research by Mariana Mazzucato, suggests that even these kinds of market failures are often the product of a lack of imagination and ambition on the part of states. She uses the example of the US defence sector as a driver of innovation and enterprise, through massive investments in research and development that helped spark technological breakthroughs, first in the defence sector and later across civilian uses.

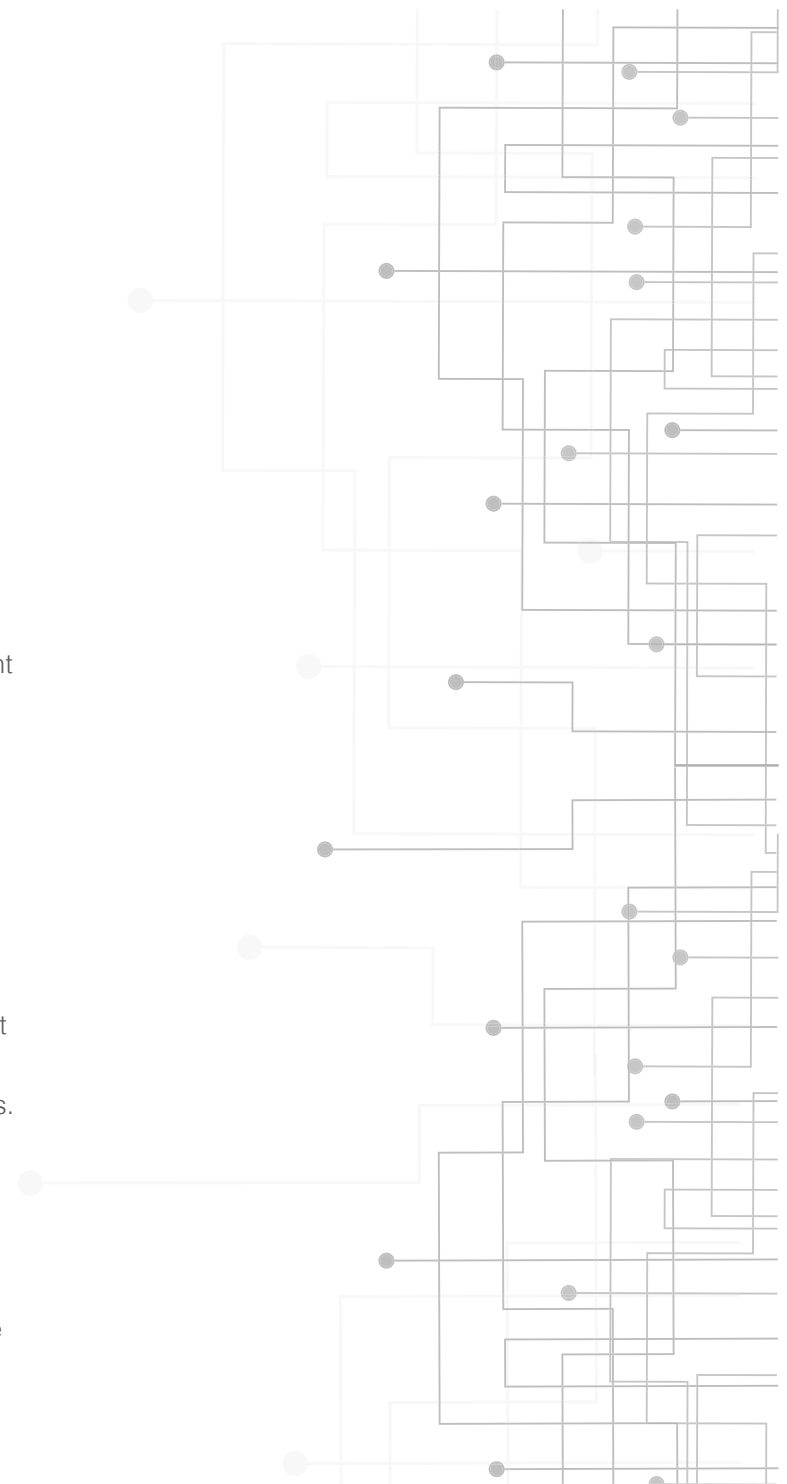
At the very top of the academic pyramid in Pakistan, both maths and science have enjoyed a prolonged status as important areas in which excellence is rewarded, but this premium is associated specifically to engineering, medicine and accounting as professions. The numbers for these professions are however regulated strictly by the professional associations in these fields (the Pakistan Engineering Council, the Pakistan Medical and Dental Council, and the Institute for Chartered Accountants of Pakistan). Only a miniscule proportion of all students that reach higher education are able to enter these fields.

