CL4STEM-E BHUTAN REPORT

Baseline-Endline

(Project Phase II)

Connected Learning for Teacher Capacity Building in STEM - Extension (CL4STEM-E)

2025

BHUTAN | NIGERIA | TANZANIA | INDIA

Preface

Connected Learning for STEM (CL4STEM)

The report presented here is an outcome of the Connected Learning for Teacher Capacity Building in Science, Technology, Engineering, and Mathematics (CL4STEM-E) extension project, which aimed to strengthen the capacity of secondary STEM teachers to promote higher-order thinking with inclusion and equity (HOTIE) in their classroom practices. The CL4STEM project was funded by the International Development Research Center (IDRC) under the Global Partnership for Education Knowledge and Innovation Exchange (GPE-KIX). It was a South-South collaboration between Samtse College of Education (SCE), Ibrahim Badamasi Babangida University Lapai (IBBUL) in Nigeria, and the Open University of Tanzania (OUT), with technical support from the Tata Institute of Social Sciences (TISS) in Mumbai, India. The consortium partners curated subject-specific, contextualised Open Educational Resources (OER) modules to support teachers' professional development in improving their knowledge, attitudes, and practices (KAP). These OERs have been curated based on the Connected Learning Initiative (CLIx) model implemented in India by the Tata Institute of Social Sciences (TISS).

The OER modules were hosted on the Moodle Learning Management System (LMS) and professional development was supported through an orientation workshop and scaffolding of their progress through the LMS and a subject-wise social learning platform, the Telegram chat group called Community of Practice (CoP). Each OER module was implemented over six weeks, with teachers expected to spend approximately 5 hours per week. Since the design of the professional development programme was practice-oriented, teachers were required to complete pre-and post-tests, design two lesson plans, implement them, conduct teaching observations by peers or supervisors, and write reflections on their experiences. Before enrolment in the programme, teachers were administered survey questionnaires and interviewed focus groups (n=30) to assess their KAP in science and mathematics classrooms. Similarly, after completing the modules, teachers were again administered a survey questionnaire and engaged in focus group interviews to evaluate changes in their KAP.

This report documents the implementation and outcomes of the professional development programme, focusing on the assessment of teachers' KAP in science and mathematics classrooms before and after the programme. It provides an overview of the sample schools, sample population, and methodologies employed, including surveys and focus group interviews, as well as insights into the effectiveness of the programme in promoting professional growth and improving classroom practices.

The knowledge and insights gained from this project will be strategically disseminated to relevant divisions within the Ministry of Education and Skills Development (MoESD) and other key stakeholders in STEM education. The primary aim is to incorporate the findings into the policy agenda of Bhutan, fostering evidence-based decision-making and promoting innovative practices in STEM education. Additionally, key learnings from this project will be shared with educators, researchers, and policymakers on a broader scale.

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Abbreviations

B.Ed	:	Bachelor of Education
B.Sc	:	Bachelor of Science
BPST	:	Bhutan Professional Standard for Teachers
CL4STEM	:	Connected Learning for STEM
CLix	:	Connected Learning Initiative
CoP	:	Community of Practice
GPE	:	Global Partnership for Education
HoD	:	Head of Department
HOT	:	Higher Order Thinking
HOTIE	:	Higher Order Thinking with Inclusion and Equity
IBBUL	:	Ibrahim Badamasi Babangida University Lapai
ICT	:	Information Communication Technology
IDRC	:	International Development Research Center
KAP	:	Knowledge, Attitudes, and Practices
KIX	:	Knowledge and Innovation Exchange
LMS	:	Moodle Learning Management System
M.Ed	:	Master of Education
M.Sc	:	Master of Science
MoESD	:	Ministry of Education and Skills Development
OER	:	Open Educational Resources
OUT	:	Open University of Tanzania
PCK	:	Pedagogical Content Knowledge
PGDE	:	Post Graduate Diploma in Education
PMO	:	Prime Minister Office
RCSC	:	Royal Civil Service Commision
RUB	:	Royal University of Bhutan
SCE	:	Samtse College of Education
SEN	:	Special Educational Needs
STEM	:	Science, Technology, Engineering, and Mathematics
TELD	:	Teacher and Educational Leadership Division
TISS	:	Tata Institute of Social Sciences
TV	:	Television
UDL	:	Universal Design for Learning
UNESCO	:	United Nation Education Scientific and Cultural Organisation
VP	:	Vice Principal

Chapter 1: Introduction

1.1 Background

Samtse College of Education (SCE) in partnership with Ibrahim Badamasi Babangida University Lapai (IBBUL) in Nigeria and the Open University of Tanzania (OUT), with technical support from the Tata Institute of Social Sciences (TISS) in Mumbai, India, implemented a consortium project titled *"Connected Learning for Teacher Capacity Building in STEM (Science, Technology, Engineering and Mathematics)"* (CL4STEM) project from April 2021 to December 2023. This project was funded by the International Development Research Centre (IDRC) of Canada, through the Global Partnership for Education Knowledge and Innovation Exchange (GPE KIX) programme. The partner countries identified the enhancement of STEM education quality, teacher capacity building, and the integration of Information and Communication Teachnology (ICT)-enabled learning, teaching, and assessment as key priority areas. The primary aim of the project was to enhance the professional development of secondary school STEM teachers by improving their knowledge, attitudes, and practices (KAP) for fostering higher-order thinking with equity and inclusion (HOTIE) leveraging Open Educational Resources (OERs) and technology. Samtse College of Education (SCE), Royal University of Bhutan (RUB), received strong support from the Ministry of Education and Skills Development (MoESD) in implementing the project's Phase 1 in the Samtse District. During this phase, the project facilitated the professional development of 39 in-service and 43 pre-service teachers. Based on the success of Phase 1, the consortium partners secured additional funding to scale the project in their respective countries as CL4STEM-E version. In Extension phase of the CL4STEM project, SCE collaborated with MoESD to support the professional development of 145 secondary school STEM teachers. The CL4STEM-E Research Framework also focused on enhancing teachers' KAP to strengthen their pedagogical competence and ability to address the diverse needs of learners in secondary science and mathematics classrooms.

The CL4STEM-E project's overall objectives were:

1. Develop Open Educational Resources (OERs) tailored to local contexts and specific needs;
2. Enhance teachers' professional capacities to foster Higher-Order Thinking with Inclusion and Equity (HOTIE);
3. Establish vibrant Communities of Practice (CoPs) to support STEM teachers' professional development;
4. Generate research-based evidence to inform policy and planning for scaled implementation.

In Bhutan, students study General Science from Grades IV to VIII, while Mathematics is introduced from the pre-primary level. Over the years, the quality of STEM education, particularly at the middle and higher secondary levels, where students transition to distinct subjects such as Biology, Chemistry, Physics, and Mathematics, has drawn significant attention (Kinley et al., 2021). The quality of STEM education in Bhutan is influenced by several factors, such as teacher competency, curriculum design, access to modern technologies, infrastructural support, etc. In Bhutan, regular STEM teachers undergo formal pre-service training at the Colleges of Education, while induction programmes are conducted for teachers recruited on a contract basis. Furthermore, the

Teacher and Educational Leadership Division (TELD) at the MoESD organises need-based PD for teachers, in alignment with the Teacher Human Resource Policy (MoE, 2014a). The policy, instituted to enhance teacher quality in the country also mandates that teachers attend 80 hours of professional development annually. Likewise, the Bhutan Professional Standard for Teachers (BPST) (MoE, 2019), a framework aimed at enhancing the quality of teaching and learning in Bhutan by setting clear expectations for teacher competencies and professional development also ensures that teachers are well-equipped to adapt to changing educational contexts. Furthermore, the Bhutan Education Blueprint 2014–2024 (Ministry of Educatioin [MoE], 2014b) provides a comprehensive framework aimed at addressing the diverse educational needs of the country, with a particular focus on inclusivity and sustainability. However, the professional development opportunities provided by the Ministry are limited, and not all teachers have equal access to them (Dhendup et al., 2020). Additionally, given the importance of STEM subjects, it is essential to enhance the pedagogical skills and subject knowledge of secondary STEM teachers (Rinchen & Utha, 2023).

1.2 Teachers Professional Development Design

As part of ongoing efforts of MoESD to enhance the quality of STEM education and teachers' competence, the CL4STEM-E project supported the professional development of 145 secondary-level STEM teachers by enhancing their classroom practices and addressing the diverse needs of learners by leveraging contextualised OERs and technology. The professional development design was practice-based, requiring teachers to apply the learned knowledge and skills in their practices. Practice-based professional development is a dynamic approach that prioritises experiential learning and real-world application to enhance teaching competencies (Ajani, 2023; Osborne et al., 2019). The professional development model specifically emphasised the integration of Universal Design for Learning (UDL) principles in designing lesson plans, implementing them, and assessing students' learning outcomes. Additionally, teachers were required to engage in reflective writing to critically evaluate and refine their practices. In fact, the Phase I and II, CL4STEM activities effectively complemented the key initiatives outlined in the ongoing Thirteenth Five-Year Plan (2024–2029) of the Royal Government of Bhutan, which aims to enhance the quality of STEM education and provide both short-term and long-term professional development opportunities for teachers (Prime Minister Office [PMO] 2023).

A total of 13 OER modules were collaboratively developed in partnership with STEM curriculum developers from the MoESD. These modules were contextualised, aligned with the National Curriculum Framework, and incorporated the principles of UDL, emphasising multiple means of representation, engagement, and expression. Table 1.1 below provides the details of the modules:

Table 1. 1 *CL4STEM-E Subject specific OER modules*

Subjects	Mathematics		Science		
			Biology	Chemistry	Physics
Topics	Algebra - Linear Equations		Introduction to Genetics and Hereditary	Atomic Structure	Force and Motion

Subjects	Mathematics		Science		
			Biology	Chemistry	Physics
	Proportion and Percentage		Ecology	Chemical Bonding	Work, Energy, and Power
	Geometry		Cell Structure and Organisation.	Organic Chemistry	Electromagnetism.

In addition to the 12 subject-specific OERs, a common pedagogy module was offered to all teachers. The OERs were hosted on the Moodle platform, and teachers were enrolled in subject-specific modules. The professional development programme was delivered through both synchronous and asynchronous sessions. The synchronous sessions included two days of face-to-face, cluster-wise workshops, where teachers were invited to a venue and briefed on the professional development modality, its requirements, and hands-on training on applying UDL principles, design thinking, using Moodle, and participating in Community of Practice (CoP) groups on Telegram. Following this orientation, teachers were given six weeks to implement and complete the tasks assigned in their respective modules. Further, teachers had to submit two lesson plans on the topic, implement them with students, and then write a reflective report based on the teaching experience. The practice of focus group teachers was observed by teacher educators, Ministry officials, and their supervisors throughout the implementation of all the modules. Additionally, other teachers conducted peer evaluations by recording their teaching sessions and sending the recordings of the lessons to an assigned peer for assessment. The peer evaluators then submitted their evaluation forms to the teacher-educator subject leaders for review. Teacher professional development learning was continuously supported through the subject-wise CoPs.

This report presents details of the CL4STEM-E project's implementation in Bhutan. It contains the programme's effectiveness in achieving its objectives, identifies challenges encountered during the process, and provides recommendations for future practice-based professional development initiatives in Bhutan. It is intended as a resource for policymakers, educators, and stakeholders seeking to enhance the quality and inclusivity of STEM education through practice-based professional development. The structure of this report is organised into the following chapters:

Chapter 1: Introduction
Chapter 2: Materials and Methods
Chapter 3: Science Teachers' Knowledge, Attitudes and Practice (Quantitative)
Chapter 4: Mathematics Teachers' Knowledge, Attitudes and Practice (Quantitative)
Chapter 5: Teachers' Knowledge, Attitudes and Practice (Qualitative)
Chapter 6: Conclusion and Recommendations

Chapter 2: Materials and Methods

This Chapter provides an overview of the methodological framework employed during the extended phase of the CL4STEM project. It offers a comprehensive overview of the Research Framework, Research Design, Instrument Development and Validation, Participants and Sampling, Data Collection, Data Analysis, and Ethical Considerations.

2.1 CL4STEM-E Research Framework

The CL4STEM-E Research Framework focused on assessing and improving teachers' Knowledge, Attitudes, and Practice (KAP) in the context of teaching Science and Mathematics. This framework shown in Table 2.1 below developed referring to previous studies (Chen, 2006; Chen et al., 2013; Gess-Newsome, 1999; Hume et al., 2019; Liang et al., 2008; Mahat, 2008; Ramchand, 2022) provided a structured approach to evaluate teachers' professional development through a thematic and practical lens. It focused on three critical domains: learners, content, and teaching and learning, with specific components under each domain. The CL4STEM-E Framework thus served as a comprehensive model for evaluating the effectiveness of practice-based professional development in enhancing teachers' pedagogical competence and their ability to meet the diverse needs of learners in science and mathematics classrooms.

Table 2. 1 *CL4STEM-E Research Framework*

Domains	Knowledge	Attitudes	Practice
1. Learners	K1.1 Recognise learners' socio-economic & linguistic backgrounds, learning abilities, and health needs *(Base-Endline survey)* K1.2 Recognise students' prior conceptions and misconceptions K1.3 Recognise areas of difficulty that students face	A1.1 Believe that all children can learn science and mathematics A1.2 Value diversity as a resource A1.3. Accept responsibility to meet the diverse needs of learners through inclusive practices.	P1.1 Promote inclusion and equity P1.2 Build on students' prior conceptions P 1.3 Address misconceptions and areas of difficulties
2. Content	K2.1 Understand the nature of science/ mathematics K2.2 Explain the goals of teaching the subject K2.3 Identify 'Big' ideas, key concepts and theories	A2. Accept attitudes, beliefs, and values aligned with the current consensus among educators on the nature of science and mathematics	P2.1 Use processes in science and mathematics P2.2 Facilitate higher-order thinking P2.3 Plan to build students' competencies to meet the goals of

Domains	Knowledge	Attitudes	Practice
	K2.4 Sequence and connect between concepts within subjects and across classes		teaching science/mathematics
3.Teaching and Learning	K3.1 Select instructional strategies to support multiple forms of students' engagement K3.2 Evaluate resources for multiple forms of representing content K3.3 Choose multiple tools of assessment to encourage multiple modes of expression K.3.4 Relate to the contexts of school, local issues and the regional/national educational system	A3.Value active learning strategies, assessments for learning, and multiple forms of representing content	P3.1 Use instructional strategies for active learning P3.2 Use multiple representations of content P3.3 Create opportunities for multiple modes of expression P3.4 Use locally available materials P3.5 Link conceptual content to students' everyday life experiences and prior knowledge

All the domains were examined through the lens of KAP as explained below:

2.1.1 Learners

This domain emphasised understanding and addressing the diverse needs of students by teachers. It included: Knowledge -Teachers' ability to understand students' socio-economic and linguistic backgrounds, learning abilities, prior conceptions, and areas of difficulty. Attitudes - Teachers' beliefs in the potential of all students to learn, value diversity, and accept responsibility for inclusive practices. Practice - Promoting inclusion and equity, building on students' prior knowledge, and addressing misconceptions.

2.1.2 Content

This domain focused on teachers' understanding of their subject matter and its pedagogical applications. Knowledge - Understanding the nature of science and mathematics, identifying key concepts, and theories, and sequencing ideas within and across classes. Attitudes -Accepting current educational consensus on the nature of science and mathematics (Chen, 2006), including their dynamic, subjective, and social dimensions. Practice - Facilitating higher-order thinking, using scientific and mathematical processes, and planning instruction to meet subject-specific learning goals.

2.1.3 Teaching and Learning

This domain explored instructional strategies, resource evaluation, and contextual learning. Knowledge - Teachers' knowledge on selecting strategies for diverse student engagement, evaluating resources, and relating content to local and national contexts. Attitudes - Teachers' attitudes towards active learning, formative assessments, and multiple representations of content. Practice - Implementation of active learning strategies, linking content to students' everyday lives, and creating opportunities for diverse modes of student expression.

2.1.4 Key Features of the Framework

- Thematic Data Collection: Data collection methods were aligned with the framework's domains to focus on KAP elements. For instance, pre and post-tests addressed knowledge domain, surveys focused on attitudes and classroom observations, lesson plans, and reflections addressed practical aspects.
- Focus on Higher-Order Thinking and Inclusion: The framework explicitly emphasised skills such as problem-solving, reasoning, and conceptual understanding, along with inclusive teaching practices.
- Alignment with Curriculum: The framework ensured that practices were tied to middle and higher secondary school curricula, making it relevant for subject-specific professional development.
- Rubrics and Tools: A set of standardised tools, such as lesson plan templates, reflection templates (Borton, 1970), and rubrics for assessing PCK, were used to evaluate and document teachers' growth in the identified domains.

2.2 Research Design

The study used a mixed-method research design, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of practice-based professional development's impact on teachers. Mixed methods research is particularly effective in capturing the complexities of educational phenomena by integrating quantitative and qualitative findings, enhancing validity, and addressing research questions from multiple perspectives (Creswell & Creswell, 2017).

The quantitative component involved collecting survey data from science and mathematics teachers to examine their attitudes toward inclusive practices, beliefs about the nature of their subjects, and active learning, teaching, and assessment strategies. Additionally, quantitative data were gathered through pre- and post-tests for all subject-based modules, lesson plans, classroom observations, and reflection reports of teachers.

The qualitative component included pre- and post-interviews with 32 focus group teachers, representing eight teachers from each subject group. These interviews explored changes in teachers' knowledge, attitudes, and practices (KAP) related to higher-order thinking and inclusive and equity (HOTIE) skills. Teachers also shared reflections on their practice and specific experiences with OER providing contextual insights into their professional learning journeys.

Subject group-wise social learning platform, Communities of Practice (CoP) was established on Telegram to facilitate collaborative learning. These CoPs enabled participants to share resources, exchange experiences, and engage in discussions with peers and tutors.

2.2.1 Instrument Development and Validation

The instruments were developed by referring to various literatures by the lead consultancy team from the Centre of Excellence in Teacher Education (CETE), Tata Institute of Social Sciences (TISS), India. The tools included the following:

1. Structured Interview Questions
2. Science Survey (Parts 1 and 2) (Chen, 2006; Chen et al., 2013; Gess-Newsome, 1999; Hume et al., 2019; Liang et al., 2008; Mahat, 2008; Ramchand, 2022)
3. Mathematics Survey (Parts 1 and 2) (Chen, 2006; Chen et al., 2013; Gess-Newsome, 1999; Hume et al., 2019; Mahat, 2008; Ramchand, 2022)
4. Lesson Plan Template
5. Reflection Template (Borton, 1970)
6. Teaching Observation Template
7. Rubric for Assessing Lesson Plans, Reflections, and Classroom Observations, focusing on Pedagogical Content Knowledge (PCK) in practice (Ramchand, 2022)
8. Module-wise Pre- and Post-Test Questions (N = 45)

The instruments underwent a rigorous validation process, which included expert reviews by consultants and Bhutanese teacher educators to assess their relevance and alignment with the study's objectives. Pilot testing was conducted with a small sample of teachers in India, who were not part of the main study to assess the clarity, reliability, and feasibility of the instruments. The results from the pilot test were analysed to identify ambiguities or inconsistencies, and necessary modifications were made to improve the instruments' quality.

2.3 Participants and Sampling

The study applied purposive sampling strategy as the secondary science and mathematics teachers were the target group. Samtse College of Education (SCE), in collaboration with the Ministry of Education and Skills Development (MoESD), disseminated information about the professional development programme through various social media platforms. While formulating the criteria, the team decided to prioritise teaching experience, leadership qualities, and a commitment to advancing STEM education in Bhutan's secondary schools. Accordingly, the following criteria were decided for the enrolment of in-service teachers in the CL4STEM professional development course:

1. A minimum of three years of teaching experience in relevant subjects.
2. Currently teaching classes VII and above in middle/higher secondary schools.
3. Teachers should not have any adverse professional records.
4. Demonstrated leadership qualities or taken initiative in teaching and professional development.

5. Possess a strong sense of professional integrity and ethical conduct.
6. Regular teachers with effective facilitation and communication skills.
7. Commitment to two academic years for professional development, with the first year undergoing training and the second-year training other teachers.

Interested teachers submitted applications, which were jointly evaluated by SCE and MoESD. A total of 145 teachers from across 20 districts, who met the selection criteria, were enrolled in the programme. The OERs developed for the programme were aligned with the middle and higher secondary curricula, and therefore, participants were selected from these educational levels. Additionally, eight teachers from each subject group (Biology, Chemistry, Physics, and Mathematics) were randomly selected as the Focus Group samples for in-depth analysis and qualitative data collection.

Each teacher was assigned a unique code that combined their subject of specialisation, gender, and a four-digit numerical identifier. For instance, in the code CM5074: the letter 'C' stands for the subject specialisation Chemistry; 'M' denotes the teacher's gender as Male; and '5074' is a unique four-digit numerical identifier assigned to the teacher for tracking and record-keeping purposes

2.4 Data Collection

Data collection was conducted thematically, specifically focusing on examining teachers' KAP related to HOTIE skills.

2.4.1 Knowledge Focused Data:

Knowledge-focused data were collected using 45 pre- and post-test questions embedded within each of the 12 subject-based OER modules. These questions addressed the domains of learners, content, and teaching and learning, further exploring the specific indicators outlined in Table 2.1.

2.4.2 Attitudes Focused Data:

Data on attitudes were collected from Science teachers using Science Surveys 1 and 2, and from Mathematics teachers using Mathematics Surveys 1 and 2. These surveys, carried out before and after the completion of the modules, measured teachers' perceptions, beliefs, and dispositions regarding inclusive practices, the nature of science and mathematics, and active teaching and assessment strategies.

2.4.3 Practice Focused Data:

Practice-focused data were collected through two lesson plans submitted per module, teaching observations conducted by teacher educators and respective Heads of Departments (HODs), and reflection reports written by the practicing teachers.

2.4.4 Interviews:

The interview tool assessed teachers' practices in three key domains: learners, content, and teaching and learning. All 30 focus group teachers were interviewed both before the modules were made available and after the completion of all three subject-based modules. The structured interviews aimed to capture qualitative insights into how teachers applied their knowledge and attitudes in classroom settings. The questions focused on teachers' efforts to promote inclusion and equity, address student misconceptions, and build on prior knowledge to support diverse learners. Additionally, the interviews explored how teachers applied subject-specific processes to enhance conceptual understanding, developed students' higher-order thinking skills, and connected key concepts within and across subjects. Furthermore, the tool examined teachers' implementation of active learning strategies, their use of multiple representations to support different learning styles, and their efforts to contextualise learning through locally available resources and real-life applications. The interview responses provided valuable reflections on teachers' pedagogical growth and the challenges they faced in translating theory into practice.

2.5 Data Analyses

Quantitative data from Baseline and endline Science and Mathematics Surveys 1 and 2 were categorised into groups such as Science (Biology, Chemistry, and Physics), Mathematics, subject and gender-wise, and analysed using descriptive statistics in Microsoft Excel according to the corresponding framework presented in Table 2.1. Module focused pre and post-tests data were analysed and presented in the respective module implementation report for all 12 subject-based modules. Practiced focused quantitative data from lesson plans, observation forms, and reflection reports were consolidated, analysed, and have been presented in the module report.

Interview data were transcribed and deductively coded using the CL4STEM-E Framework shown in Table 2.1 and were thematically analysed following the approach of Clarke and Braun (2017). Finally, both quantitative and qualitative data were integrated into the key findings, which are presented in the main sections of this report.

The Telegram CoP platform was utilised as a key tool in implementing OER initiatives. Both quantitative and qualitative data were extracted from the CoPs to analyse participation levels, the nature of interactions, and the impact of the platform on teachers' learning and professional development. Given the distinctive nature of discussions, resource sharing, information dissemination, and instructions specific to each subject module, the Telegram CoP data was analysed and incorporated into the corresponding module reports.

2.6 Ethical Considerations

Formal permission to use secondary schools and science and mathematics teachers was obtained from the Department of School Education, MoESD. Open Educational Resources (OERs) were curated in collaboration with curriculum developers from the MoESD and were aligned with the national curriculum framework to ensure consistency with educational standards and to support the curriculum's objectives effectively. Participants were thoroughly informed about the purpose of the study, their role, and the various instruments used. Written consent was obtained from all participants to ensure voluntary participation. The instruments employed in the study were developed with strict adherence to ethical standards, ensuring that all questions were non-intrusive and respectful of the participants' experiences. Every effort was made to protect the rights and dignity of the participants throughout the research process.

2.7 Demographic Profile of Participating Schools

2.7.1 Overview of the Bhutanese Secondary School System

The CL4STEM-E project was designed to support the professional development of secondary school STEM teachers. In the context of Bhutan, secondary education is categorised into three levels: lower secondary (classes VII–VIII), middle secondary (classes VII–X), and higher secondary (classes VII–XII). Teachers currently employed in middle and higher secondary schools were enrolled in the professional development programme.

The administrative structure of secondary schools in Bhutan is headed by the Principal, who primarily oversees the school's administrative operations. Two Vice Principals (VPs) support the Principal, each managing a distinct domain: academic affairs and student affairs. The Vice Principal for Academic Affairs oversees key responsibilities, including the allocation of teaching subjects and classrooms, preparation of teachers' timetables, procurement of teaching and learning resources, development of academic calendars, facilitation of teachers' professional development programmes, ensuring the efficient and timely execution of academic activities such as tests and examinations, and the monitoring of attendance and academic progress. Similarly, the Vice Principal for Student Affairs oversees student welfare, discipline, the promotion of cultural practices and traditions, engagement in extracurricular activities, counseling support, leadership development, and safety and crisis management.

2.7.2 Description of Partner Schools

Altogether 82 government middle and higher co-educational schools were part of this project. Based on the geographical distribution of the schools they were divided into four clusters: Thimphu; Phuntsholing; Trashigang; and Gelephu. Figure 2.1 below shows the cluster-wise division of schools and Table 2.2 shows the number of schools in each cluster.

Figure 2. 1 *Cluster-wise Division of Schools*

Table 2. 2 *Number of Schools in each Cluster*

Cluster Name	Number of Schools
Thimphu Cluster	21
Phuntsholing Cluster	20
Trashigang Cluster	23
Gelephu Cluster	18
Total	**82**

The schools were categorised based on their locations into rural, semi-urban, and urban groups. In total, there were 24 rural schools, 36 semi-urban schools, and 22 urban schools. All schools within a district are managed by the District Education Officer (DEO), who operates from the district administrative office. Schools located in municipal cities such as Thimphu, Phuntsholing, and Gelephu are overseen by the *Thromde* (Municipal) Education Officer. School resources are centrally and equally distributed by the MoESD. The class levels varied across the partner schools. Generally, schools offering the highest class, XII, are referred to as higher secondary schools, while those with classes up to class X are called middle secondary schools. The lowest class levels offered also differed among the partner schools. Around 15 schools offered classes from pre-primary (PP) to XII, 14 schools catered to classes IX to XII, 23 schools provided classes from VII to XII, 26 schools had classes from PP to X. One school offered classes from class IV to XII. In total, there were 53 boarding schools and 29-day schools.

2.7.3 School Principal

There were 73 male principals and only nine female principals, highlighting a significant gender disparity in school leadership. Before taking up the principal's post, they were either school teachers or VP and were appointed through a competitive interview process conducted by the MoESD and the Royal Civil Service Commission (RCSE). Seventy-six principals hold master's degrees, three have a Postgraduate Diploma in Education (PGDE), and three hold a Bachelor of Education (B.Ed) qualification.

2.7.4 Physical Infrastructure

The physical infrastructures of the partner schools were evaluated based on the following criteria: access to an all-weather road, all-weather school building, availability of a playground, a separate principal's office, separate staff room, provision of safe drinking water, separate male/female toilets, kitchen garden, and facilities ensuring inclusive access. All the partner schools met the stated physical infrastructure criteria, except for inclusive access, as only 21 schools indicated the presence of inclusive access facilities. The lack of comprehensive inclusive access highlights an area requiring further attention to ensure equitable educational opportunities for all students. Additionally, all (N=53) boarding schools-maintained kitchen gardens, where students actively participated in cultivation. The produce, predominantly vegetables, is supplied to the school mess.

2.7.5 Student Welfare Programmes

The evaluation criteria included provisions such as free lunch, textbooks, uniforms, health check-ups, and transportation. All students received free health check-ups and textbooks.

However, only boarding schools provided free lunches, while one day school additionally offered midday meals to needy students. Day scholars were required to bring their lunch. One school reported providing free uniforms to all students, while another offered uniforms specifically to needy students. Additionally, 18 schools reported offering free two-way transportation for their students. The number of students with smartphones varied across the schools, as school policies prohibit students from using mobile phones on campus. English is the medium of instruction in Bhutanese schools, and students typically converse in both English and *Dzongkha*, the national language, within classrooms and schools. However, due to the country's rich diversity and ethnic composition, students are also fluent in their local dialects, such as *Tshangla* in the eastern region, *Lhotshamkha* in the southern region, and others.

2.7.6 Facilities

School facilities were assessed based on the availability of functional laboratories, libraries, computers for office use, computer labs for students, electricity, internet access, internet connection speed (measured in Mbps), and functional ICT infrastructure. A total of 79 schools have separate Physics, Chemistry, and Biology functional laboratories, while three have a common Science lab. All schools have a library and separate computers designated for office use and students. All the schools also have a secure supply of electricity and internet. The internet speed ranged from 7 to 100Mbps. Unique facilities established in some schools included a history museum in one school, a geography lab in another, a Special Educational Needs (SEN) room in one school, and mathematics resource rooms in four schools. All schools were equipped with functional ICT devices, including desktops, projectors, laptops, printers, and scanners. Additionally, 76 schools had Digital (Smart) Boards or Smart TVs. However, the survey recorded only the types of devices available and not their quantities, making it unclear whether the schools have an adequate number of these devices or not.

2.8 The Demographic Profiles of Participants

2.8.1 Gender

The study included 145 teacher participants across different subjects such as Biology, Chemistry, Physics, and Mathematics. Male teachers constituted the majority, with 72.2% in Biology, 78.9% in Chemistry, 88.9% in Physics, and 68.6% in Mathematics. Female teachers represented a fewer in number, indicating the smaller number of female teachers in the sampled schools. However, this distribution demonstrates a diverse range of expertise within the sample, providing comprehensive insights relevant to the study's objectives.

Table 2. 3 *Gender-wise Distribution of Teacher Participants by Subject (n=145)*

Gender	Subjects			
	Biology	Chemistry	Physics	Mathematics
Male	26	30	32	24
Female	10	8	4	11
Total	**36**	**38**	**36**	**35**

2.8.2 Age Range

As shown in Table 2.4, the majority of teacher participants across all subjects are in the 31–40 age range, representing 94 out of 145 (64.8%), with minimal representation in the 21–30 and 41–50 age ranges, and none above 50 years.

Table 2. 4 *Distribution of Teacher Participants by Age Range and Subjects (n=145)*

Age Range	Biology	Chemistry	Physics	Mathematics
21-30	0	8	3	4
31-40	26	26	25	17
41-50	10	4	8	14
Above 50	-	-	-	-
Total	**36**	**38**	**36**	**35**

2.8.3 Professional Qualifications

As shown in Table 2.5, the professional qualifications of the teacher participants included B.Ed (Bachelor of Education), B.Sc (Bachelor of Science), PGDE (Post Graduate Diploma in Education), M.Ed (Master of Education), and M.Sc (Master of Science), with no participants holding a PhD and one participant identified under 'others.'

Table 2. 5 *Professional Qualifications of Teacher Participants by subjects (n=145)*

Subject	BEd	BSc.	PGDE	MEd	MSc.	PhD	Others
Biology	5	-	4	17	10	-	-
Chemistry	8	1	7	17	5	-	-
Physics	-	2	4	18	12	-	-
Mathematics	6	-	11	10	7	-	1

2.8.4 Subject Specialisation in Teacher Education Training

Table 2.6 below highlights the subject of specialisations pursued by teacher participants during their teacher training. Interdisciplinary specialisations were less common, indicating a more focused or streamlined selection of subjects. This distribution reflects diverse academic backgrounds among teacher participants, with an emphasis on core sciences and mathematics.

Table 2. 6 *Subject of Specialisations during their Teacher Training (n=145).*

Subjects	Biology	Chemistry	Physics	Maths
Bio	34	-	-	-
Bio/HP	2	-	-	-
Che	-	33	-	-
Bio/Che	-	3	-	-
Che/Phy	-	1	-	-
Che/ICT	-	1	-	-
Phy	-	-	25	-
Phy/Che	-	-	2	-
Phy/Maths	-	-	7	-

Subjects	Biology	Chemistry	Physics	Maths
Phy/Maths/IT	-	-	1	-
Phy/Agri	-	-	1	-
Maths	-	-	-	34
Math/Eng	-	-	-	1

2.8.5 School Subjects that you are Currently Teaching

Table 2.7 below provides details of the school subjects currently taught by the teacher participants. The data reveals that while most teacher participants handle a single specialised subject, some teach more than one. Combinations like Biology & Science (14) are the most common, while others, such as Physics/Science (5) and Chemistry & Science (4), occur less frequently. Rare combinations, such as Biology & Geography and Chemistry & ICT, appear only once. Overall, the data highlights that although single-subject teaching is prevalent, some teacher participants manage multiple core subjects, reflecting diverse teaching responsibilities in the schools.

Table 2. 7 *Distribution of School Subjects Currently Taught by Teacher Participants*

Subjects	Counts
Biology & Chemistry	-
Biology & Science	14
Biology & Geography	1
Biology	21
Chemistry & Science	4
Chemistry& Physics	1
Chemistry & ICT	1
Chemistry	32
Physics	26
Physics/Maths	4
Physics/Sci	5
Physics/ICT	1
Maths	34
Maths & physics	1
TOTAL	**145**

2.8.6 Years of Experience

Most teacher participants fall within the 11–15 years category, indicating a strong cohort of mid-career professionals. Table 2.8 provides details of participants' total years of teaching experience in Biology, Chemistry, Physics, and Mathematics.

Table 2. 8 *Total Number of Years of Experience as a School Teacher*

No. of Years	Biology	Chemistry	Physics	Mathematics
0-5	1	6	3	5
6-10	5	15	12	8
11-15	17	14	17	7
16-20	7	2	3	15
Above 20	6	1	1	-
Total	**36**	**38**	**36**	**35**

2.8.7 ICT Devices and Usage

Table 2.9 summarises the usage of ICT devices across different subjects. ICT devices are essential for enhancing teaching and learning by providing access to digital resources, improving communication, and facilitating interactive educational experiences. The study indicates that personal laptops are the most widely used ICT devices, particularly in Chemistry and Physics, while smartphones show significant usage across all subjects. Desktops are the least used, with this low usage attributed to teachers primarily relying on their personally owned ICT devices, as schools do not provide desktops. Overall, Physics has the highest total number of ICT users, followed by Chemistry, with Biology and Mathematics showing comparatively lower but still notable usage. This highlights the adaptability of teachers in integrating ICT into their teaching, despite limited government institutional support for desktop availability.

Table 2. 9 *ICT Device Usage among Teacher Participants across Different Subjects (n=145).*

Device	Biology	Chemistry	Physics	Mathematics
Desktop	1	1	1	4
Personal Laptop	35	37	36	31
Personal Tablet	-	2	3	2
Smartphone	29	28	32	25
Total	**65**	**68**	**72**	**62**

2.8.8 ICT Readiness

The ICT readiness levels align closely with the patterns observed in ICT device usage across subjects. Table 2.10 shows the ICT readiness levels of teacher participants across different subjects. The data suggests that the majority of teachers are at the intermediate level of ICT readiness, with the lowest number of beginners, indicating a solid foundation of ICT skills across all subjects. However, the relatively low number of proficient-level teachers across all subjects highlights the need for more professional development opportunities to help teachers enhance their ICT skills beyond the intermediate level.

Table 2. 10 *ICT Readiness Levels of Teacher Participants across Subjects*

Levels	Biology	Chemistry	Physics	Mathematics
Beginner	2	3	2	1
Intermediate	30	33	31	31
Proficient	4	2	3	3
Total	**36**	**38**	**36**	**35**

2.8.9 ICT Devices Frequently Used for Teaching

Figure 2.2 and Table 2.11 show ICT devices frequently used for teaching across different subjects. Personnel-owned laptops and smartphones are the most frequently used ICT devices across all subjects, emphasising their key role in teaching. Desktops and government-provided tablets have minimal usage, suggesting limited availability or integration in their teaching. Smart boards, smart TVs, and projectors are used to varying degrees, with projectors being particularly highest in Physics, followed by Chemistry, Mathematics and Biology. Overall, the findings indicate that while teachers primarily rely on their personal devices, there is potential for greater use of other ICT tools with more institutional support and availability.

Figure 2. 2 *ICT Devices Frequently Used for Teaching (n=145)*

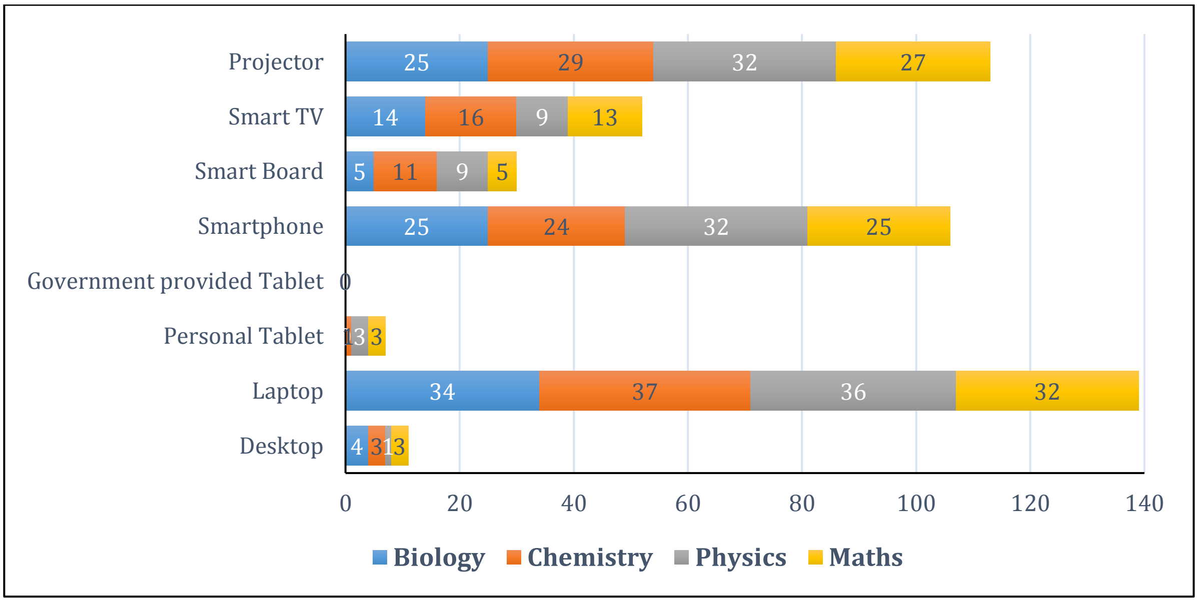


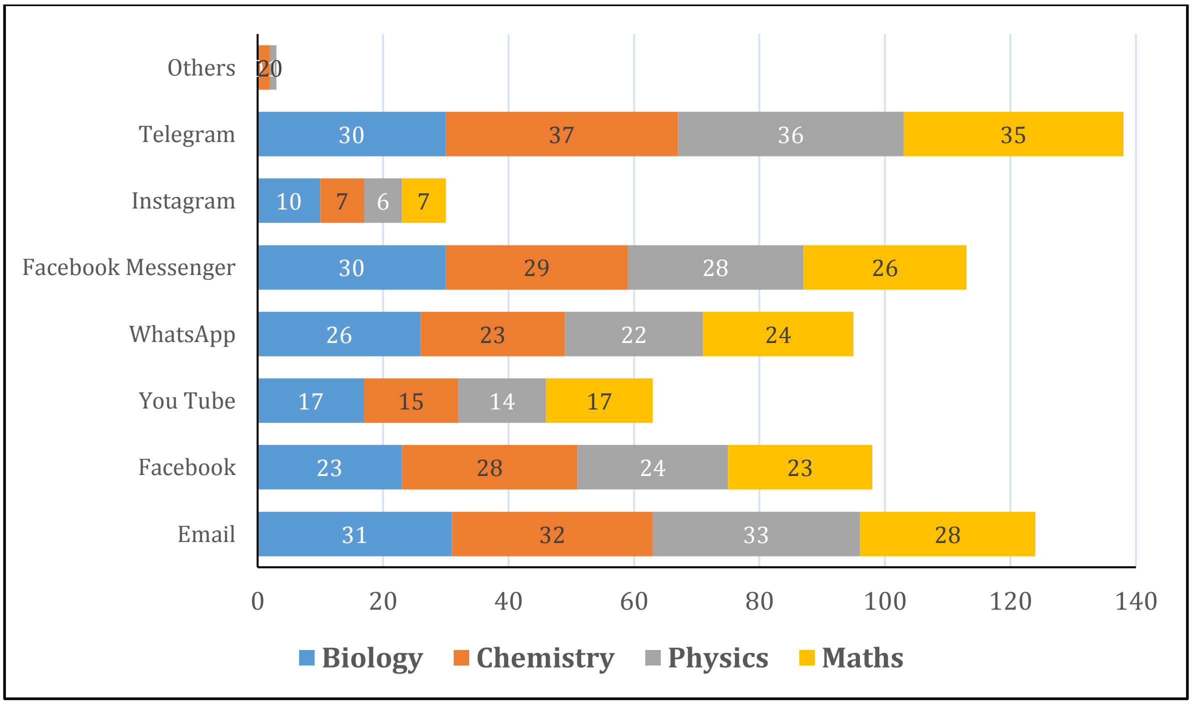
Table 2. 11 *ICT Devices Frequently Used for Teaching*