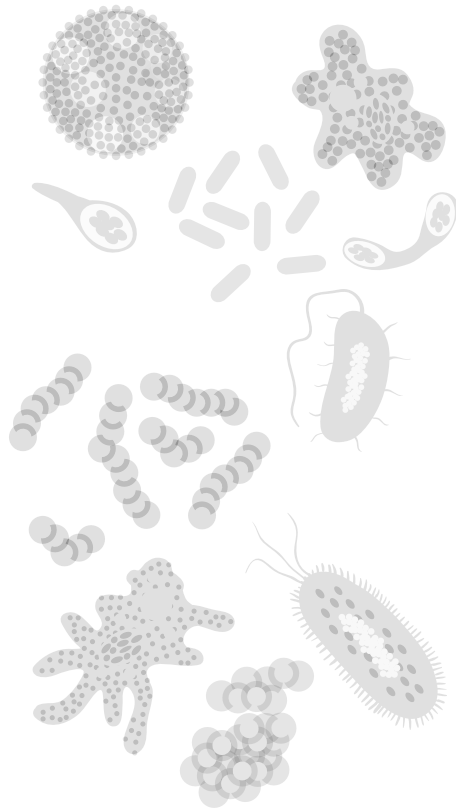
6.1.3 Maths and science as a community failure

Low maths and science achievement levels in Pakistani schools are not just a product of the attendant factors at play at the moment, but the confluence and accumulation of a history of failures. Government schools

that were, less than a generation ago, capable of producing a quantum of high quality graduates, have been reduced to least preferred options for the poorest and most vulnerable. In part this has happened because community, neighbourhood and household level engagement with government schools has disappeared. The quantum of agency exercised by the parents of children enrolled at government schools is so low that teachers and school administrators do not have any incentive to be responsive to constantly falling test scores and failing classrooms. This corrosion of the agency of the average parent whose child is enrolled in government schools has occurred concurrent to Pakistan becoming the scene of one of the world's fastest growing private school sectors.

A combination exists of a cultural vacuum in which maths and science scores can be in free-fall, a set of market signals in which agents and principals are not motivated to improve maths and science learning (despite global and regional signalling in the opposite





direction) and a country-wide series of failures of communities to cultivate schools in which the future of children is treated with respect. Maths and science scores are not yet seen to be barometers of whether neighbourhoods should be satisfied or dissatisfied with a given school and its management, including teachers.

6.2 Structural and systemic challenges

There are two broad categories of constraints relating to the system in which maths and science education is delivered. The first is related to policy-making, including data and budget making. The second is related to the structures with which the system is administered. Part of the challenge at the structural or systemic level is that neither maths and science, nor any other subjects (including languages) receive any bespoke treatment. Even if they did, they would still suffer from the limitations described below.

6.2.1 Policy-making constraints

There is no bespoke planning for maths and science education in any province in the country. This means that the grand architecture of policy-making for education is 'one size fits all', with no specific customisation or tailoring for maths or science. The policy-making architecture is not amenable to being tailored to produce specific outcomes in any subject area, including maths or science. The biggest reason for this is that the two immutable areas that would enable tailor-fitting policy to achieve specific goals do not offer any room for specificity: a data regime that would enable a greater analytical lens into what is working and what is not, and a budgetary system, or public financial management system, that would enable the targeting of policies with specific financial inputs and/or incentives.

6.2.1.1 Data

As described in Section 2, there is no official,

consolidated national data on maths and science learning outcomes. At the provincial level, only Sindh and the Punjab conduct standardised annual testing below the Class X (or Grade 10) level. Both those exercises were initiated through donor-funded programmes, but have now been almost fully integrated into the provincial architecture. Still, there is little evidence that learning outcomes or testing results are fed back into the decision-making system that explores and makes decisions on teacher recruitment, or on the specific areas in which students need greater support, or on the deployment of maths or science teachers. Education data is also entirely housed at the provincial level, where it may offer a dashboard for top-level decision-makers. Whilst this is a valuable change from the past, when data played no role at all in decision-making, there is still no coherent data regime for decision-makers at the district, or sub-district level. This means that school level decision-making is still a substantial vacuum in the data regime employed for education. Decisions that could enable improved maths

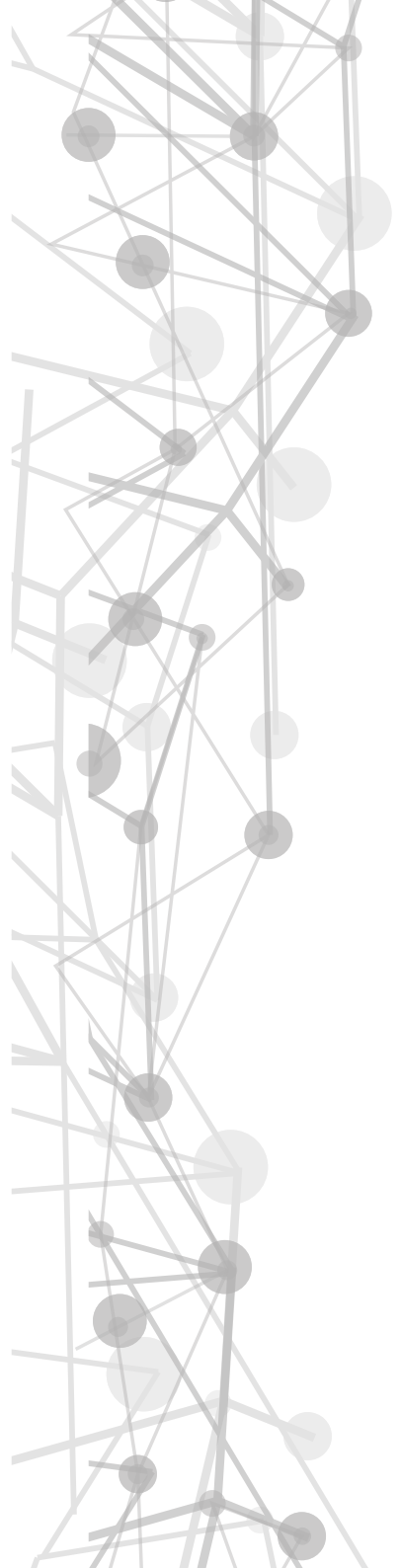
and science learning need to be made about absent data that could either inform decision-makers about the need for a change, and/or data that could inform decision-makers about the effectiveness or lack thereof, of a change already made. Essentially, at the national, provincial, district and school level, maths and science education decisions are thus being made on the fly and blind.