ICT Devices	Biology	Chemistry	Physics	Mathematics
Desktop	4	3	**1**	**3**
Laptop	34	37	36	32
Personal Tablet	-	1	3	3
Government provided Tablet	-	-	-	-
Smartphone	25	24	32	25
Smart Board	5	11	9	5
Smart TV	14	16	9	13
Projector	25	29	32	27

2.8.10 Communication Media Frequently Used

The data on communication media frequently used with students reveals a strong reliance on widely accessible and functional platforms. **Email** is the most commonly used medium, particularly in Physics (33), Chemistry (32), and Biology (31), followed by Mathematics (28). Telegram also shows significant usage across all subjects, with the highest in Chemistry (37) and Physics (36). Facebook Messenger is another frequently used platform, with consistent usage across all subjects, ranging from 26 in Mathematics to 30 in Biology. Moderately used platforms include WhatsApp, ranging from 22 in Physics to 26 in Biology, and Facebook, which shows similar usage. YouTube is less frequently used, with usage ranging from 14 to 17. In contrast, Instagram and Others have minimal usage, indicating limited relevance for teaching settings. Despite being general-purpose platforms, these tools are valued for their convenience and functionality in supporting communication for teaching.

Figure 2. 3 *Communication Media Frequently Used Across Subjects (n=145)*



2.8.11 Online Teaching and Professional Development

The data suggests that teachers in Biology, Chemistry, Physics, and Mathematics engage in various forms of online professional development, with Biology and Physics showing higher levels of participation in online courses and forums (Table 2.12). Online teaching experiences are more prevalent in Chemistry and Mathematics. Overall, there is a varied level of engagement in online professional development, indicating that some teacher participants are more active in utilising online resources for their professional growth.

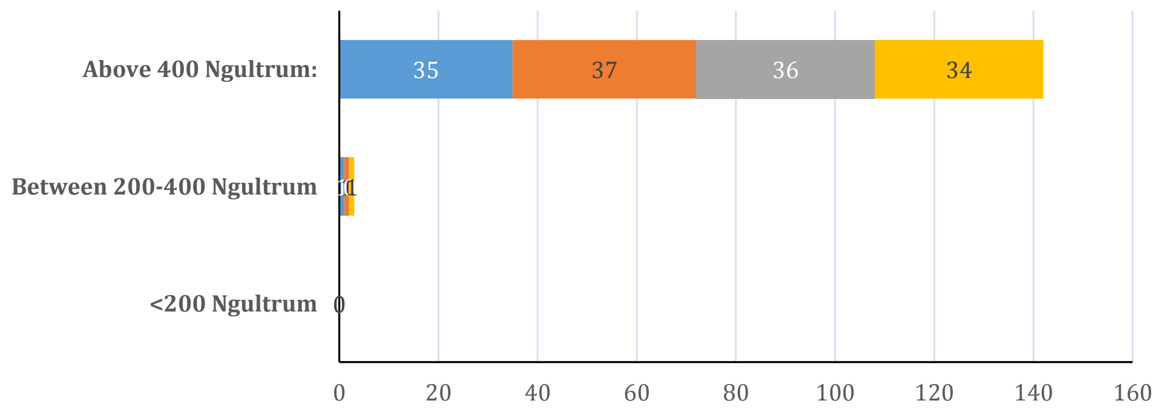
Table 2. 12 *Online Teaching and Professional Development*

Professional Development	Biology	Chemistry	Physics	Mathematics
Taught online	16	24	19	21
Taken an online course	28	1	28	26
Participated in online forums	20	18	19	16
Others	0	0	0	**2**

2.8.12 Approximate Monthly Expenses on Internet (data) Access

The data on the amount spent in local currency (Ngultrum) for internet access across subjects revealed the following trend: Most teachers across all subjects incur monthly internet expenses above 400 Ngultrum, indicating significant reliance on internet access for their teaching and professional development. The number of teacher participants spending between 200-400 Ngultrum is minimal, with no teachers reporting spending less than 200 Ngultrum, highlighting relatively higher internet usage (Figure 2.4). This finding suggests that the majority of teacher participants prioritise internet access for their professional activities and are able to afford higher amounts for monthly data expenses.

Figure 2. 4 *Approximate Monthly Expenses on Internet (data) Access Across Subject (n=145)*



	<200 Ngultrum	Between 200-400 Ngultrum	Above 400 Ngultrum:
Biology	0	1	35
Chemistry	0	1	37
Physics	0	0	36
Maths	0	1	34

2.8.13 Approximate Monthly Data Usage Across Subjects

Teacher participants in all subjects show significant data usage, with a substantial number using 16-30 GB or opting for unlimited data plans (Table 12). For example, Biology (15), Chemistry (14), Physics (17), and Mathematics (12) teacher participants all show notable usage in the range of 16-30 GB. Additionally, a considerable number of teacher participants in all subjects also have unlimited data plans, indicating a high reliance on the internet for their professional activities. This connection suggests that the teachers not only prioritise internet access but are also investing in sufficient data packages to support their teaching, professional development, and other work-related activities.

Table 2. 13 *Approximate Monthly Data Usage Across Subjects (n=145)*

Data usage	Biology	Chemistry	Physics	Mathematics
<1GB:	1	0	0	0
Between 2-5 GB	4	3	5	1
Between 6-15 GB	5	8	6	7
Between 16-30 GB	15	14	17	12
Unlimited:	11	13	8	15

Chapter 3: Science Teachers' Knowledge, Attitude and Practice (Quantitative)

This Chapter presents the findings from the CL4STEM-E Science (Biology, Chemistry & Physics) Survey Part I and Part II, interviews, structured around the Knowledge, Attitudes, and Practices (KAP) framework, with a focus on three key areas: Learners, Content, and Teaching and Learning. It highlights science teachers' understanding of student diversity, beliefs about inclusive education, and the implementation of strategies to address varied learner needs. The analysis also explores teachers' perceptions of science content, emphasizing alignment with modern educational values, and their adoption of active learning strategies, assessment practices, and ICT tools in teaching. This unit provides a comprehensive impression of how the educational intervention OER modules influenced these interconnected dimensions, shaping inclusive and effective Science Education practices.

3.1 Baseline – Endline Science Data Findings (Part I)

The Baseline-Endline Science Data findings Part I analysed the effectiveness of the OER modules on Secondary Science Teachers specifically in Biology, Chemistry, and Physics. It assessed how science teachers used resources, structured lessons, and conducted assessments following the intervention. The analyses also explored science teachers' perceptions of diversity, inclusion, and gender equality, along with their commitment to adapting teaching strategies to meet diverse student needs. This section focused on how the OER modules influenced the adoption of active learning strategies, assessment for learning, and inclusive practices in the science classroom.

3.1.1 Resources Used

The survey analysis examined the use of various educational resources among science teachers to assess their alignment with active learning strategies, diverse assessment methods, and multiple forms of content representation. The survey focused on 10 specific questions related to educational resources, such as own education, textbooks, internet usage, science-related magazines, television, current event, and real-life experiences. Below is an interpretation based on the survey data collected. Major source means frequently used and minor source means less frequently used.

Analysis: The comparison of overall resource usage trends (Table 3.1.1) shows a slight increase in reliance on resources used as "major sources", from 45.5% at Baseline to 48.2% at Endline (2.7% improvement). The use of resources as "minor sources" remained stable, with a small decline from 45.5% to 43.8%. Resources categorized as "Not a source" decreased from 5.2% to 4.4%, and inaccessibility issues dropped from 3.7% to 3.6%. These findings suggest the educational intervention led to modest improvements in resource usage and reduced barriers in science education, though further efforts are needed for more significant change.

Table 3.1.1 *Resource used in Relation to Active Learning Strategies at Baseline and Endline (n=110)*

Data type	Major source	Minor source	Not a source	Do not have access
Baseline (%)	45.5	45.5	5.2	3.7
Endline (%)	48.2	43.8	4.4	3.6

Trend in Gender: In terms of gender differences (Table 3.1.2), males exhibited a small but consistent increase in the use of major sources, rising from 47.5% to 48.0%. Similarly, minor source usage among males rose from 41.9% to 43.7%, while inaccessibility decreased significantly from 4.6% to 3.1%. Females, however, demonstrated a more substantial improvement in the use of major sources, increasing from 43.6% to 48.4%, a 4.8% rise. Their reliance on minor sources slightly decreased from 49.3% to 43.9%, but the percentage of resources categorised as "Not a source" dropped from 4.3% to 3.6%. Interestingly, inaccessibility for females increased from 2.8% to 4.1%. This finding indicates progress for both genders, with females benefiting more in terms of increased resource adoption and males experiencing better access. However, persistent challenges, particularly for females regarding inaccessibility, require further attention.

Table 3.1.2 *Gender-wise Comparison of Resource Used (M=88, F=22)*

Data type	Major source (%)	Minor source (%)	Not a source (%)	Do not have access (%)
Baseline Male	47.5	41.9	6.0	4.6
Endline Male	48.0	43.7	5.2	3.1
Baseline Female	43.6	49.3	4.3	2.8
Endline Female	48.4	43.9	3.6	4.1

Key Findings: In general, the study highlights a general increase in the use of major resources for learning science, with a particular emphasis on active learning strategies and resource diversity. Across both genders, there was an observable reduction in inaccessibility, indicating improved access to educational materials. Gender-specific trends reveal that while males consistently relied more on major sources at both Baseline and Endline, females demonstrated a remarkable improvement over the study period, closing the gender gap in major resource usage. This shift underscores the positive impact of interventions (Open Educational Resources Modules) that aimed at improving resource utilisation.

3.1.2 Characteristics of Science Lesson

This section of the report assesses the characteristics of science lessons, focusing on the extent to which active learning strategies, assessments, and multiple forms of content representation are integrated into the classroom. The survey questions cover activities such as problem-solving, discussions, explaining concepts to students, and conducting experiments. The data collected from science teachers at Baseline and Endline reveals trends suggesting a shift toward more active and student-centered learning practices in science education.

Analysis: Analysis of the overall science data (Table 3.1.3) on the characteristics of science lesson shows a clear trend towards more consistent use of active learning strategies. The percentage of teachers who responded 'Always' using these strategies increased by 5.9%, from 34.6% at Baseline to 40.5% at Endline. While the percentage of teachers responding 'Frequently' using these strategies dropped slightly by 2.1%, from 53.6% to 51.5%, indicating variations in how teachers perceive their engagement in active learning practices.

The "Rarely" category saw a decline of 3.7%, moving from 11.7% to 8.0%, and no teachers reported "Never" using these strategies by the Endline. This reflects a shift towards greater consistency in the integration of active learning.

Table 3.1.3 *Characteristics of Science Lesson at Baseline and Endline (n=110)*

Data type	Always (%)	Frequently (%)	Rarely (%)	Never (%)
Baseline	34.6	53.6	11.7	0.1
Endline	40.5	51.5	8.0	-

Furthermore, the data presented in Table 3.1.4 provides insights into science teachers' engagement with classroom experiments based on the overarching question: 'Do you conduct science experiments in the class?' The survey included a set of predefined statements as response options, allowing participants to select those that best described their situation.

The analysis (Table 3.1.4) indicates a slight decline in the proportion of teachers conducting classroom experiments, with an increasing number citing practical barriers such as time, resources, and overcrowding. For example, the proportion of teachers citing barriers to conducting experiments, such as lack of resources (from 0.9% to 1.8%) and reliance on textbooks (from 0% to 1.8%), increased slightly, reflecting persistent challenges that may hinder the implementation of hands-on learning. However, the increase in teachers acknowledging the value of experiments for understanding scientific inquiry (69.1% to 72.8%), suggests a positive *trend* towards a more conceptual appreciation of experimentation, despite logistical barriers.

Although the importance of experiments in fostering scientific inquiry remains acknowledged, additional efforts may be required to support teachers in overcoming these challenges and integrating practical science more effectively into their teaching practices.

Table 3.1.4 *Comparison of Science Teachers' Responses on Conducting Classroom Experiments at Baseline and Endline (n=110)*

Statements	BL_Yes (%)	EL_Yes (%)	BL_No (%)	EL_No (%)
No, because they learn about experiments by reading it in textbooks	-	1.8	100	98.2
No, because our school doesn't have science lab/ resources	0.9	1.8	99.1	98.2
No, because we don't have enough time	10	8.2	90	91.8
No, because my class is overcrowded	4.5	5.5	95.5	94.5
Yes, because it helps in clarifying the science concept	75.4	69.2	24.6	30.8
Yes, because my students enjoy it	56.3	45.4	43.7	54.6
Yes, because it helps in understanding the process of scientific inquiry	69.1	72.8	30.9	27.2

Note: BL-Baseline, EL-Endline

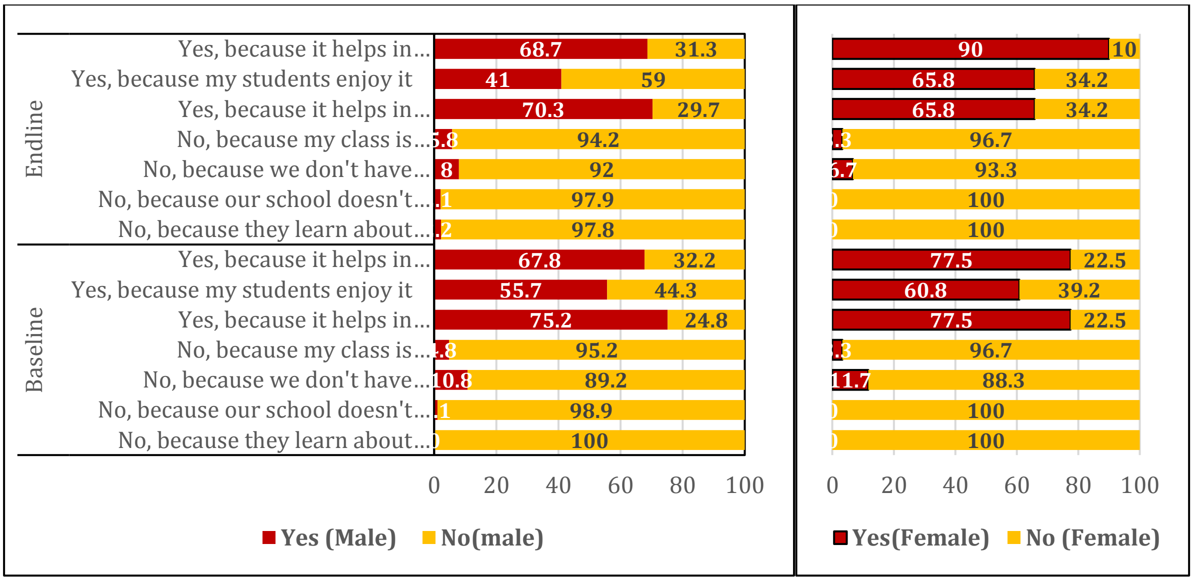
Trend in Gender: In terms of gender differences (Table 3.1.5), male teachers observed a slight increase in the use of active learning strategies, with "Always" responses rising from 35.0% to 40.2%. Meanwhile, female teachers showed a more significant improvement, with "Always" responses increasing by 6.6%, from 34.2% to 40.8%. Additionally, female teachers showed a notable reduction in "Rarely" responses, decreasing by 6.5%, from 13.8% to 7.3%, suggesting that they moved away from less interactive teaching approaches at a greater rate than their male counterparts.

Table 3.1.5 *Gender-wise Comparison of Characteristics of Science Lesson (M=88, F=22)*

Data type	Always (%)	Frequently (%)	Rarely (%)	Never (%)
Baseline Male	35.0	55.4	9.5	0.1
Endline Male	40.2	51.1	8.7	-
Baseline Female	34.2	52.0	13.8	-
Endline Female	40.8	51.9	7.3	-

Gender-specific findings on the reason for conducting science experiment provide additional insights. Female teachers showed greater improvement in using experiments for fostering scientific inquiry, with the percentage increasing significantly from 77.5% at the Baseline to 90% at the Endline. Male teachers, on the other hand, showed only a marginal increase for the same purpose, from 67.8% to 68.7% (Figure 3.1.1). Female teachers were also more likely to conduct experiments for student enjoyment and concept clarification compared to male teachers, highlighting their stronger inclination toward experimental teaching practices.

Figure 3.1.1 *Gender-wise Comparison of Reason for Conduct of Science experiment at Baseline and Endline (n=110)*



Key Findings: Overall, the finding indicates a positive change towards more interactive and inclusive teaching practices in science lesson, with a notable improvement among female teachers, reducing the gender gap, and a decrease in passive teaching methods. These findings underscore the mixed progress in integrating science experiments into classroom teaching. While the focus on scientific inquiry has improved, the decline in experiments conducted for concept clarity and enjoyment raises concerns. Persistent barriers like lack of resources and overcrowding remain significant challenges. The gender-based differences suggest that female teachers are leading the effort to promote hands-on learning, but systemic changes, such as improved infrastructure and smaller class sizes, are needed to support all teachers in conducting effective science experiments.

3.1.3 Assessment of Student Learning

This section of the report assesses how frequently science teachers use various methods to assess student learning in science classrooms, with a focus on practices that support active learning, formative assessment, and varied content representation. The survey questions explored strategies such as problem-solving, peer discussions, and listening carefully to students' ideas. The findings from Baseline and Endline data reveal key trends in the adoption of these assessment strategies.

Analysis: The data reveals a complex shift in the frequency of assessment methods used by science teachers. Overall, there is a noticeable trend toward more frequent use of varied learning assessments, particularly among male teachers, though this comes with some variation. The percentage of teachers reporting that they use specific assessment methods "In all or nearly all lessons" decreased from 20.7% at Baseline to 11.5% at Endline, while the percentage using these methods "Frequently" dropped from 46.2% to 35.8%. Conversely, the category of "Occasionally" saw a small increase of 3.8%, and the percentage of teachers who reported using these methods "Never or almost never" increased significantly, rising from 1.5% to 17.3% (Table 3.1.6). This suggests that while there is an overall trend toward incorporating more diverse assessments, there is also a shift away from their frequent use in some classrooms, with science teachers potentially using other alternative assessment methods.