We don't even have enough data to know our local strengths and the local landscape - Dr Faisal Khan CECOS University, Peshawar.

6.2.1.2 Budget allocation

The argument in favour of increased budgetary allocations for education in general, and for improved quality, especially better learning outcomes in maths and science tends to be made on the basis of the already strong expressions of commitment by various political parties, and governments, to increase funding for education. However, these





increases, even when made, are rarely able to be directed for specific policy outcomes. This is because of the existing public financial management system, in which allocations are divided neatly into recurring expenditures (like salaries) and development expenditures (like new classrooms, and new furniture). Because the overarching public financial management system is 'one-size-fits-all' across the public sector, there are no options for specific allocations that would enable or empower maths teachers, or provide extra materials for science experiments. In addition to this, the high personal cost that is borne by officials found to have audit observations on processes undertaken on their watch means that there is a wholesale disincentivisation of innovative or 'out-of-the-box' ideas for how to spend money, even when money is made available for quality initiatives. The fate of science laboratories, where they exist, tends to be that they are locked up and 'protected' from students and teachers alike. This culture of treating learning materials as sacred flows from the public financial management

system, which is structured to reward and punish officials who are there to manage and protect the public sector, rather than to deliver outcomes for citizens, or in the case of children, students of maths and science.

6.2.2 Administrative & structural constraints

The challenge of measuring maths and science learning, or of financing improvements in maths and science, is difficult enough with a data regime, and public financial management regime that limits policy options. Yet even if there was a perfect system of data collection, analysis and reporting, and funding was not only adequate in magnitude but in targeting, the system would still suffer from structural and administrative limitations that constrain the ambitions and will of maths and science educators across the country. The administrative and structural constraints inform teacher transfers and postings, school autonomy, parental participation, and the system's treatment of private schools, all of

which limit the degree to which the system can generate the impetus for improved maths and science learning, or respond to poor maths and science outcomes.

6.2.2.1 Education department

Education has been a deeply contested area of service delivery in the constitutional and federal context of Pakistan, and was devolved to provinces as part of a transformational package of Constitutional reforms in 2010. In part, this contestation helped create a bifurcated set of capacities at the federal and provincial level. Federal level decision-makers would be invested in overall policy whilst provinces were grant managers, disbursing salaries, and other payments, managing construction projects, but rarely, if ever, framing or driving policy and overall direction. Concurrent to this federal-provincial dichotomy, education, and especially quality maths and science teaching and learning, have largely been subject areas that elicit very limited

interest from the bureaucratic structures, or elected leaders. Until 2010 most reform initiatives and new ideas at the education ministry in Islamabad, and the provincial departments in the respective capitals, were therefore initiated and incubated by multilateral and bilateral donors.

Today, with the mainstream education sector entirely within the uncontested domain of provinces, each province has a political interest in growing its respective capacity to drive policy in its entirety, but no province has the structural capacity to take that narrative forward. Every province has substantial donor-funded input co-located within the department, and in large part these inputs have helped deliver a range of changes to the system, including the merit-based recruitment, which is possibly the most wide-ranging of the many changes and reforms that have been attempted in recent years. Education departments do not have subject specific units or departments and do not have any means of incorporating learning outcomes into policy.





For the most part, education departments have subordinate units that work on data collection and analysis, and on teacher capacity, yet those units operate largely independently with little input or feedback shaping training and capacity building plans. All four of the provincial departments for education are essentially structures that help manage the substantial populations of government schools teachers, particularly their transfers and postings. Different provinces have adopted different approaches to local governments, yet despite several years of discussions and plans, no province has attempted to dismantle the centralised teacher management that all four provincial departments have adopted as their core, existential body of work.

Departments have also rarely, if ever, considered internal restructuring or reform, even to the extent of expanding the size of the department to cope with the managerial burden of teacher populations that range from roughly fifty thousand in Balochistan,

to well over three hundred thousand in the Punjab. Departments that were originally formed to handle several thousand (at most) teachers have expanded dramatically in terms of responsibility to manage, without any increase in the capacity to manage. In part, this has been sustained because of the in-built incentives to retain and deepen powers within the bureaucracy. The chief complaint of top officials—that too much of their time is taken up by managing transfers and postings of teachers—could easily be addressed by decentralizing control over these issues or, alternatively, expanding capacity at the top of education departments (for example by increasing the number of senior officer positions, and recruiting civil servants or specialists to fill them). Yet no such measures are taken, possibly as a reflection of the hidden incentives to sustain the status quo. In addition to the problem of real resource constraints that most relevant departments operate under, there are also cases of bureaucratic inertia that prevents even some well-resourced departments with

adequate funding and human resource from taking meaningful steps in ensuring better maths and science education. This is one of the reasons why we have not seen any significant remedial steps taken by relevant departments to improve test scores in any significant way. These structural realities translate into very clear constraints to the adoption of quality maths and science education as areas of priority.

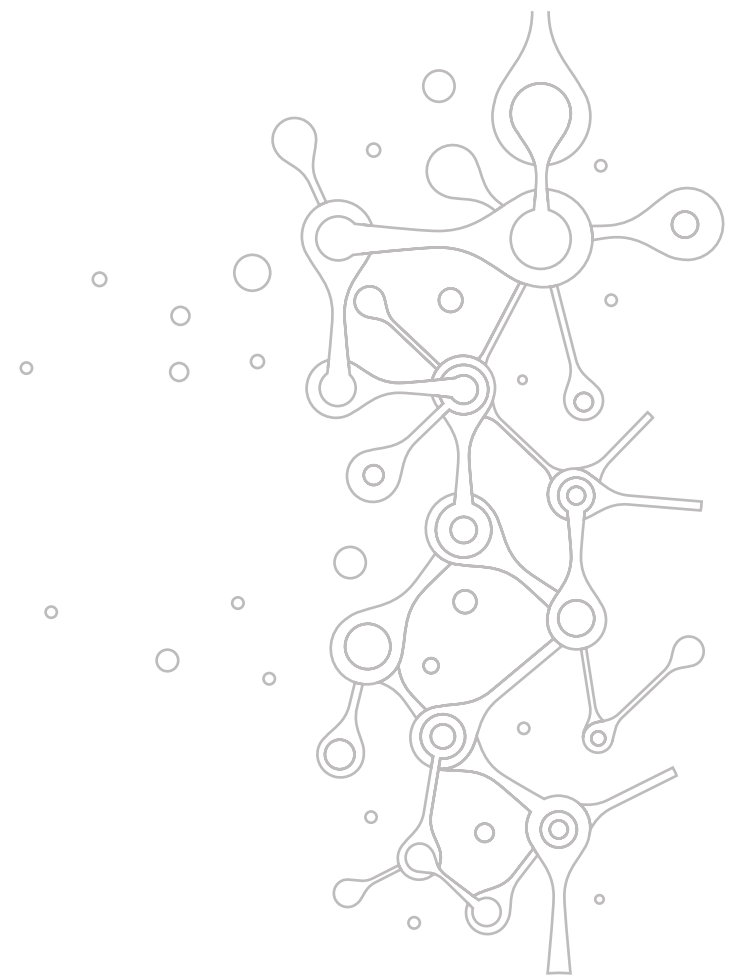
6.2.2.2 Private schools, innovations in the public funding model

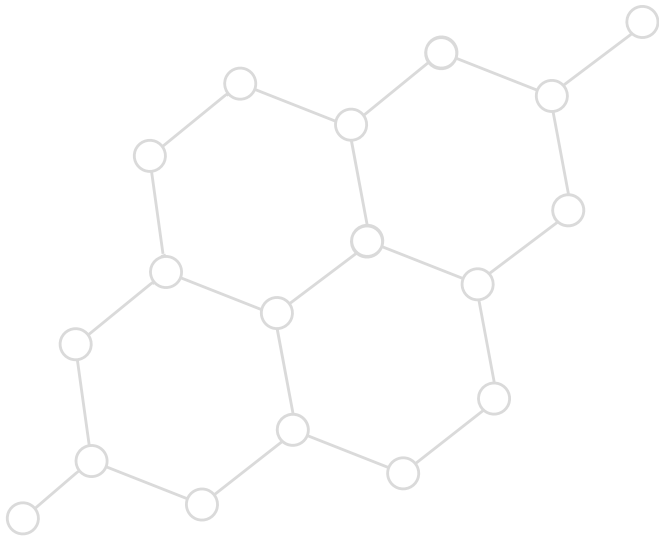
Among the several changes that have been prompted by external interventions into the government, the most successful and widely cited has been the creation of vehicles that divert public funding for education away from the traditional, straitjacket of government schools through education departments, toward payments to private organisations (both for profit schools, and non profit groups that run schools). The theory of change behind this innovation in the delivery of education has been that the government run schools system is incapable of

efficiently processing resources and generating higher rates of enrolment, retention and quality.

Yet to date, the success of this innovation that accounts for the enrolment of well over two million students in the Punjab and smaller numbers in Sindh and Khyber Pakhtunkhwa is based purely on the claims of high levels of enrolment and the relatively lower costs this model entails in comparison to tradition government schools run by the education departments. The annual Quality Assurance Test conducted by the Punjab Education Foundation (PEF), which is the principal vehicle for public financing of private actors for the provision of education tests publicly funded private schools for the following:

- Student enrolment and their verification from admission/withdrawal register
- School infrastructure
- Furniture
- Cleanliness and hygiene
- Availability of rooms for each class





Thus even in the innovative model adopted by ostensibly the most progressive regimes in the country, maths and science learning outcomes (and indeed learning outcomes in any discipline) have no bearing on the award of grants, or the sustenance of arrangements for public financing of private actors (including large non profit school management organisations, and wholly for profit schools and school networks) .