Table 3.1.6 *Assessment of Student Learning (n=110)*

Data types	Never or Almost never (%)	Occasionally (%)	Frequently (%)	In all or nearly all lessons (%)
Baseline	1.5	31.6	46.2	20.7
Endline	17.3	35.4	35.8	11.5

Trend in Gender: Looking at gender differences, male teachers show a substantial increase in the use of assessment methods "In all or nearly all lessons," with this category rising from 3% at Baseline to 16.5% at Endline. However, the percentage of male teachers reporting "Frequently" using these methods remained largely unchanged. Female teachers, on the other hand, reported a notable increase in the "In all or nearly all lessons" category, rising from 0% to 22%, but experienced a significant drop in the "Frequently" category, from 40.2% to 28% (Table 3.1.7). This analysis indicates that while female teachers are incorporating more assessment methods into their lessons, they are using them less frequently compared to Baseline, although they still show improvement in overall engagement with these methods.

Table 3.1.7 *Gender-based Comparison of Assessment of Student Learning (M=88, F=22)*

Data types	Never or Almost never (%)	Occasionally (%)	Frequently (%)	In all or nearly all lessons (%)
Baseline Male	3.1	32.9	50	14.0
Endline Male	18.2	33.2	38.8	9.8
Baseline Female	-	30.3	42.3	27.4
Endline Female	16.3	37.6	32.9	13.2

Key Findings: Finding shows a trend toward more frequent and varied assessment practices in science education, with notable gender differences. Male teachers display greater consistency in using diverse assessments, while female teachers have made significant strides in increasing assessment frequency. Overall, these shifts reflect an evolving approach to student evaluation, with some teachers adopting varied strategies and others focusing on consistent engagement.

3.1.4 Perceptions Towards Diversity, Inclusion and Gender

Table 3.1.4a and Table 3.1.4b provide insights into science teachers' perceptions regarding diversity, inclusion, and gender differences, particularly in relation to students' socio-economic, linguistic, and health needs. The survey addresses how well teachers recognise and respond to these factors, specifically focusing on basic nutrition, mental or emotional impairments, and language comprehension.

Analysis: The data indicates a slight decline in the perceived relevance of issues related to nutrition, mental health, and language barriers over time, with more teachers becoming less engaged or seeing these issues as less significant as reflected in Table 3.1.8.

For instance, regarding students suffering from a lack of basic nutrition, the percentage of teachers who perceived this problem as 'a lot' decreased significantly from 13.7% at Baseline to 3.5% at Endline, while those who perceived it 'not at all' increased from 26.4% to 42.4%. This suggests that fewer teachers recognised this as a critical challenge by the Endline survey. Similarly, for students facing difficulties understanding the language of instruction, the percentage of teachers who perceived this issue as severe ('a lot' or 'some') decreased slightly, while those who perceived it 'not at all' increased from 3.8% to 7.6%. These trends could indicate a shift in focus or a belief that conditions have improved.

Regarding students with mental, emotional, or psychological impairments, the perception remained relatively stable, with only a slight increase in the percentage of science teachers who perceived this issue as 'a lot' (from 20.8% to 22.7%). This consistency suggests that teachers continue to recognise these challenges as recurring. However, looking at overall diversity and inclusion issues, there is a noticeable decline in the percentage of teachers who perceived the issues as severe (some and a lot), from 64.9% to 61.7% and 20.4% to 17%, respectively. Those who perceived these issues 'not at all' increased from 14.7% to 21.3%, reflecting a general reduction in perceived challenges related to diversity and inclusion.

Table 3.1.8 *Science Teachers' Perceptions towards Diversity, Inclusion and Gender (n=110)*

Statements	Some (%)	A lot (%)	Not at all (%)	Never (%)
BL_Students suffering from lack of basic nutrition	59.9	13.7	26.4	-
EL_Students suffering from lack of basic nutrition	54.1	3.5	42.4	-
BL_Students with mental, emotional, or psychological impairment	65.4	20.8	13.8	-
EL_Students with mental, emotional, or psychological impairment	63.5	22.7	13.8	-
BL_Students with difficulties understanding the language of instruction	69.4	26.8	3.8	-
EL_Students with difficulties understanding the language of instruction	67.4	25	7.6	-
Overall Baseline	64.9	20.4	14.7	-
Overall Endline	61.7	17	21.3	-

Trend in Gender: The analysis of gender-based perceptions of Science teachers towards diversity, inclusion, and gender reveals a shift between Baseline and Endline as indicated in Table 3.1.9. Male teachers showed a slight increase in perceiving "some" issues, while female teachers reported a decrease in this perception. Male teachers also experienced a significant reduction in perceiving "a lot" of issues, while female teachers reported a slight increase. Both male and female teachers exhibited a rise in perceiving "not at all" regarding these issues. These findings suggest evolving attitudes towards diversity, inclusion, and gender, potentially influenced by broader contextual changes.

Table 3.1.9 *Gender-based Perceptions towards Diversity, Inclusion and Gender (M=88, F=22)*

Data type	Some (%)	A lot (%)	Not at all (%)	Never (%)
Baseline Male	67.7	20.5	11.8	-
Endline Male	69.3	10.4	20.3	-
Baseline Female	62.2	20.3	17.5	-
Endline Female	54.1	23.6	22.3	-

Key Findings: Overall, the findings reveal a declining intensity of concern for diversity and inclusion issues among science teachers, particularly in areas like basic nutrition and language barriers. However, mental health challenges remain a more consistently recognized concern. To address these trends, targeted interventions are needed to ensure areas with declining attention, such as basic nutrition, are not overlooked. Gender-specific training programmes can help bridge the differing levels of awareness between male and female teachers. Regular surveys and monitoring should also be conducted to maintain consistent sensitivity to diversity and inclusion issues and address emerging challenges proactively.

3.1.5 Teacher Enthusiasm/Perseverance/Perceptions

3.1.5.1 Sources of Success

This section measures science teachers' perceptions of the factors they believe contribute to student success in achieving learning objectives. The survey data investigates teachers' views on various potential sources of success in relation to students' background, intellectual ability, enthusiasm, and the teacher's role in providing effective instruction, attention to individual needs, and enthusiasm or perseverance. The data analysis from the Baseline and Endline surveys provide insights into how teachers' perceptions may have shifted over time, with a particular focus on how teachers attribute success to factors such as enthusiasm, perseverance, and the effectiveness of teaching methods.

Analysis: The data on teachers' perceptions of the sources of student success in science indicates some shifts between the Baseline and Endline surveys (Table 3.1.10). There is a slight decline in the percentage of teachers attributing student success to home background, decreasing from 6.0% to 5.7%, suggesting that teachers place slightly less emphasis on external socio-economic or familial factors. Similarly, the belief that students' intellectual ability contributes to success increased marginally from 5.3% to 5.8%, indicating that while teachers acknowledge natural aptitude as a factor, it remains a relatively low priority in their perceptions.

Notably, the perceived importance of student enthusiasm and perseverance as a key factor in success declined from 41.6% to 36.3%. Despite this decrease, it remains the most widely recognised factor, suggesting that teachers still consider intrinsic motivation crucial, albeit to a lesser extent over time. In contrast, teachers increasingly recognised the significance of addressing students' unique interests and abilities, with the percentage rising from 22.0% to 23.1%, reflecting a growing appreciation for personalised teaching approaches. Likewise, the belief that effective teaching methods contribute to student success increased from 24.5% to 26.9%, highlighting a shift towards recognising the impact of instructional strategies in supporting learning.

Interestingly, there is a notable increase in the percentage of teachers who view their own enthusiasm and perseverance as a key contributor to student success, rising from 0.6% to 2.2%. While still a relatively small percentage, this suggests a growing awareness among teachers of their motivational influence on students. Overall, the data indicates a shift in perceptions towards recognising the teacher's role—through effective methods and personalised attention—as critical to student success, alongside students' own efforts and enthusiasm.

Trend in Gender: Gender analysis further reveals both similarities and differences. The significance of home background for student-related factors slightly increases for male (3.6% to 4.7%) and lightly decreases for female (8.3% to 6.7%) science teachers, while intellectual ability stays relatively stable, increasing slightly for male teachers (7.1% to 8.2%) and changing very little for female teachers (3.3% to 3.5%). While still the top priority, the emphasis on student enthusiasm or perseverance decreases for both genders from Baseline to Endline, falling from 40% to 37.7% for males and from 43.4% to 35.0% females' science teachers as reflected in Table 3.1.11.

Table 3.1.10 *Teachers' Perceptions of the Sources of Student Success in Science (n=110)*

Sources of Success	Baseline (%)	Endline (%)
Student's home background	6.0	5.7
Student's intellectual ability	5.3	5.8
Student's enthusiasm or perseverance	41.6	36.3
Teacher's attention to the unique interests and abilities of students	22.0	23.1
Teacher's use of effective methods of teaching	24.5	26.9
Teacher's enthusiasm or perseverance	0.6	2.2

Table 3.1.11 *Gender Differences in Teachers' Perceptions of the Sources of Student Success in Science (M=88; F=22)*

Sources of Success	BL_Male (%)	EL_Male (%)	BL_Female (%)	EL_Female (%)
Student's home background	3.6	4.7	8.3	6.7
Student's intellectual ability	7.1	8.2	3.3	3.5
Student's enthusiasm or perseverance	40.0	37.7	43.4	35.0
Teacher's attention to the unique interests and abilities of students	25.7	19.6	18.3	26.7
Teacher's use of effective methods of teaching	22.3	25.5	26.7	28.3
Teacher's enthusiasm or perseverance	1.3	4.3	-	-

Key Findings:

Overall, the findings indicate a noticeable shift in teachers' perceptions towards recognising their own role in fostering student success. Teachers are increasingly attributing achievement to their use of effective teaching methods and personalised attention to students' unique interests and abilities. This suggests a growing awareness that instructional strategies and tailored support play a critical role in enhancing learning outcomes. While intrinsic student factors such as enthusiasm and perseverance continue to be valued, their perceived importance has diminished slightly over time. This shift may reflect an evolving perspective where teachers see themselves as active facilitators of learning, capable of influencing student engagement and performance through well-designed pedagogical approaches, rather than relying solely on students' inherent motivation and effort. The increase in the perceived significance of teacher enthusiasm and perseverance further reinforces the idea that educators recognise their own persistence and passion as key contributors to student success, alongside other influencing factors.

3.1.5.2 Sources of Failure

This section seeks to understand science teachers' views on the primary sources of student failure, exploring both student-related and teacher-related factors.

Analysis: The data analysis (Figure 3.1.2) shows that teachers are increasingly attributing student failure to factors within the students themselves, particularly their indifference or lack of perseverance, which rose from 29.8% to 37.7%. This result suggests that teachers view student attitude and effort as central to academic success, highlighting a growing recognition among teachers of the importance of student motivation and effort. At the same time, teachers are less likely to blame external factors, such as home background, which decreased from 5.6% to 4.0%, indicating a notion away from socio-economic influences as the primary cause of failure. Similarly, the perception that teachers' failure to consider individual needs or use effective methods contributes to failure has decreased, with only 21.1% attributing failure to ineffective teaching methods, down from 24.8%. Lastly, teachers are less likely to blame their own indifference or lack of perseverance, as this dropped sharply from 3.6% to 1.1%. These trends suggest a shift towards viewing student-related factors as more significant than teacher-related factors in student failure.

Trend in Gender: Analysis of gender differences (Table 3.1.12) shows that male teachers increased their attribution of failure to "students' enthusiasm or perseverance," rising from 20.5% to 36.5%, in line with the overall trend. They also reduced the attribution to "teacher's attention to students' unique interests," from 37.3% to 30.7%, indicating less emphasis on teacher engagement as a key factor in student failure. Female teachers maintained their attribution of 39.2% to "students' enthusiasm or perseverance" but increased their attribution to "teacher's attention to unique interests," from 22.5% to 27.5%. Notably, female teachers attributed no failure to "teacher's enthusiasm or perseverance" in the Endline, down from 3.3% in the Baseline, possibly reflecting changes in teaching practices.

Figure 3.1.2 *Teachers' Perceptions of the Sources of Student Failure in Science (n=110)*

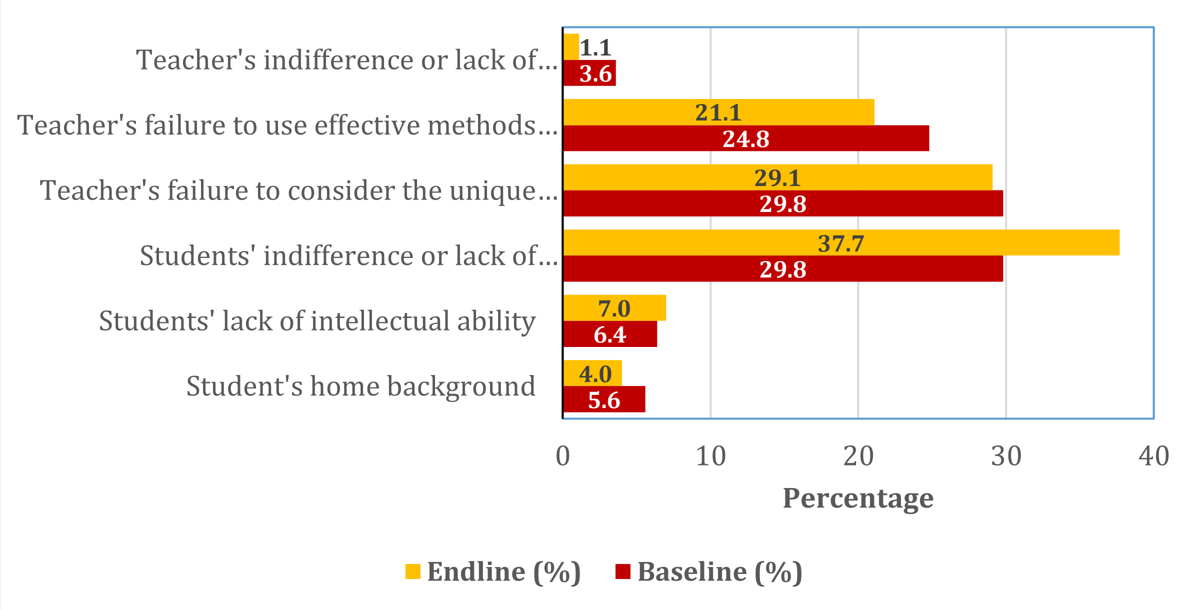


Table 3.1.12 *Gender Differences in Teachers' Perceptions of the Sources of Student Failure in Science (M=88; F=22)*

Sources of Failure	BL_Male (%)	EL_Male (%)	BL_Female (%)	EL_Female (%)
Student's home background	6.9	4.5	4.2	3.3
Student's intellectual ability	9.3	10.6	3.3	3.3
Student's enthusiasm or perseverance	20.5	36.5	39.2	39.2
Teacher's attention to the unique interests and abilities of students	37.3	30.7	22.5	27.5
Teacher's use of effective methods of teaching	22.2	15.5	27.5	26.7
Teacher's enthusiasm or perseverance	3.8	2.2	3.3	-

BL=Baseline; EL=Endline

Key Findings: Overall, the findings indicate a clear shift towards attributing student failure more to student-related factors, particularly students' motivation and effort. This is reflected in the significant increase in the belief that a lack of enthusiasm or perseverance from students is the primary cause of failure, rising from 29.8% to 37.7%. At the same time, there is a reduced focus on teacher-related factors, such as ineffective teaching methods or lack of engagement with students' individual needs. This suggests that teachers now view student effort as more crucial to success than previously.

Gender analysis highlights slight differences between male and female teachers in how they attribute failure. Male teachers have increasingly linked failure to students' perseverance, while placing less emphasis on teacher engagement. In contrast, female teachers have maintained a similar view on student motivation but have slightly increased their focus on the importance of teachers addressing individual student needs. Additionally, female teachers have moved away from attributing failure to their own lack of enthusiasm or perseverance, suggesting a shift in their approach to teaching.

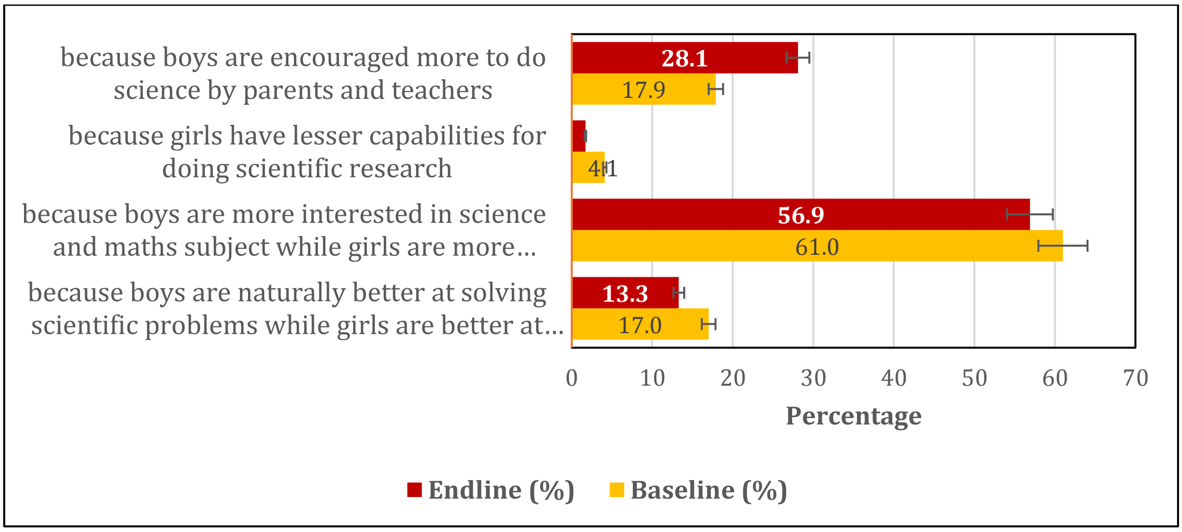
3.1.6 Perceptions Towards all Genders Can Learn

Figure 3.1.6a and Table 3.1.6a highlight science teachers' perceptions of gender disparities in engineering education and their belief in the potential of all children to learn. These insights are based on responses to the United Nation Education Scientific and Cultural Organisation [UNESCO] Report (2021) question: women make up just 28% of graduates in engineering, while boys constitute 72%. Why do you think there are more boys in engineering graduates?"

Analysis: The data (Figure 3.1.3) indicates progress in shifting science teachers' perceptions of gender roles in STEM education. There has been a decline in the belief that boys are naturally better at scientific problem-solving and that boys prefer science while girls prefer arts. A significant drop in the perception that girls lack scientific research capabilities, from 4.1% to 1.7%, reflects a growing recognition of their potential in STEM fields and challenges traditional gender biases. Similarly, the belief that boys are naturally better at solving scientific problems while girls are better at artistic skills has decreased from 17.0% to 13.3%, suggesting that fewer teachers hold this outdated stereotype. The perception that boys are more interested in Science and Mathematics while girls prefer Arts and Languages has also declined slightly, from 61.0% to 56.9%. This indicates a shift towards more balanced views of subject preferences, although societal expectations still influence perceptions.

However, despite these positive changes, the data highlights ongoing systemic biases. There has been a notable increase in the belief that boys receive more encouragement from parents and teachers to pursue science, rising from 17.9% to 28.1%. This suggests a growing awareness of the external influences that contribute to gender disparities in STEM education, particularly in engineering fields, where boys may receive more support and encouragement compared to girls. While gender stereotypes are being challenged, unequal support and encouragement continue to reinforce the gender imbalance in STEM-related fields.

Figure 3.1.3 *Teachers' Perceptions on Gender Disparities in Engineering Education (n=110)*



Trend in Gender: Gender-specific analysis (Table 3.1.13) provides further insight. Male science teachers were more likely to believe that boys were more interested in science and mathematics, while girls preferred art and languages. The percentage of male teachers with this perception increased from 58.9% to 64.7%, while it decreased from 63.3% to 49.1% for female science teachers. This suggests that 14.2% of female science teachers have ultimately changed their perceptions.