6.3 The quality of our schools

A good maths and science education is contingent on a variety of factors, and the quality of schools has been shown to be essential in this regard. There are several dimensions to the consistently low quality of schools in Pakistan. The first is what we call school facilities, which is the infrastructure of a school, and specifically, the presence of boundary walls, the availability of working bathrooms, the provision of drinking water and the presence of a working electricity connection. Despite the fact that a rich

database of information about these aspects of school facilities exist, almost half of all government schools across the country are missing at least one of these facilities .

The quality of schools only gets worse from the vantage point of basic facilities. Science laboratories and libraries are notoriously under-furnished, and where they are well-stocked, access is privileged and restricted. Similarly, there is almost no focus on the use of technology as an enabler for teaching students nor as a tool to empower teachers to learn on their own. There are a number of recent experiments in this regard, but there is no systemic uptake of the work that has been done by groups like the Punjab Information Technology Board (PITB).

"We gave telescopes to a school but the head master would not take them for there were no teachers up to the task of visiting the school after sunset for lunar or stellar observation"
- Dr Sabieh Anwar, Lahore University of Management Sciences (LUMS), Lahore

6.4 Teachers

6.4.1 Recruitment

For decades, the recruitment, hiring and appointment of teachers has been a principally political process, generating jobs for those with the personal networks that offer access to influential, both elected representatives, and unelected officials from the bureaucracy. The worst affected were primary school students, as the qualifications for being hired as a primary school teacher were kept deliberately low, making it easier for patrons within the system (politicians and bureaucrats) to bring in any manner and any number of individuals associated with them.

In 2009, based on years of advocacy and high level engagement with political leaders across both provincial and federal education departments and ministries, a concerted effort to change the recruitment process and incorporate merit as the driving motivation for teacher hiring was initiated. Since then several rounds of recruitment in the Punjab,

at least two rounds of recruitment in Khyber Pakhtunkhwa and Sindh respectively have taken place. An effort to reverse previous processes that did not consider merit has been made in Sindh, at substantial political costs.

There are a total of roughly 645,000 teachers in the government schools system across the country. Of these, over the last four years, Punjab has recruited over 81,000 under its merit-based recruitment scheme. Over the last two years, Khyber Pakhtunkhwa has recruited approximately 25,000. Last year, Sindh recruited over 14,000 teachers under its merit-based recruitment policy. Balochistan has recruited about 4,500 teachers using the same methodology. Our own estimate is that of these newly recruited teachers, the vast majority have been recruited with a view to their ability to provide instruction in maths and science. There are two basic tools available to provincial governments in ensuring that recruitment of teachers is on the basis of ability, rather than personal





networks and relationships. The first is the use of the National Testing Service (NTS) to test applicants on their basic cognitive skills, as well as preparation for the jobs they are applying to. The second is the prevention of both formal and informal involvement of members of parliament in the process of hiring teachers.

The growing population of qualified teachers, hired on the basis of strict merit, in the government school system across the country

however does not mean that the crisis of teaching—especially the teaching of maths and science—is over. Quite the contrary, in fact. Provincial governments and the political leaders that have overseen this bold new change are often lulled into a sense of complacency about effective teaching as being directly related to the recruitment and hiring process for teachers. However there are a range of issues that continue to plague the teaching domain in Pakistan, especially in the areas of maths and science.

Provincial Breakdown of Teachers and Recruitment

	Merit based teacher recruitment in 2013	Merit based teacher recruitment in 2014	Merit based teacher recruitment in 2015	Merit based teacher recruitment in 2016	Total teachers recruited through NTS	Change 'PES' to Pakistan Education Statistics 2014-15	Percentage of total that was recruited on strict merit (through NTS)
Balochistan	0	0	0	4,500	4,500	50,381	8.9
KP	0	0	0	25,000	25,000	123, 291	20.2
Punjab	29,822	14,470	0	33,622	81,914	321,064	25.5
Sindh	0	0	0	14,433	14,433	144,170	10.0
ICT	0	0	0	0	0	6,463	0.0
Total	29,822	14,470	0	77,555	125,847	645,369	19.5

6.4.2 Teacher's education: higher education

The total enrolment in colleges and universities (or where degrees are awarded) in 2014-15, the most recent such data available was over 1.4 million. This represents a remarkable increase from 2002 when just under 300,000 students were enrolled in degree-awarding programmes. This growth in the higher education enrolment in Pakistan has been concurrent with a wide array of reforms launched in 2002 as Pakistan

converted its University Grants Commission into its Higher Education Commission and dramatically increased the funding available to universities.

One of the constant criticisms of this reform effort has been that quality has been sacrificed at the altar of quantity. Some international publications have made the observation that this, “is a situation that should correct itself over time as Pakistan’s schools improve”. This is a substantial leap of faith that involves a problem of cyclical interdependence. The problem of higher education quality can indeed be solved through a sustained improvement in the input that degree-awarding institutions are receiving through improved schools. However, improved schools require improved teachers. And improved teachers come from improved higher education systems.