A significant percentage of science teachers believe that boys are naturally better at solving scientific problems, while girls excel at artistic skills. Although this perception has decreased from Baseline to Endline (from 18.9% to 14.9% for male teachers and from 15.0% to 11.7% for female teachers), it remains and contributes to the stereotype that the engineering field was better suited for boys.

Although the belief that girls have less ability to scientific research has declined over time with only 3.4% of male teachers and 0% of female teachers endorsing this view at the Endline, it remains an ongoing issue. Similarly, the perception that parents and teachers encourage boys more to study science and mathematics has barely changed among male teachers (17.4% to 17.0%) but has increased significantly among female teachers from 18.3% to 39.2%. This suggests female teachers' awareness of the preferential support boys receive is increasing, potentially contributing to the gender gap in STEM.

Table 3.113 *Gender Differences in Science Teachers' Perceptions of Gender Disparities in Engineering (n=110*

Statements	Baseline Male (%)	Endline Male (%)	Baseline Female (%)	Endline Female (%)
Boys are naturally better at solving scientific problems while girls are better at artistic skills	18.9	14.9	15.0	11.7
Boys are more interested in science and maths subject while girls are more interested in art and language	58.9	64.7	63.3	49.1
Girls have lesser capabilities for doing scientific research	4.8	3.4	3.4	0.0
Boys are encouraged more to do science and mathematics by parents and teachers	17.4	17.0	18.3	39.2

Key Findings: The data underscores a positive shift in science teachers' perceptions of gender roles within STEM fields, as evidenced by a marked reduction in the belief that boys are inherently better at scientific problem-solving and that boys are naturally more inclined toward science, while girls are predisposed to the arts. Notably, the perception that girls lack the capabilities necessary for scientific research has significantly decreased, reflecting an evolving recognition of their potential within STEM domains. Although progress is evident in challenging gender stereotypes, the data highlights the persistence of systemic biases, particularly the increasing belief that boys receive more encouragement from both parents and teachers to pursue scientific disciplines. Gender-specific analysis further reveals that male teachers are more likely to maintain the view that boys exhibit a stronger preference for science and mathematics, with this perception becoming more pronounced over time. In contrast, female teachers have demonstrated a shift, with a reduction in the attribution of these preferences to boys. While the belief that boys possess superior problem-solving abilities has declined, it remains prevalent, perpetuating the stereotype that engineering is a field more suited to boys. Additionally, although fewer teachers now consider girls to lack the requisite skills for scientific research, female teachers are increasingly attuned to the preferential support that boys receive, a factor that may continue to contribute to the gender disparity in STEM education, particularly within engineering disciplines.

3.1.7 Value Diversity as a Resource

This section assesses how often science teachers use diverse group settings, specifically mixed-ability and mixed-gender groups, in their teaching. It aligns with the statement by assessing whether teachers "value diversity as a resource" in classroom practices.

Analysis: The analysis of the data (Figure 3.1.4) suggests that science teachers increasingly value student diversity as a resource in their teaching practices. The rise in the use of mixed-ability and mixed-gender groupings "every or almost every lesson" indicates a growing recognition of the benefits of collaborative and inclusive learning environments. The decline in the "some lessons" and "never" categories highlights a shift toward more consistent implementation of these strategies. This trend reflects a commitment to fostering equity, leveraging diverse student strengths, and promoting interaction among students with varying abilities and perspectives.

Trend in Gender: Looking at the trend of gender differences, data reveals that female teachers consistently demonstrated a stronger commitment to employing diverse groupings compared to male teachers. Female teachers showed higher rates of using mixed-ability and mixed-gender groupings "every or almost every lesson," increasing from 61.3% to 70.4%, while male teachers' usage increased from 46.8% to 52.8% (Table 3.1.14). Both genders, however, exhibited a clear trend toward valuing diversity as a teaching resource, with female teachers maintaining consistently higher adoption rates.

Figure 3.1.4 *Science Teacher Perception Data on Using Mixed-Ability and Mixed-Gender Groupings (n=110)*

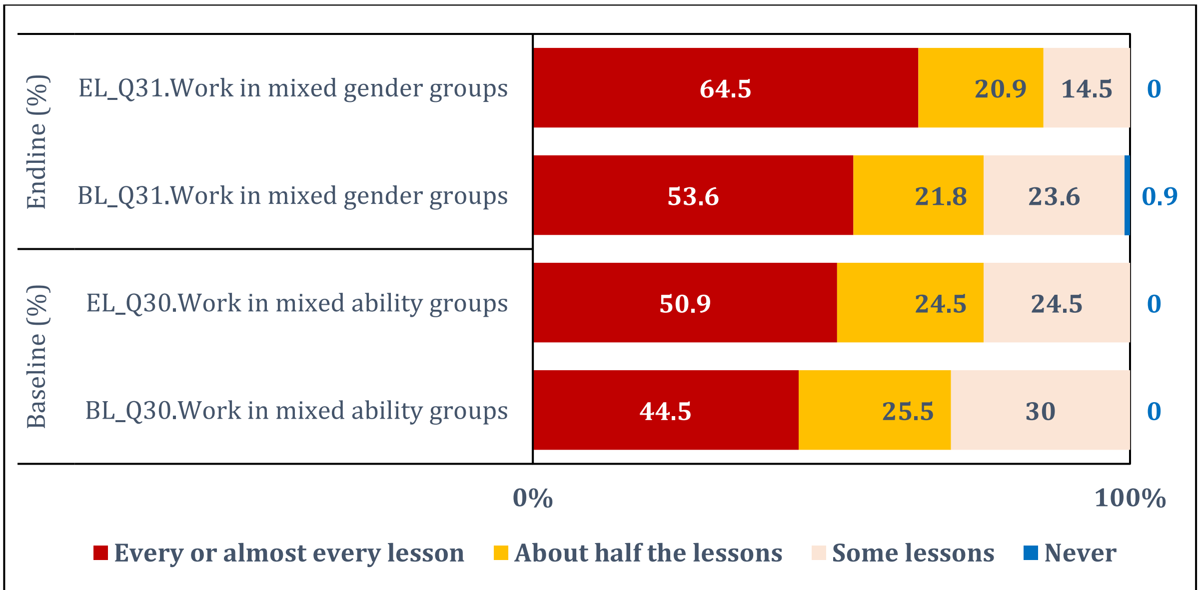


Table 3.114 *Gender Differences in Frequency of Using Mixed-Ability and Mixed-Gender Groupings (M=88; F=22)*

Data type	Every or almost every lesson (%)	About half the lessons (%)	Some lessons (%)	Never (%)
Baseline_Male	46.8	23.4	29.8	-
Endline_Male	52.8	25.3	21.9	-
Baseline_Female	61.3	21.3	17.4	-
Endline_Female	70.4	15.8	13.8	-

Key Findings: The data reveals a notable shift in science teachers' perceptions regarding the value of diversity as a pedagogical resource. An increasing number of teachers report employing mixed-ability and mixed-gender groupings "every or almost every lesson," indicating a growing recognition of the educational benefits of fostering collaborative and inclusive learning environments. This trend is further evidenced by a decline in the frequency with which such diverse groupings are used "some lessons" or "never," suggesting a move towards more consistent and purposeful integration of diversity into teaching practices. These shifts reflect a stronger commitment to equity, as teachers increasingly draw upon the varied strengths and perspectives of their students to enhance the learning experience in science classrooms.

When examining gender differences, the data reveals that female teachers demonstrate a more pronounced commitment to valuing diversity as a resource. The proportion of female teachers employing mixed-ability and mixed-gender groupings "every or almost every lesson" increased from 61.3% to 70.4%, while male teachers' use of these groupings rose from 46.8% to 52.8%. This trend indicates a clear gendered disparity, with female teachers consistently adopting inclusive teaching strategies at higher rates. This suggests that female science teachers are more likely to recognise and leverage diversity as a critical resource in fostering an equitable and engaging classroom environment.

3.1.8 Summary (Survey Part I)

Overall, the findings from Science Survey Part I indicate a positive shift in science teachers' knowledge, attitudes, and practices, particularly in relation to diversity, inclusion, and student-centred pedagogies. The evidence suggests that teachers are increasingly adopting inclusive teaching strategies, incorporating active learning methods, and recognising the value of diverse student backgrounds and abilities. There has been a notable shift towards more personalised approaches, with teachers emphasising the importance of catering to individual student needs, while acknowledging the growing role of teacher enthusiasm and perseverance in fostering student success.

The findings also reveal a significant change in teachers' perceptions of gender roles within STEM, with a decrease in traditional stereotypes about boys and girls' academic interests and abilities. While progress is evident, persistent biases remain, particularly in relation to the differential encouragement boys and girls receive from teachers and parents. This underscores the need for continued efforts to address gender disparities in STEM education and promote equal opportunities for all students, regardless of gender.

Additionally, the data highlights that female science teachers consistently demonstrated a stronger commitment to using diverse group settings and valuing diversity as a resource in the classroom, compared to their male counterparts. This trend suggests that female teachers are more inclined to foster an inclusive and collaborative learning environment, although there remains room for improvement across both genders.

In conclusion, these findings illustrate a positive trend in science education practices, driven by the implementation of Open Educational Resources modules and a growing awareness of the importance of equity, inclusion, and personalised learning. However, challenges persist, particularly in addressing gender bias and ensuring that all students receive the support and encouragement they need to succeed in STEM fields. Future efforts should focus on further reducing these disparities and strengthening the role of inclusive teaching practices in science education.

3.2 Baseline – Endline Science Data Findings (Part II)

Survey Part II of the Baseline-Endline study focuses on assessing science teachers' attitudes, beliefs, and practices in biology, chemistry and physics. It includes questions related to the nature of science, students' socio-economic and linguistic backgrounds, and the teachers' mindset and attitudes towards diverse learners. Key research parameters involve exploring the recognition of learners' diverse needs, beliefs in all students' ability to learn, and the responsibility teachers feel to meet these needs through inclusive practices. The survey also covers science teachers teaching strategies specifically in biology, chemistry and physics classrooms, the use of active learning methods, and the value science teachers place on diversity as a resource in the classroom.

3.2.1 Nature of Science

Figure 3.2.1 illustrates the overall percentage distribution of responses among Science teachers (Biology, Chemistry, and Physics) across five levels of agreement: strongly disagree, disagree, agree, and strongly agree. Notable changes were observed, particularly in the strong agreement category, which increased from 27.8% at Baseline to 29.1% at Endline. These findings indicate that teachers are gradually embracing attitudes, beliefs, and values that align more closely with the prevailing consensus among educators regarding the nature of science. This shift, though subtle, underscores the potential impact of interventions or professional development in shaping educators' perceptions and alignment with educational standards.

Analysis: Building on this analysis**,** Figure 3.2.2 provides a more detailed comparative analysis of teachers' attitudes towards the nature of science across Biology, Chemistry, and Physics, with notable gender differences. There is a general trend of increasing critical thinking, as teachers are more likely to question the objectivity and neutrality of scientific observations. In Biology, there is a slight increase in disagreement with the nature of science statements at the Endline, indicating a growing awareness or scepticism about the scientific process. Similarly, in Chemistry, teachers show a modest shift towards a more favourable view of the nature of science, with an increase in agreement at the Endline. In contrast, Physics teachers exhibit less significant change, with a large proportion continuing to disagree with statements about the nature of science, despite a slight increase in agreement.

Figure 3.2.1 *Overall Attitudes of Science Teachers on the Nature of Science between Baseline and Endline.*

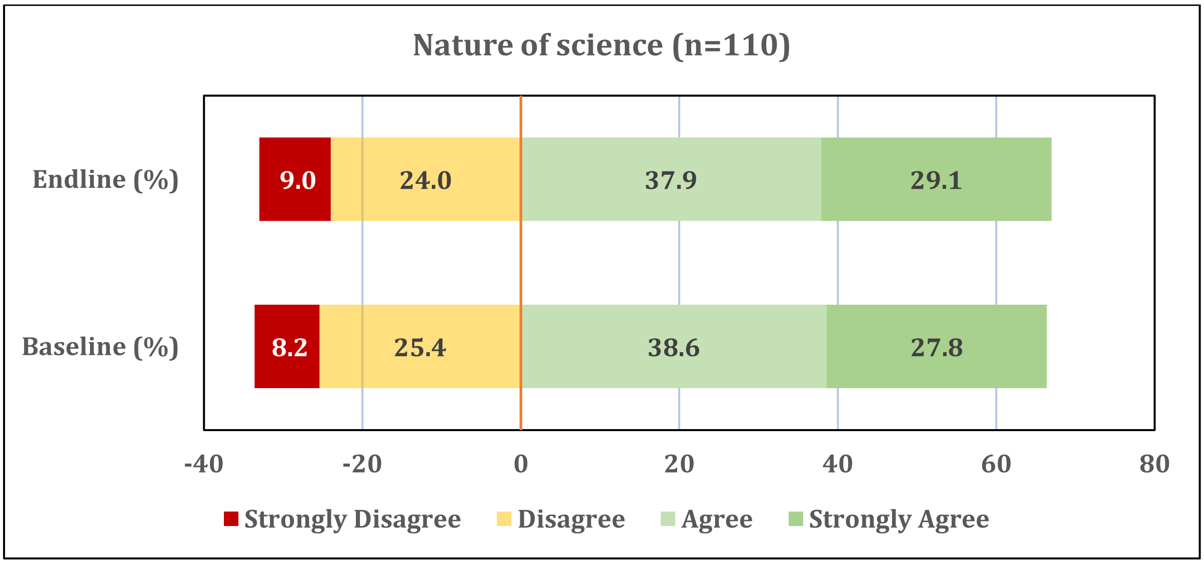
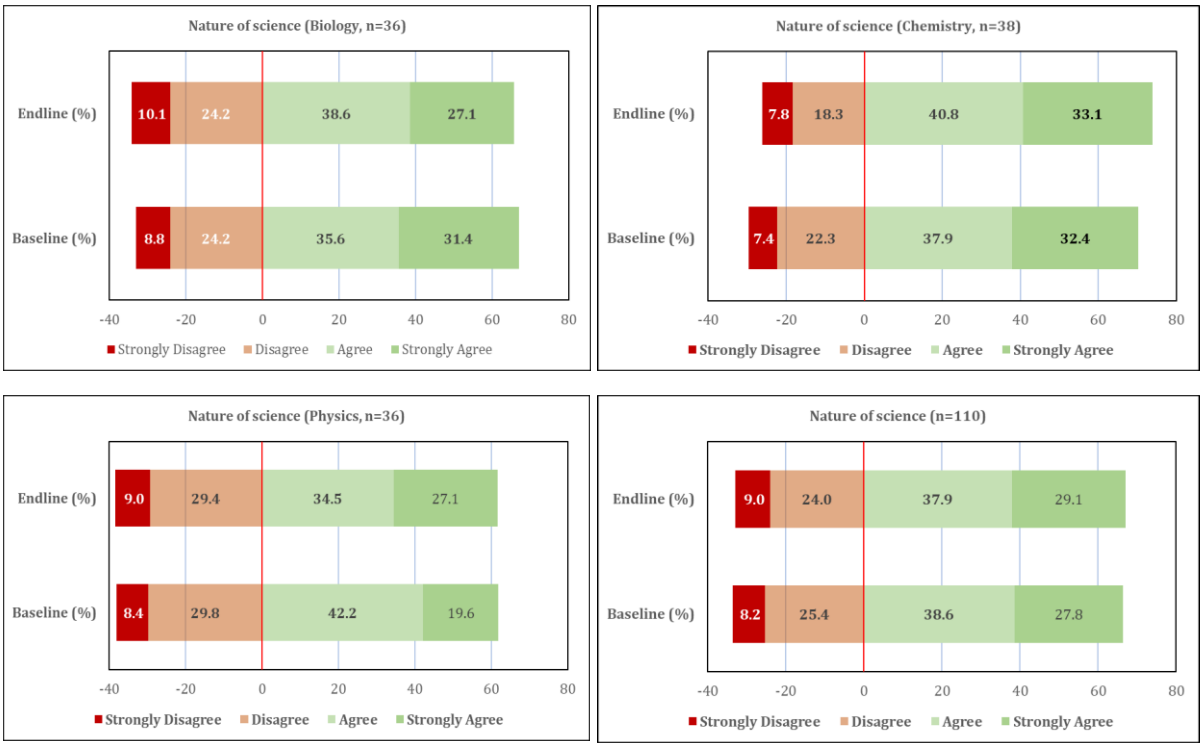
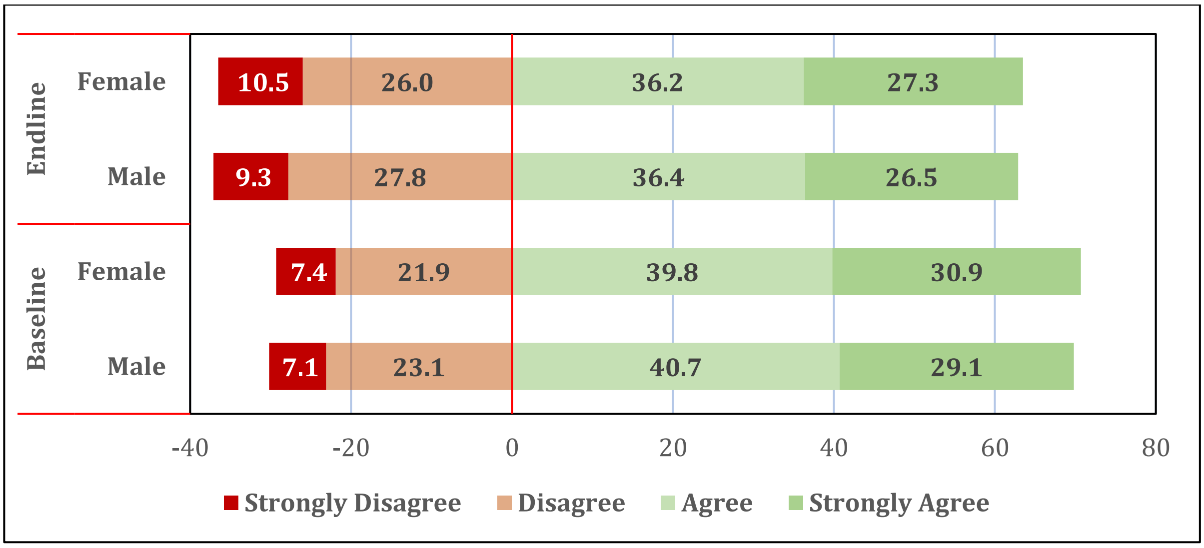


Figure 3.2.2 *Subject-Based Comparison of Teachers' Attitudes towards the Nature of Between Baseline and Endline Survey*



Trend in Gender: Figure 3.2.3 displays the trend in male and female science teachers' perceptions towards the Nature of Science based on the Baseline and Endline survey analysis. While both male and female teachers exhibit similar trends of decreasing agreement and increasing disagreement from Baseline to Endline, the shift appears to be more pronounced among female teachers. For instance, the increase in strong disagreement is more pronounced among female teachers (7.4% to 10.5%) than male teachers (7.1% to 9.3%), indicating increasing scepticism about the nature of science among females. This suggests female teachers may be more influenced by evolving perspectives or external factors. However, male teachers consistently report slightly higher disagreement at both Baseline and Endline.