Maths and science teachers, in particular, require a grounding in cognitive abilities that can help them become enablers for students at the very foundational level of education in primary and middle schools. The education

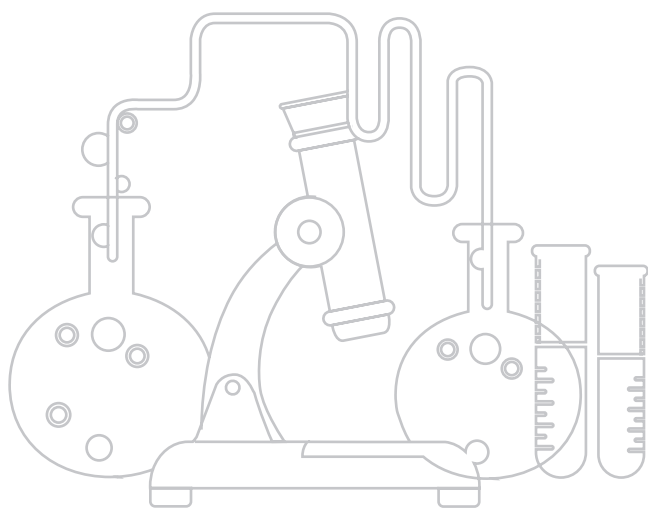
reform community in Pakistan has argued for a long time that the challenge of improving learning outcomes and the challenge of enhancing the ability of teachers to make the time in classrooms worthwhile cannot be met without addressing the overall quality of higher education.

6.4.3 How we prepare and develop teachers

There are a total of roughly 645,000 government school teachers in the country. To cater for the training needs of these teachers,

Provincial/Regional Breakdown of Teacher Training Institutes in the Public Sector

Province/Region	Institutions	Enrolment	Teachers
Punjab	59	31,988	1,805
Sindh	32	5,067	748
Khyber Pakhtunkhwa	27	7,890	136
Balochistan	12	1,380	129
Azad Jammu & Kashmir	11	661	107
Gilgit-Baltistan	3	276	-
FATA	4	566	-
Pakistan	148	47,828	2,925



according to data from 2014-15, there are only 148 public sector teacher training institutes across the country, with only 2,925 full-time teachers (or trainers of teachers). If every single teacher were to be provided with at least one opportunity for training annually, each institute would need to be able to train more than 4,300 teachers every year. Ideally, teachers require multiple opportunities each year to be engaged in a capacity building or training opportunity.

The overall capacity of the architecture of teacher training is obviously inadequate to deal with the challenge of addressing the professional development of teachers, but what about the quality of training on offer and especially what of the nature of capacity-building to enable better maths and science instruction, in government school classrooms in particular?

6.5 The challenge of content

There is a wide array of issues associated with maths and science education in Pakistan, from who is doing the teaching, to what context the teaching is being done in, to who is learning, but perhaps the most critical element of the equation is what is being taught. The content of maths and science education offers a deep stock of material that merits analysis. In this section we will only explore examinations as a proxy for assessment of what has, or has not been learnt, and the limits of the debate on curriculum.

6.5.1 Assessments and examinations

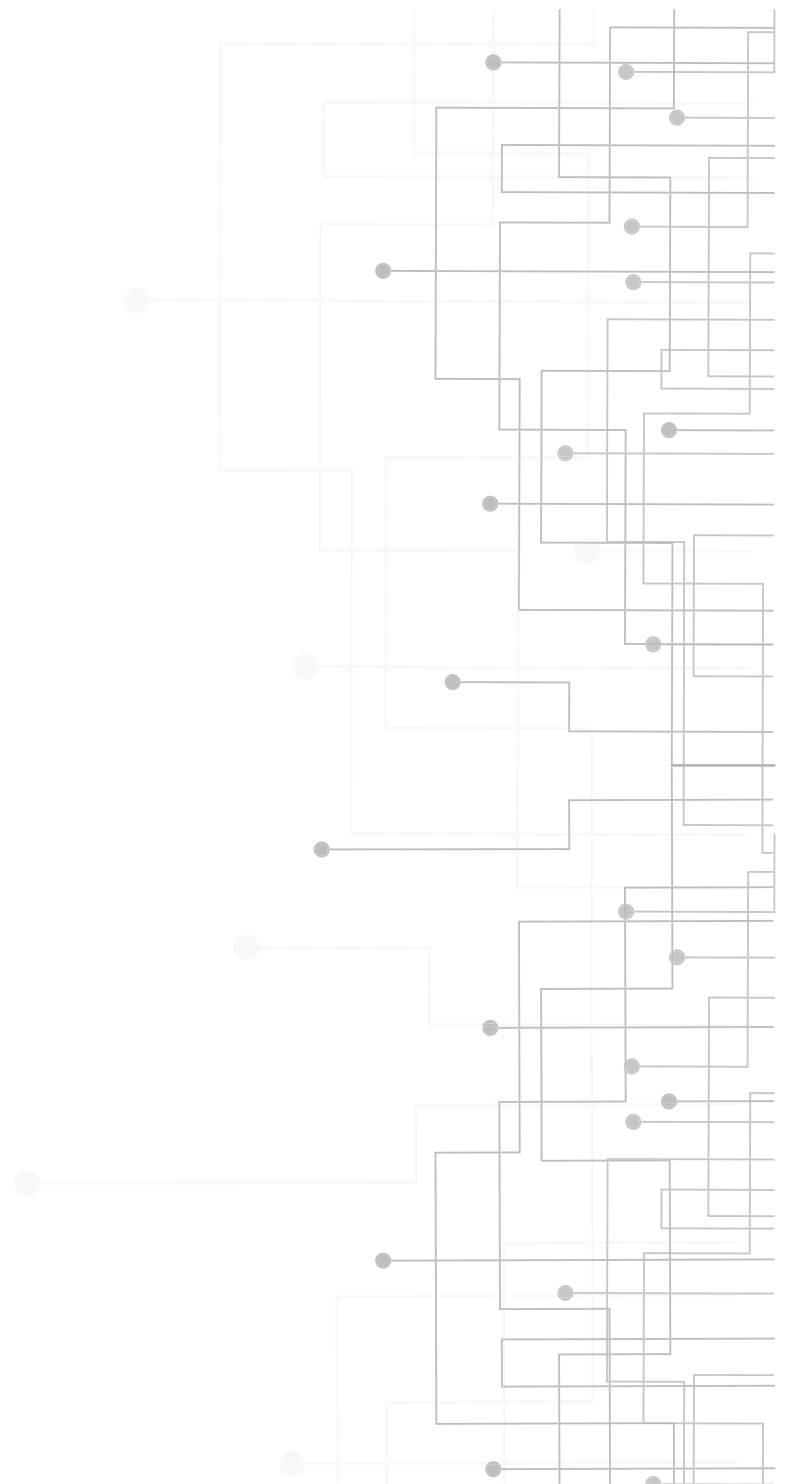
Examinations are a critical component of the country's education landscape especially