Figure 3.2.3 *Comparison of Male and Female Science Teachers' Perceptions of the Nature of Science at Baseline and Endline (M=88; F=22)*



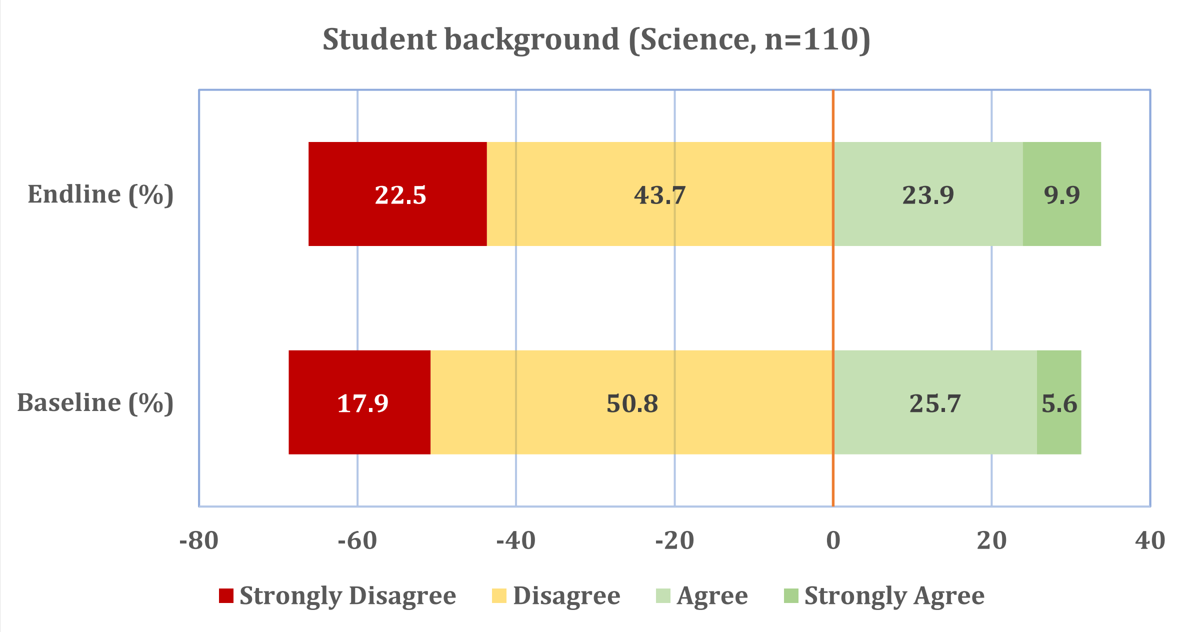
Key Findings: The overall findings indicate a positive shift in science teachers' attitudes towards the Nature of Science, evident in an increase in agreement. Although variations exist across subjects, the general trend suggests a greater alignment with contemporary educational standards and interventions, such as Open Educational Resources, over time. The trend in gender differences reveals that while perceptions of the Nature of Science have evolved for both genders, female teachers demonstrate a slightly greater tendency towards increased disagreement. This observation suggests potential differences in how professional development interventions or experiences have influenced their perspectives.

3.2.2 Student Background

The survey data (Figure 3.2.4) provides insights into teachers' attitudes regarding the statement, "When working with students from low-income families, teachers should rely primarily on teacher-directed, focused, whole-group instruction."

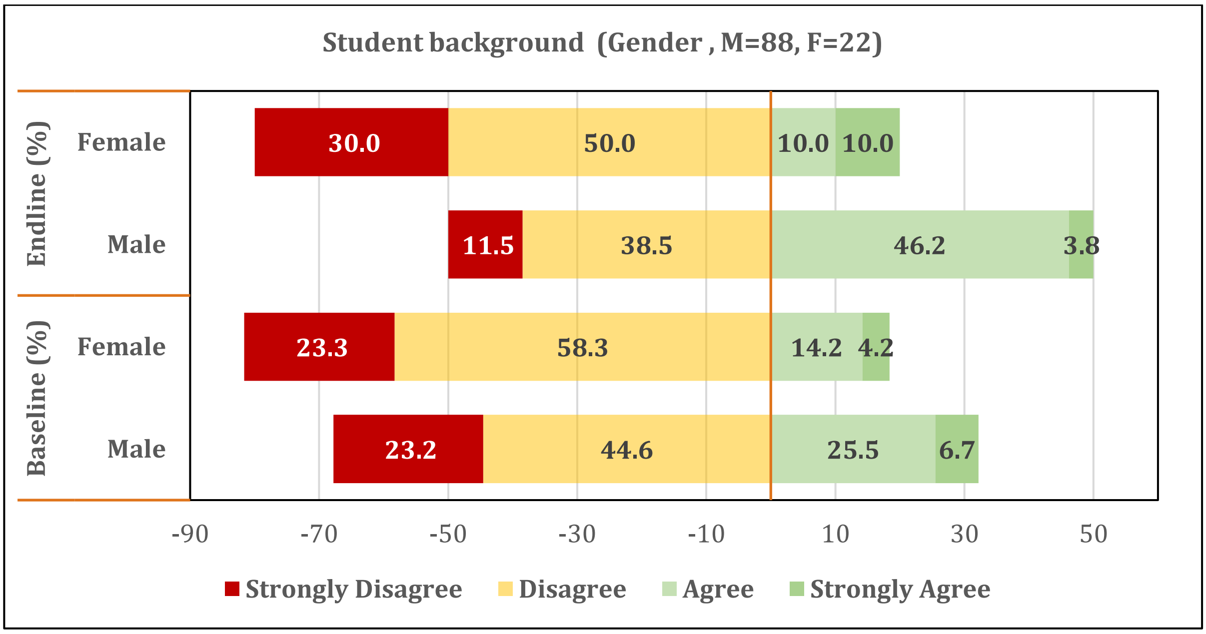
Analysis: At the Baseline, 5.6% of teachers strongly agreed, 25.7% agreed, 50.8% disagreed, and 17.9% strongly disagreed, indicating that disagreement (68.7% combined) was the dominant attitude. In the Endline data, 9.9% of teachers strongly agreed, 23.9% agreed, 43.7% disagreed, and 22.5% strongly disagreed. This shows a slight decrease in agreement from 25.7% to 23.9% and a modest increase in both strong agreement and disagreement. While disagreement (66.2% combined) remained the majority attitude, the rise in agreement suggests a gradual shift, with some teachers becoming more open to teacher-directed, whole-group instruction. Overall, the data reflects varied attitudes towards instructional approaches, as teachers appear cautious about relying solely on whole-group methods, likely valuing differentiated strategies to address the socio-economic and linguistic diversity of learners. This demonstrates their awareness of the need to tailor teaching methods to meet the varied needs of students effectively.

Figure 3.2.4 *Teachers' Attitudes Towards Student Background from Low-Income Families at Baseline and Endline*



Trend in Gender: Analysis of gender-specific survey data (Figure 3.2.5) suggests a gender-based divergence in attitudes towards teacher-directed, whole-group instruction for low-income students. Male teachers showed a shift towards agreeing with the approach over time, with an increase in agreement (from 25.5% to 46.2%) and a decrease in disagreement (from 46.6% to 38.5%). In contrast, female teachers became more strongly opposed, with a notable rise in strong disagreement (from 23.3% to 30.0%) and a significant drop in agreement (from 14.2% to 10.0%), although a significant increase in strong agreement (from 3.8% to 10.0%) emerged. This indicates that male teachers are more likely to favour this instructional method, while female teachers increasingly reject it, pointing to differing perspectives on the most effective teaching strategies for students from low-income backgrounds.

Figure 3.2.5 *Gender-wise Attitudes of Teachers Towards Student Background from Low-Income Families at Baseline and Endline*



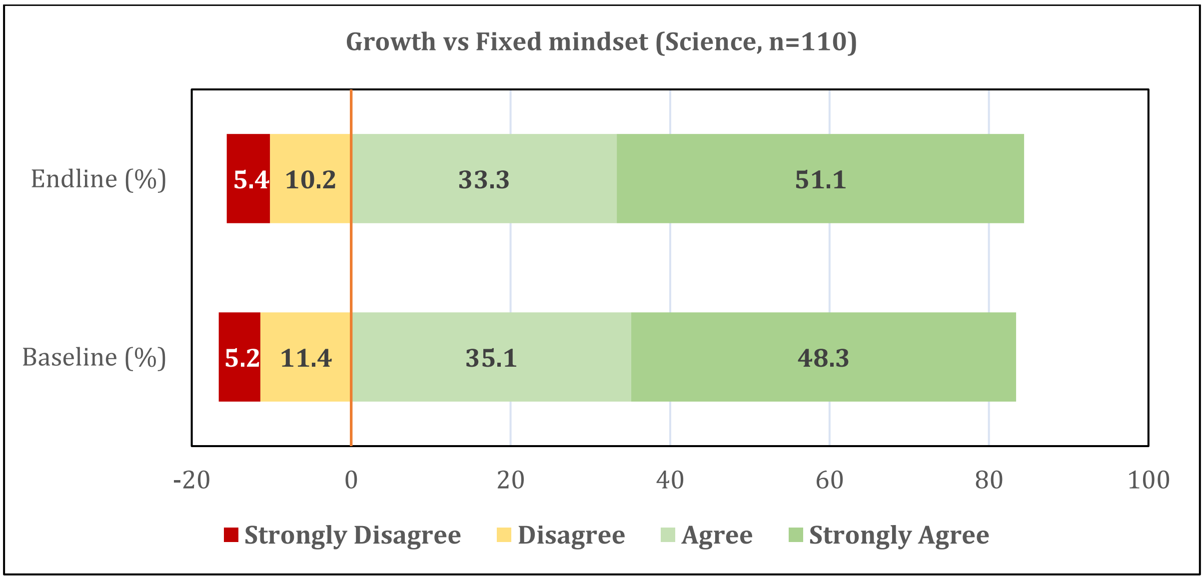
Key Findings: While teachers generally remain cautious about relying solely on teacher-directed, whole-group instruction for low-income students, there is a gradual shift towards greater acceptance of this method among male teachers. Conversely, female teachers increasingly favour differentiated approaches, emphasising the need for tailored strategies to address diverse teaching perspectives and effectively support students from low-income backgrounds.

3.2.3 Growth vs. Fixed Mindset

Figure 3.2.6 and Figure 3.2.7 depict the overall percentage perception of teachers and gender difference regarding their beliefs on learning science categorised under growth vs. fixed mindset.

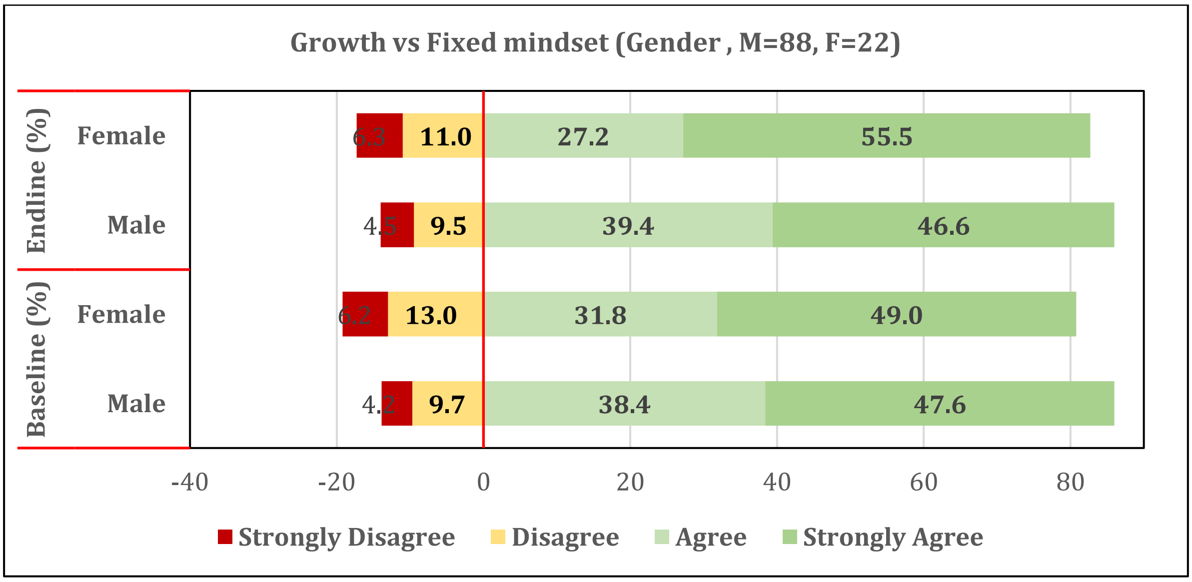
Analysis: Analysis indicates a positive and consistent belief in the potential of all children to learn science, with minimal change between Baseline and Endline. For example, at Baseline, the majority of teachers (35.1%) agreed, and 48.3% strongly agreed, that all children can learn science. By the Endline, the percentage of strong agreement slightly increased to 51.1%, while disagreement decreased marginally to 10.2%. These results suggest that the teachers' mindset regarding the capability of all children to learn science remained stable, with a slight shift towards stronger agreement over time.

Figure 3.2.6 *Teachers' Perception Towards Students' Growth and Mindset at Baseline and Endline*



Trend in Gender: Gender-wise survey data (Figure 3.2.3b) on growth and mindset reveals trends in male and female teachers' beliefs regarding the potential of all children to learn science, reflecting growth versus fixed mindset perspectives. The findings indicate that both male and female teachers generally hold a positive belief in the ability of all children to learn science, with a slight shift towards a growth mindset over time. While male teachers exhibited a small decrease in strong agreement and an increase in agreement, female teachers demonstrated a more significant shift, marked by a notable rise in strong agreement (from 49.0% to 55.5%) and a corresponding decrease in agreement (from 31.8% to 27.2%). These trends suggest that, by the Endline, female teachers were more strongly aligned with the belief that all children can succeed in science, while male teachers maintained a relatively stable stance.

Figure 3.2.7 *Gender-wise Teachers' Opinions Towards Students' Growth and Mindset at Baseline and Endline*



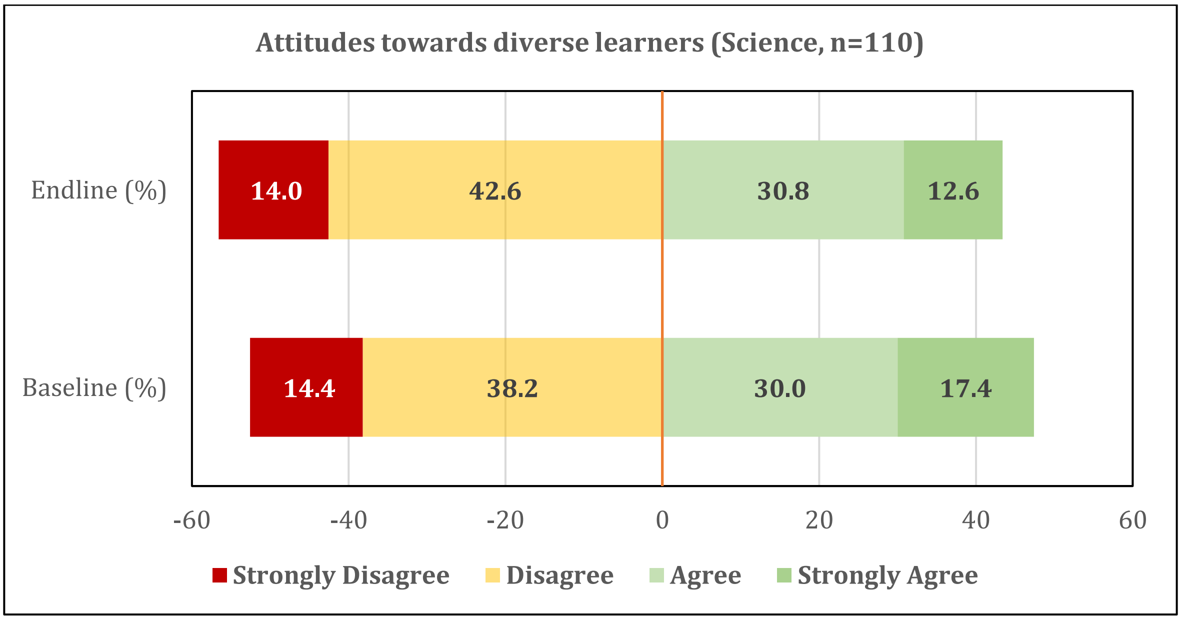
Key Findings: The survey indicates a generally positive shift in teachers' attitudes and practices, with most teachers supporting inclusive education, active learning, and a growth mindset. While progress is evident, further growth is needed in areas like gender perceptions and inclusive practices.

3.2.4 Attitudes towards Diverse Learners

Figure 3.2.8 shows teachers' attitudes toward meeting the diverse needs of learners through inclusive practices at both Baseline and Endline.

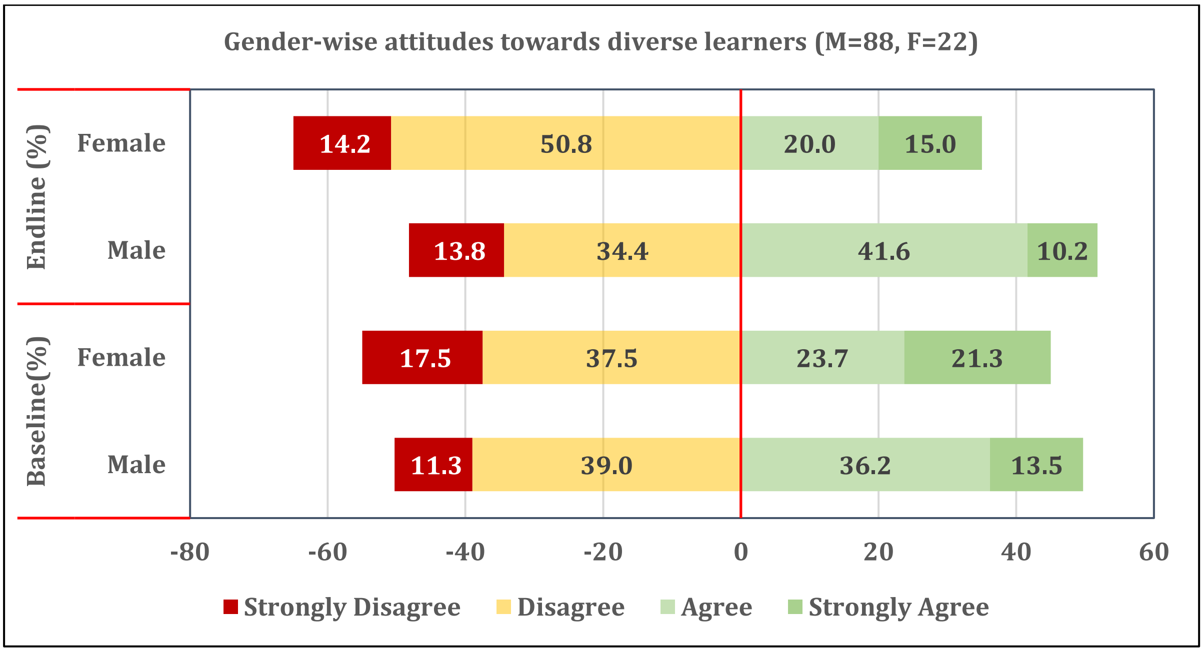
Analysis: At Baseline, 38.2% of teachers disagreed with the statement that students with disabilities should not be expected to keep up with the rest of the class, while 30.0% agreed with it and 17.4% strongly agreed. By the Endline, the percentage of teachers disagreeing slightly increased to 42.6%, while the percentage agreeing rose to 30.8%. Strong agreement also decreased from 17.4% at Baseline to 12.6% at Endline. This shift suggests that, over time, teachers were more likely to agree with the idea of focusing on minimum competency objectives for slower learners, indicating a noticeable change towards a more fixed mindset regarding expectations for students with diverse learning needs.

Figure 3.2.8 *Science Teachers' Attitudes Towards Learners*



Trend in Gender: Figure 3.2.9 illustrates how male and female teachers' attitudes towards meeting the diverse needs of learners, particularly students with disabilities and slow learners, evolved over time. The study indicates that while male teachers showed a shift towards more inclusive attitudes, with an increase in agreement and a decrease in strong agreement, female teachers became more sceptical, with an increase in disagreement and a decrease in strong agreement. This suggests that male teachers were more open to embracing inclusive practices, whereas female teachers grew less confident in their responsibility to meet the diverse needs of learners over time.