“There is an obsession that questions in the examinations will come from those given at the end of course books” - Dr Khurshid Hasanain, COMSTECH

in terms of assessing learning outcomes. Secondary and higher secondary boards responsible for administering annual examinations are thus key stakeholders central to any meaningful conversation about the quality of education. The question of the quality of examinations becomes even more important when we investigate the quality of maths and science education in the country. Dr. Irfan Muzaffar is a notable education sector researcher and practitioner. He captures the essence of the problem in a newspaper article he published in 2016. “Look through the test papers, talk to the teachers, and you will not help but notice that nothing has changed in how we assess the achievements of our youth at the secondary and higher secondary levels. In fact what they can achieve is, in no small measure, determined by these examinations. Rote learning is what we did in the SSC/HSSC stream decades ago. Rote learning is what the students preparing for these examinations do these days. One teacher that I interviewed was teaching both the SSC/HSSC and O/A-

level streams at a private school. As he put it: “I teach both streams on the same day. My teaching attitude and methods change as I move from my matric to the O-level classroom. In my matric class, I must make them learn the text by heart. But in the O-level class I have to help them develop conceptual understanding.” Thus, a miniscule fraction of the youth, mostly from privileged backgrounds, seem to be getting an education that is at par with what their peers would receive in high performing countries. The majority of them, however, are consigned to receive a stagnant secondary education in which the teaching and learning practices remain what they were four decades ago.”

Students at the secondary and higher secondary levels tend to tailor the level of commitment and time they dedicate to a subject according to the requirements set out in the annual board examinations. The boards should thus ensure that exams are set in a way to test foundational conceptual clarity acquired by the students during their classes. This can not only





wean students away from focusing exclusively on rote memorisation but also motivate teachers to prepare students adequately.

Given that board examinations form a critical piece of the puzzle, we conducted a preliminary analysis of board examinations from the perspective of quality teaching and learning. We selected the Larkana and Peshawar boards and examined the quality of questions for maths and science exams over the last five years (2010 to 2015). We developed a framework to assess the quality of questions included in the examinations with a particular focus on the following:

1. Repetition: Is a given question in an exam repeated within the previous five years?
2. Rote memorisation: Does a given question test the conceptual understanding or does it test the memory of facts?
3. Grammar/syntax: Does a given question contain grammatical/syntax issues that make it difficult for students to understand it?
4. Relevance: Does a given question test material that is relevant to the curriculum, or not?

Our preliminary analysis of board examinations in maths and science for two boards (Larkana and Peshawar) indicates that exam questions are deeply problematic. The questions largely test students' ability to memorize either the contents of textbooks or answers keys from previous years' exams.

The following table shows the number of problematic questions in science examinations from the last five years set by the Peshawar board. Some of the

Number of Problematic Questions in Science Examinations in Peshawar Board (Yearly)

Year	Number of questions repeated	Number of questions relying exclusively on rote learning	Number of questions with grammatical/syntax issues	Number of questions that are irrelevant	Total number of questions
2009	10	9	-	2	33
2010	8	5	3	6	33
2011	5	5	-	4	33
2012	12	9	2	7	33
2013	-	15	4	9	33

major problems observed in the science examinations are:

- There is a lack of questions testing core underlying concepts
- There is an undue focus on irrelevant themes or issues
- A significant proportion of questions for each year are repeated from very past examinations
- The grammar and/or syntax of questions and their framing makes it difficult to ascertain what is being asked

The following table details the analyses of questions in maths exams from the last five years set by the Larkana board. The biggest issues in maths examinations are the repetition of questions and the grammatically incorrect framing of questions that make it hard for students to understand what is being asked.

This preliminary diagnostic analysis illustrates the considerable scope for a much deeper

Number of Problematic Questions in Maths Examinations in Larkana Board (Yearly)

Year	Number of questions repeated	Number of questions relying exclusively on rote learning	Number of questions with grammatical/syntax issues	Number of questions that are irrelevant	Total number of questions
2007	1	-	4	-	10
2008	2	-	3	-	10
2009	2	-	3	-	10
2010	1	2	5	1	10
2011	1	-	7	-	10

exploration of secondary and higher secondary board examination questions. Suffice it to say for the purposes of this analysis, the assessment of what students have learnt between the ages of five and sixteen (the constitutionally mandated age bracket for which education is guaranteed) leaves much to be desired.

6.5.2 Curriculum

The dominant narratives in the curriculum debate in Pakistan are, at best, only tangentially related to the content taught to

children in classrooms, and their ability to demonstrate facility with that content. Instead, the dominant aspects of the curriculum debate have been around the political preferences reflected in Pakistani curriculum, and the tier of government responsible for shaping Pakistani curricula. These two dominant aspects of the curriculum debate have generated a concurrent failure in the public discourse on issues of the curriculum related to the material or content that children or taught, their ability to retain that material and the appropriateness of that material to their future ability to engage in gainful employment. Changes that are made to the curriculum tend to take a long time to travel from the policy level to textbooks.

In part the long lags between ideas, debates, decisions and delivery related to curriculum has to do with the absence of narratives specific to subject areas. Debates about language of instruction are much more common than debates about the rigour of mathematics syllabi as they are more prone to being framed from

existing filters of political preferences. More worryingly, science has commonly been relegated to a battleground for ideological contestation. This contestation is often framed as a dichotomy between traditional values that vest explanations for scientific phenomena in dogma, versus modern values that seek explanations for scientific phenomena in evidence and research.

Pakistan is certainly not unique in this regard, although many have argued that the isolation of the scientific community, even those among this community that are explicitly respectful of traditional values, has helped deepen a generic aversion to science at large. Partly because of this political debate, and partly because of structural factors such as the capacity of the bureaucracy and the limits of operating in a charged context, the curriculum in Pakistan is not designed from the standpoint of the kinds of economic outcomes that are being sought as a result of education policy. This has meant that the overwhelming incentives for changes to the curriculum tend to be during periods

of political and social upheaval—where the outcomes being sought through the curriculum are largely social in nature. The impact of this context on language, history and art is explicit and the subject of much consternation, but the impact of this context on maths and science is perhaps even more pernicious, partly because it is more implicit.

Reformers have tended to rail against the specific social outcomes and political motives that have instigated changes in the past, and many tend to position their arguments not in service of coherent and defensible narratives that are about long term economic outcomes, or the well-being of children, but rather as a counter-factual to an opposing set of political and social values. This has made any discussion about curriculum or the syllabus in Pakistan a hair trigger issue, and rendered pedagogical experts invested in better maths and science outcomes almost irrelevant to the debate.

Volume III: The Roadmap

Volume III of the Powering Pakistan for the 21st Century will present a roadmap for how Pakistan can address the crisis of maths and science teaching and learning. The central thrust of the roadmap will entail a series of recommendations that seek to address the macro and micro factors that impinge on the ability of children to learn maths and science, starting at the primary level, through high school. These factors will flow from the analysis of where the problems lie, as presented in the previous section:

- The political economy of maths and science education.
- Government structures and systems, at both the policy level and the administrative level
- Low quality government schools
- Teachers that lack confidence, and in whom adequate investments have not been made
- Low quality content being taught in maths and science, and the low quality means of assessments

In addition to specific measures that government, civil society and the private sector need to take to ameliorate the situation, Volume III will propose a set of proposals to address emergent opportunities and challenges. In this way, the roadmap will be prescriptive, but also seek to be predictive.



Endnotes & References

About - PISA. 2017. Oecd.Org. <https://www.oecd.org/pisa/aboutpisa/>

About - TIMSS & PIRLS International Study Center. 2017. Timssandpirls.Bc.Edu. <http://timssandpirls.bc.edu/about.html>

Alif Ailaan, 2015. Government Allocations for Education in Pakistan: The Road to Getting To 4% Of GDP. Islamabad: Alif Ailaan. https://d3n8a8pro7vhmx.cloudfront.net/alifailaan/pages/1006/attachments/original/1474365126/Govt._Allocations_for_Edu_in_Pakistan.pdf?1474365126

Annual Status of Education Report (ASER), 2015. Annual Status of Education Report, National (Rural). Lahore: South Asian Forum for Education Development (SAFED). http://www.aserpakistan.org/document/asere/2015/reports/national/ASER_National_Report_2015.pdf

Annual Status of Education Report (ASER), 2015. Annual Status of Education Report, National (Urban). Lahore: South Asian Forum for Education Development (SAFED). http://aserpakistan.org/document/asere/2015/reports/Urban_2015.pdf

Education and Literacy Department, Government of Sindh, 2015. Standardized Achievement Test (SAT) - IV, Technical and Statistical Analysis Report. Sukkur: Government of Sindh and Sukkur Institute of Business Administration (IBA)

"GDP Per Capita - Countries - List". 2017. Tradingeconomics.Com. <http://www.tradingeconomics.com/country-list/gdp-per-capita>

National Education Assessment System (NEAS), 2014. National Assessment Report. Islamabad: National Education Assessment System (NEAS)

Punjab Examination Commission, 2016. Punjab Examination Commission Exam Analysis Report. Lahore: PEC Research and Analysis Wing

Muzaffar, Irfan. The Science of Learning. The News on Sunday, July 26, 2015