Figure 3.2.9 *Gender-Based Teachers' Attitudes Towards Learners*



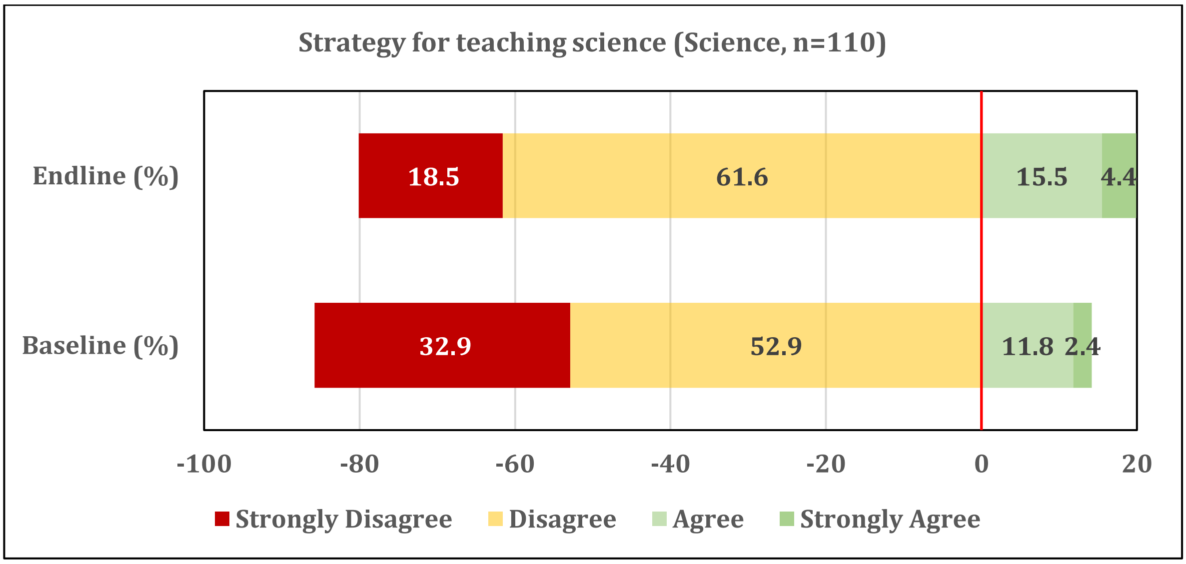
Key Findings: This finding indicates a positive shift in teachers' attitudes towards inclusive education, with male teachers increasingly supporting the diverse needs of learners. Female teachers, while showing some initial skepticism, demonstrated thoughtful reflection and a shift in their perspectives, highlighting a continued commitment to exploring ways to support all students effectively.

3.2.5 Strategy for Teaching Science

The survey data (Figure 3.2.10) highlights teachers' strong belief in the continued importance of using models and visual aids in science teaching, even for older students.

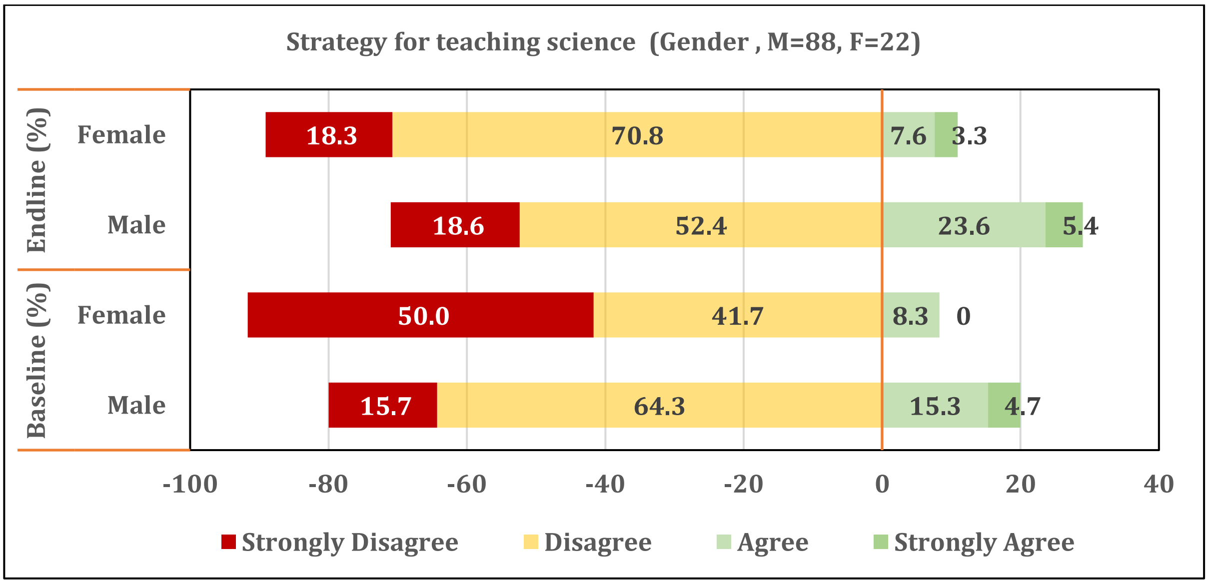
Analysis: At Baseline, 52.9% of teachers disagreed with the statement that older students no longer need these tools due to their ability to reason abstractly, while 32.9% strongly disagreed. By the Endline, this perspective shifted, with 61.6% still disagreeing and 18.5% strongly disagreeing. Additionally, the percentage of teachers agreeing with the statement increased slightly to 15.5%, and strong agreement rose to 4.4%. These findings suggest that the majority of teachers value models and visual aids, aligning with active learning strategies and the belief that diverse methods of content representation benefit all learners, regardless of age.

Figure 3.2.10 *Overall Science Teachers' Attitudes Towards the Use of Visual Aids and Models for older Students in Science Teaching (n=110).*



Trend in Gender: Further analysis of gender differences (Figure 3.2.11) reveals that both male and female teachers strongly oppose the idea that models and visual aids become less necessary for older students. At Baseline, 80% of male teachers and 91.7% of female teachers disagreed or strongly disagreed with the statement. By the Endline, this opposition remained high, with 71.0% of male teachers and 89.1% of female teachers maintaining their stance. These findings highlight a consistent belief among teachers, regardless of gender, in the ongoing importance of models and visual aids for teaching science to older students, irrespective of their age or reasoning abilities.

Figure 3.2.11 *Gender-Based Science Teachers' Attitudes Towards the Use of Visual Aids and Models for older Students in Science Teaching (n=110).*



Key Findings: The survey results indicate that the majority of science teachers, regardless of gender, continue to believe in the importance of using models and visual aids for older students. This finding reflects a strong, consistent preference for diverse teaching methods, emphasising the value of models and visual aids in promoting effective science learning for all students.

3.2.6 Attitudes towards Diversity

Figure 3.2.12 illustrates teachers' attitudes towards valuing diversity as a resource in science teaching, as reflected in their levels of agreement with statements on inclusion and teaching students with diverse abilities.

Analysis: The survey data highlights a generally positive attitude among science teachers towards diversity and inclusion in classrooms. At both Baseline and Endline, the majority of teachers agreed or strongly agreed that diversity benefits students socially and academically, and that inclusion enhances teaching effectiveness. Over time, these positive attitudes showed a slight improvement, with an increase in agreement from 42.3% to 44.0%, and in strong agreement from 43.2% to 45.8%. Additionally, the percentage of science teachers who strongly disagreed and disagreed decreased from 4.2% and 10.3% at Baseline to 1.9% and 8.3% at Endline, respectively. These changes reflect a growing appreciation for diversity as a resource in classrooms.

Trend in Gender: Gender-wise analysis (Figure 3.2.13) reveals incremental progress in positive attitudes towards diversity and inclusion. Science teachers expressing strong disagreement decreased notably, while agreement and strong agreement increased, indicating a shift towards more inclusive perspectives. This trend is particularly evident in gender-specific findings. Among male teachers, positive attitudes (combining agree and strongly agree) improved slightly from 86.3% at Baseline to 88.0% at Endline. In contrast, female teachers showed a more substantial increase in positive attitudes, rising from 84.7% at Baseline to 91.6% at Endline. This increase was primarily driven by a rise in the percentage of strongly agree responses among female teachers, suggesting a stronger endorsement of diversity as a resource and inclusive practices over time.

Figure 3.2.12 *Teachers' Attitudes Towards Valuing Students' Diversity as a Resource in Teaching Science.*

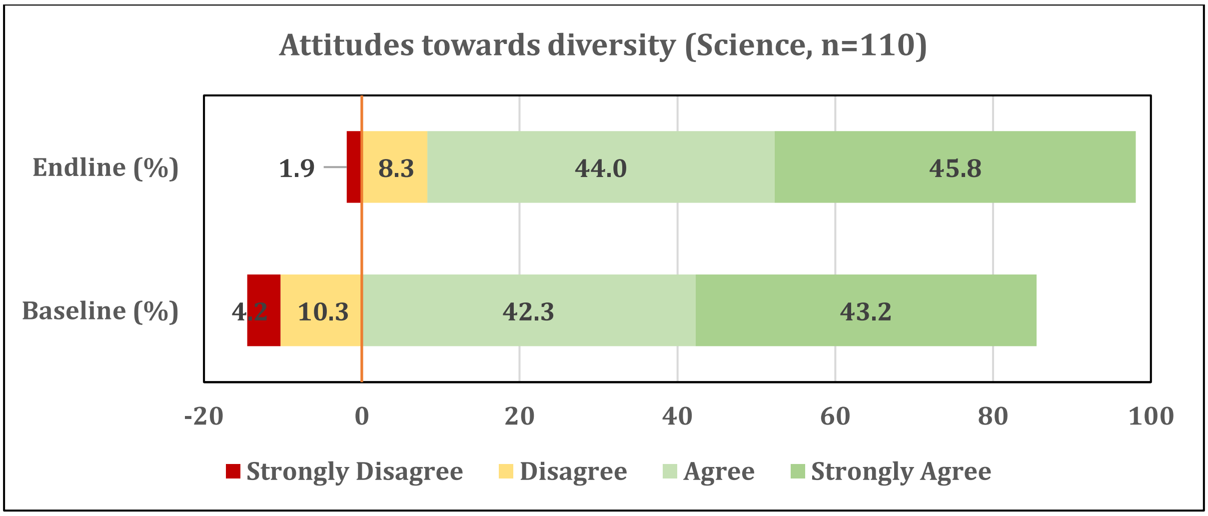
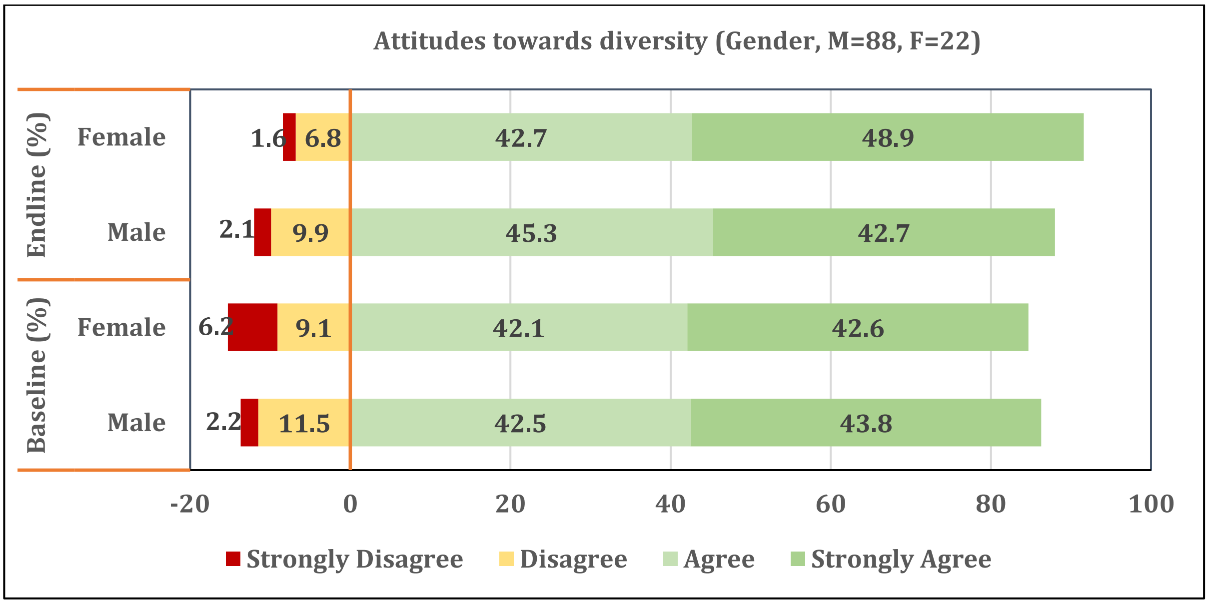


Figure 3.2.13 *Gender-Based Attitudes Towards Valuing Students' Diversity as a Resource in Teaching Science.*



Key Findings: Overall, the findings underline a broad consensus among science teachers that diversity and inclusion are valuable components of effective teaching and learning. The positive shift in attitudes, particularly among female teachers, suggests an increasing recognition of the social and academic benefits of inclusion and its potential to enhance teaching effectiveness. These trends affirm the importance of fostering supportive attitudes towards diversity in educational settings and highlight the growing commitment of teachers to embrace inclusion in their classrooms.

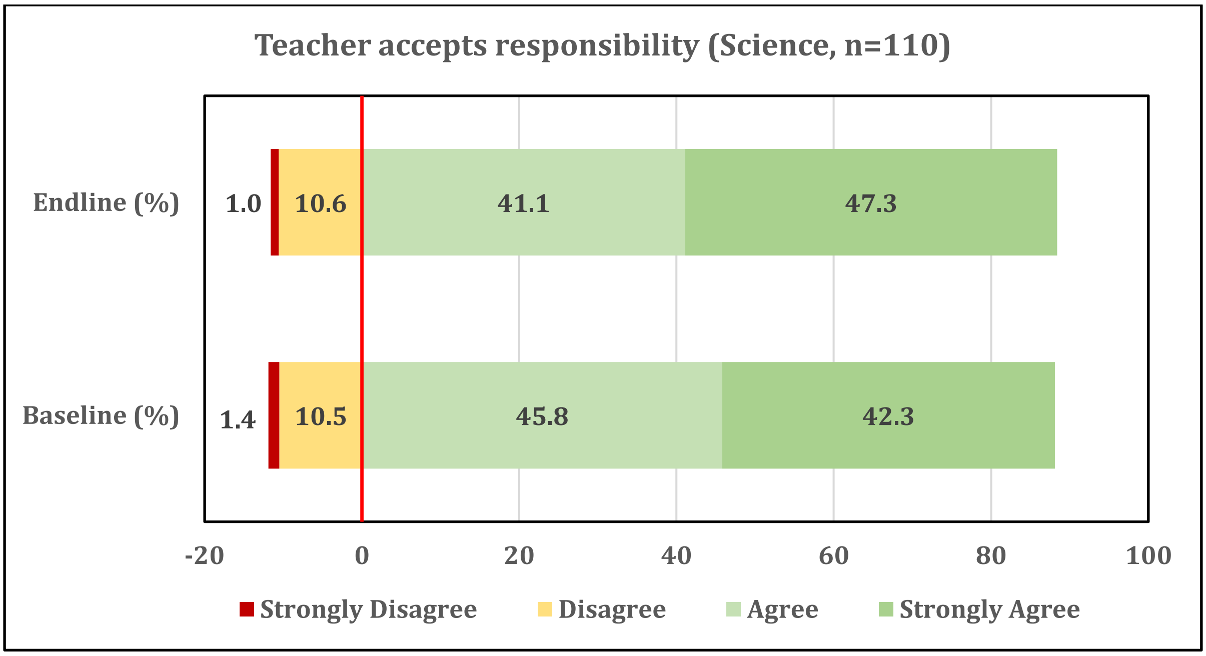
3.2.7 Teacher Accepts Responsibility

Figures 3.2.14 and 3.2.15 illustrate the trend of positive attitudes of science teachers towards accepting responsibility to meet diverse learners' needs through inclusive practices between the Baseline and Endline data.

Analysis: The survey results suggest that science teachers largely take responsibility for all students' learning and view learning challenges as professional opportunities rather than problems inherent to students. At both the Baseline and Endline, the majority of teachers agreed or strongly agreed with statements reflecting these beliefs. Over time, there was a slight shift from Agree to Strongly Agree, suggesting that teachers' commitment to inclusive education and their role in adapting the curriculum to meet different needs was strengthened. This shift signifies an increasing recognition of the importance of their role in promoting inclusive classrooms and addressing the needs of all learners.

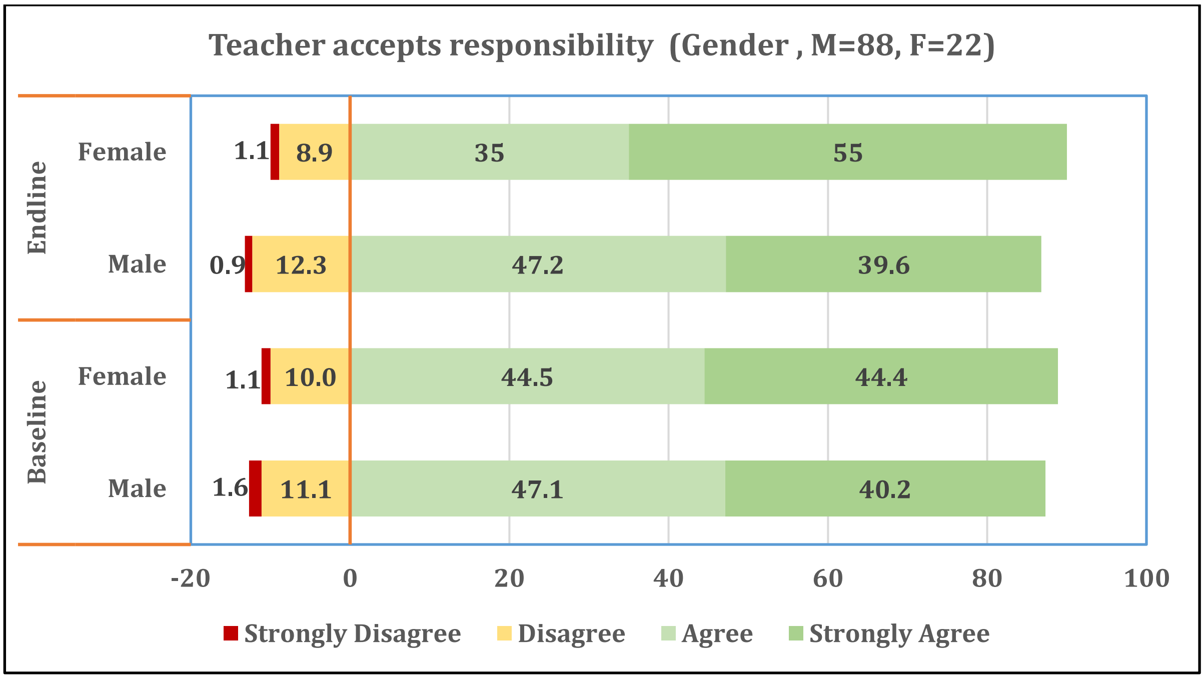
Comparing the Baseline and Endline data, the overall trend shows a slight decrease in the percentage of science teachers who agreed, from 45.8% to 41.1%, while the percentage who strongly agreed increased from 42.3% to 47.3%. This reflects a growing intensity with which teachers affirm their responsibility for student learning. Meanwhile, the percentage of teachers who strongly disagreed remained minimal, with a slight decline from 1.4% to 1.0%, and the percentage who disagreed remained stable at around 10.5% to 10.6%. These changes demonstrate an overall positive shift in teachers' attitudes, suggesting that more teachers are becoming strongly committed to inclusive practices and viewing learning difficulties as challenges that they can address through professional development and curriculum adaptation (Figure 3.2.14).

Figure 3.2.14 *Teacher Responsibility Acceptance in Science Teaching - Baseline and Endline Comparison (n=110)*



Trend in Gender: The gender analysis (Figure 3.2.15) revealed interesting differences in attitudes between male and female teachers. Male science teachers demonstrated stable attitudes over time, with minimal changes in their responses. At both the Baseline and Endline, 47.1% and 47.2% of male science teachers, respectively, agreed with the responsibility to adapt to diverse learners, while those who strongly agreed fell slightly from 40.2% to 39.6%. However, there was a more pronounced positive change among female science teachers. While the percentage of female science teachers who agreed decreased from 44.5% at the Baseline to 35.0% at the Endline, the percentage of those who strongly agreed increased significantly from 44.4% to 55.0%. This suggests that over time, female science teachers became more confident and committed to fulfilling their responsibilities in inclusive education, which could reflect both personal and professional growth in the field of inclusion.

Figure 3.2. 15 *Gender-wise (M=88, F=22) Analysis of Teachers' Acceptance of Responsibility in Science Teaching*



Key Findings: The findings show that science teachers, overall, accept responsibility for inclusive education and view diverse learning needs as professional challenges rather than student shortcomings. The shift from agree to strongly agree over time indicates a deepening commitment to inclusion. The gender-based differences suggest that female science teachers may have undergone a more significant transformation in their attitudes towards inclusive education, indicating a growing confidence in their ability to meet the needs of all students. These trends emphasise the importance of continued professional support to foster inclusive teaching practices and address gender-based variations in attitudes.

3.2.8 Summary (Survey Part II)

Survey Part II of the Baseline-Endline study reveals key shifts in science teachers' attitudes, beliefs, and practices. Overall, teachers showed a growing commitment to inclusive education, with an increasing number acknowledging the importance of adapting their teaching to meet the needs of diverse learners. Teachers' views on the nature of science became more aligned with contemporary educational standards, though female teachers showed a greater tendency to question scientific objectivity.

Attitudes towards teacher-directed, whole-group instruction for low-income students shifted, with male teachers becoming more open to this approach, while female teachers increasingly rejected it, favouring differentiated methods. Teachers generally held a positive belief in all students' ability to learn science, with female teachers showing a stronger shift towards a growth mindset.

While both male and female teachers recognised the importance of inclusive practices, male teachers showed more consistent support, while female teachers expressed growing skepticism, reflecting challenges in implementing inclusion effectively. Teachers continued to value the use of models and visual aids in science teaching, regardless of students' age or reasoning ability.

Teachers also expressed a greater appreciation for diversity as a resource in the classroom, particularly female teachers, who showed a marked increase in support for diversity. Finally, teachers’ sense of responsibility for meeting diverse learners’ needs grew over time, with female teachers demonstrating a more significant shift towards strong agreement.

In conclusion, the findings from Survey Part II reveal a positive shift in science teachers' attitudes, beliefs, and practices, particularly in areas of inclusive education, active learning, and the nature of science. While both male and female teachers demonstrated progress, gender-based differences were evident, with female teachers showing a more pronounced shift in areas such as growth mindset, attitudes towards diversity, and a sense of responsibility for meeting the needs of diverse learners. These findings emphasise the importance of professional development in supporting teachers to further enhance their practices and promote inclusive education for all students. Moreover, addressing gender perceptions and fostering inclusive teaching practices will be crucial in ensuring that science education remains accessible and effective for all learners.

Chapter 4: Mathematics Teachers' Knowledge, Attitude & Practice (Quantitative)

Chapter 4 presents the findings of Baseline-Endline Mathematics Surveys (CL4STEM Phase II Bhutan), which aimed to analyse various aspects of Mathematics teaching and learning, with a particular focus on active learning strategies, inclusive practices, and teachers' perceptions. The survey was organised into two parts, each evaluating distinct research parameters through a series of questions related to teaching resources, lesson characteristics, assessment methods, perceptions of diversity, and teacher responsibility. Key pedagogical considerations include the promotion of inclusion, the facilitation of higher-order thinking, and the provision of multiple modes of expression. Furthermore, the survey highlights fundamental Mathematical processes such as problem-solving, reasoning, communication, connections, and representations. The insights derived from this study will contribute to the advancement of inclusive and effective teaching practices, ensuring equitable learning opportunities for all students in Mathematics.

4.1 Baseline-Endline Mathematics Survey (Part I)

The Baseline-Endline Mathematics Survey (Part I) explores key aspects of Mathematics teaching and learning based on data collected from secondary Mathematics teachers. The survey analyses the resources used, lesson characteristics, and student assessment practices. It also examines teachers' perceptions of diversity, inclusion, and gender - taking into account students' socio-economic and linguistic backgrounds, learning abilities, and health needs. Additionally, the analysis considers teacher enthusiasm, perseverance, and beliefs about the learning potential of all genders, emphasising the value of diversity as a resource. The findings are derived through summarisation and demographic comparisons, providing insights into active learning strategies, inclusive practices, and diverse content representation.

4.1.1 Resources Used

The data presented in Table 4.1 shows the percentage distribution of Mathematics teachers' responses to various resources used in their teaching. These resources include: personal education in science and technology, the textbook or teaching materials associated with the curriculum, other school science textbooks, popular science magazines, articles and reports in newspapers, television programmes about science, the Internet, magazines and journals aimed at science teachers, real-life experiences of science outside the school, and current events related to science.

Analysis: The Analysis indicates an increase in the use of key resources by Mathematics teachers from Baseline to Endline. For example, the overall resource utilization, the percentage of Mathematics teachers identifying resources as a major source increased from 41% to 47%, reflecting a significant shift toward resource utilization. Conversely, the percentage of Mathematics teachers responses on "Do not have access" dropped sharply from 11.3% to 3.7%, indicating improved availability and integration of teaching learning materials.

Table 4. 1 *Resource Used in Relation to Active Learning Strategies at Baseline and Endline (n=35)*

Data type	Major source	Minor source	Not a source	Do not have access
Baseline (%)	41	40.3	7.4	11.3
Endline (%)	47	42	7.3	3.7

Trend in Gender: The gender-wise trend shows overall improvement in resource access for both male and female teachers from Baseline to Endline. Analysis evident that male teachers show a notable increase in major resource usage from 37.5% to 49.6%, accompanied by a significant decrease in lack of access from 12.5% to 4.6%. However, their reliance on resources as a minor source declined slightly. Female teachers maintained the same level of major resource use at 44.5%, but their use as a minor source increased from 37.3% to 44.5%, with a significant drop in lack of access from 10% to 2.7% (Table 4.2). This indicates that while male teachers showed greater improvement in major resource utilisation, female teachers benefited from improved access and diversified their resource use.

Table 4. 2 *Gender-wise Comparison of Resource Used (M=24, F=11)*

Data type	Major source (%)	Minor source (%)	Not a source (%)	Do not have access (%)
Baseline Male	37.5	43.3	6.7	12.5
Endline Male	49.6	39.6	6.2	4.6
Baseline Female	44.5	37.3	8.2	10
Endline Female	44.5	44.5	8.3	2.7

Key Findings: The overall findings indicate a positive trend in resource utilisation, with an increase in the use of key resources and a significant reduction in lack of access. This suggests improved availability and integration of teaching materials. Gender-wise, male teachers demonstrated greater improvement in major resource utilisation, while female teachers benefited from enhanced access and a more diversified use of available materials.

4.1.2 Characteristics of Mathematics Lesson

The data, derived from the Baseline and Endline study of Mathematics teachers, examines the characteristics of Mathematics lessons. It highlights various aspects of teaching and learning, including initiating new learning with real-world problems, fostering student discussions on problem-solving, encouraging careful listening and explaining of concepts, and promoting peer interactions to share and explain ideas. Additionally, it explores the use of examples from personal experience, the observation of problem-solving demonstrations, and the application of concepts to real-life scenarios. It also includes the exploration of patterns and the creation of formulas for solving mathematical problems.

Analysis: The Analysis indicates a slight increase in the percentage of teachers who always incorporate the discussed characteristics in their Mathematics lessons, from 37.1% at Baseline to 41.4% at Endline. Conversely, the percentage of teachers who rarely use these strategies decreased from 10.1% to 7.6%, while the percentage of teachers who never use them is now absent in the Endline data. This suggests a general positive shift in the implementation of these teaching practices (Table 4.3).

Table 4. 3 *Characteristics of Mathematics Lesson at Baseline and Endline (n=35)*

Data type	Always (%)	Frequently (%)	Rarely (%)	Never (%)
Baseline	37.1	52.6	10.1	0.2
Endline	41.4	51	7.6	-

Trend in Gender: The trend in gender shows a slight increase in the percentage of male teachers who always use the discussed teaching characteristics, rising from 34.2% at Baseline to 38.3% at Endline. Similarly, female teachers also experienced an increase in the "Always" category, from 40% at Baseline to 44.5% at Endline. For both genders, the percentage of teachers who rarely use these strategies decreased, with males dropping from 12.1% to 8.8%, and females from 8.2% to 6.4%. This suggests that both male and female teachers are increasingly adopting these practices in their classrooms.

Table 4. 4 *Gender Comparison of Characteristics of Mathematics Lesson (M=24, F=11)*

Data type	Always (%)	Frequently (%)	Rarely (%)	Never (%)
Baseline Male	34.2	53.3	12.1	0.4
Endline Male	38.3	52.9	8.8	-
Baseline Female	40	51.8	8.2	-
Endline Female	44.5	49.1	6.4	-

Key Findings: The data from the Baseline and Endline study indicates a positive shift in the adoption of key teaching characteristics among Mathematics teachers. Teachers are increasingly incorporating strategies such as using real-world problems, fostering peer discussions, and encouraging careful listening and explanation of concepts. The trend shows a decrease in the number of teachers who rarely use these strategies, reflecting a broader implementation of effective teaching practices.

Regarding gender, both male and female teachers have shown an increase in the consistent use of these characteristics. Both groups are using these strategies more frequently, with a reduction in the number of teachers who use them rarely. This suggests that both male and female teachers are adopting these practices more consistently in their classrooms.

4.1.3 Assessment of Student Learning

The survey data, derived from the Baseline and Endline study of Secondary Mathematics teachers, focuses on the theme of *Assessment of Student Learning.* It assesses the frequency of teachers use various methods to analyse student learning. These methods include developing and administering their own assessments, administering standardised tests, having students answer questions in front of the class, providing written feedback alongside numeric scores or letter grades, allowing students to evaluate their own progress, and observing students during tasks to offer immediate feedback.

Analysis: The Analysis indicates an increase in the frequency of practices related to student success in achieving learning goals between the Baseline and Endline studies.

Specifically, the percentage of teachers who reported using these practices frequently rose from 41.6% at Baseline to 50.3% at Endline, while those who reported using them "in all or nearly all lessons" decreased slightly from 21.3% to 19.5%. Conversely, the percentage of teachers who reported using these practices "never or almost never" dropped from 2.9% to 0.4%, and those using them "occasionally" decreased from 34.2% to 29.8%. This suggests that there was a general shift towards more consistent and frequent use of effective practices in the classroom. Overall, the data reflects a general improvement in assessment frequency, with a notable shift towards more consistent practices.

Table 4. 5 *Assessment of Student Learning in Mathematics (n=35)*

Data types	Never or Almost never (%)	Occasionally (%)	Frequently (%)	In all or nearly all lessons (%)
Baseline	2.9	34.2	41.6	21.3
Endline	0.4	29.8	50.3	19.5

Trend in Gender: Trends that are specific to gender (Table 4.6) draw attention to variations in assessment procedures. The percentage of male Mathematics teachers who use assessments frequently rose from 34.7% to 50.7%, while those who use occasionally fell from 47.2% to 34%, indicating a notable improvement. Their usage of assessments in "all or nearly all lessons" decreased marginally, though, from 15.3% to 14.6%. Use of assessments among female Mathematics teachers was consistently higher, as evidenced by the increase in the use of assessment frequently from 48% to 50%. While the percentage of female Mathematics teachers who use assessments in all or nearly all lessons decreased from 27.3% to 24.3% but it still remained significantly higher than that of male Mathematics teachers.

Table 4. 6 *Gender-Based Assessment of Student Learning in Mathematics (M=24, F=11)*

Data types	Always (%)	Frequently (%)	Rarely (%)	Never (%)
Baseline Male	2.8	47.2	34.7	15.3
Endline Male	0.7	34	50.7	14.6
Baseline Female	3	21.2	48.5	27.3
Endline Female	-	25.7	50	24.3

Key Findings: Overall, the findings indicate significant progress in integrating assessment into classroom practices, with a significant reduction in non-usage and increased frequently usage. Female Mathematics teachers maintained higher levels of integration, suggesting opportunities for targeted interventions to support male teachers in achieving similar levels of engagement.

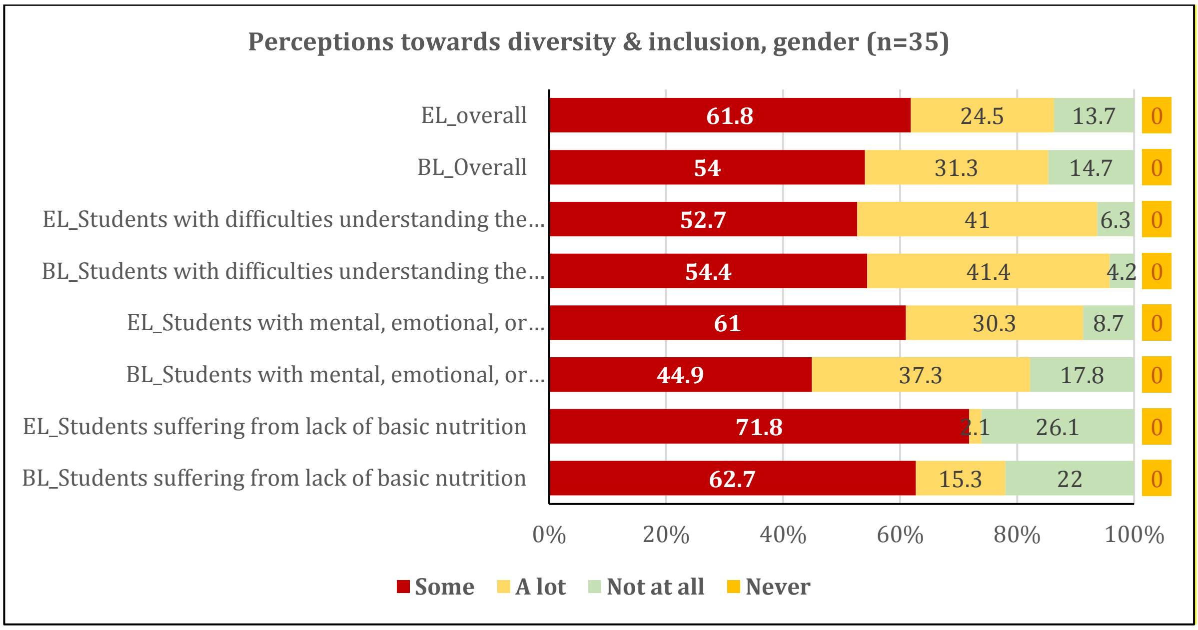
4.1.4 Perceptions towards Diversity, Inclusion and Gender

The survey examined Mathematics teachers' perceptions of diversity, inclusion and gender, focusing on challenges faced by students with inadequate nutrition, mental or emotional impairments, and language difficulties.

Analysis: The survey data (Figure 4.1) shows varying trends in Mathematics teachers' perceptions of diversity challenges. For students lacking basic nutrition, the percentage of Mathematics teachers who reported some increased from 62.7% Baseline to 71.8%

Endline, but those who responded a lot fell sharply from 15.3% to 2.1%, and "not at all" rose from 22% to 26.1%. Awareness of students with mental, emotional, or psychological impairments improved overall, with the percentage of Mathematics teacher reporting some increased from 44.9% to 61% and not at all dropped from 17.8% to 8.7%, though those who responded a declined from 37.3% to 30.3%. For students struggling with the language of instruction, the percentage of Mathematics teachers who reported a lot decreased slightly from 41.4% to 41%, but those who responded some fell from 54.4% to 52.7%, while those responding not at all rose slightly from 4.2% to 6.3%. These findings indicate progress in overall awareness but highlight a decline in deeper recognition for some challenges.

Figure 4. 1 *Mathematics Teachers' Perceptions towards Diversity, Inclusion and Gender*



Trend in Gender: Gender-specific (Table 4.7) findings reveal notable differences in perceptions. Among male Mathematics teachers, those who responded a lot increased slightly from 26.4% to 27.8%, but those responding some decreased from 62.5% to 56.9%. Additionally, the percentage of male teachers reporting not at all rose from 11.1% to 15.3%, suggesting a slight decline in sensitivity. In contrast, female Mathematics teachers showed significant progress. The percentage of female Mathematics teachers recognizing diversity challenges "some" of the time increased dramatically from 45.5% to 66.7%, while percentage of those reporting "not at all" decreased from 18.2% to 12.2%. However, the percentage of female Mathematics teachers who reported a lot of challenges saw a decline from 36.3% to 21.2%.

Table 4. 7 *Gender Perceptions towards Diversity, Inclusion and Gender (M=24, F=11)*

Data type	Always (%)	Frequently (%)	Rarely (%)	Never (%)
Baseline Male	62.5	26.4	11.1	-
Endline Male	56.9	27.8	15.3	-
Baseline Female	45.5	36.3	18.2	-
Endline Female	66.7	21.2	12.2	-

Key Findings: Overall, the findings suggest progress in general awareness of diversity and inclusion, with more teachers recognizing these challenges at some level. However, the decline in those who responded a lot and the slight increase in those who responded not at all underscore the need for sustained efforts to deepen teachers' understanding and actionable engagement. Addressing gender disparities in perceptions and providing training on specific challenges, such as mental health and language barriers, will be critical to fostering a more inclusive learning environment.

4.1.5 Teacher Enthusiasm/Perseverance/Perceptions

4.1.5.1 Sources of Success

This section assesses Mathematics teachers' perceptions of the factors they believe contribute to student success in achieving learning objectives. The survey investigates Mathematics teachers' views on various potential sources of success relative to students' background, intellectual ability, enthusiasm, and the teacher's role in providing effective instruction and attention to individual needs.

The survey (Table 4.8) results show a significant change in Mathematics teachers' perceptions of the sources of student success. The findings between Baseline and Endline show notable changes. Attributions to student-driven factors, particularly enthusiasm or perseverance increased significantly, reflecting a growing recognition of students' active role in their success. This factor increased from 37.6% at Baseline to 58.4% at Endline, while the attribution to intellectual ability fell from 17.5% to 6.7%. Conversely, teacher-driven factors saw a decline. The percentage of Mathematics teachers attributing success to effective teaching methods dropped from 26.2% to 15.8%, and those highlighting attention to students' unique needs fell from 16.6% to 12.4%. Teacher enthusiasm or perseverance saw a slight increase, rising from 2.1% to 6.7%.

Table 4. 8 *Teachers' Perceptions of the Sources of Student Success in Mathematics (n=35)*

Source of Success	Baseline (%)	Endline (%)
Student's home background	-	-
Student's intellectual ability	17.5	6.7
Student's enthusiasm or perseverance	37.6	58.4
Teacher's attention to the unique interests and abilities of students	16.6	12.4
Teacher's use of effective methods of teaching	26.2	15.8
Teacher's enthusiasm or perseverance	2.1	6.7

Trend in Gender: Gender-wise (Table 4.9), the percentage of male Mathematics who attributed success of students to their perseverance increased significantly from 20.8% at Baseline to 62.4% at Endline. Despite being consistent in attributing success to student perseverance (54% at Baseline and Endline) and the use of effective teaching methods (27.3% at Baseline and Endline), female Mathematics teachers demonstrated an increase in recognising teacher's perseverance or enthusiasm, increased from 0 to 9.1%. By the Endline, both male and female Mathematics teachers placed less value on the students' intellectual ability, with the decline being more pronounced for male Mathematics teachers.

Table 4.9 *Gender Differences in Teachers' Perceptions of the Sources of Student Success in Mathematics (M=24; F=11)*

Statements	Baseline Male (%)	Endline Male (%)	Baseline Female (%)	Endline Female (%)
Student's home background	-	-	-	-
Student's intellectual ability	16.7	4.2	18.2	9.1
Student's enthusiasm or perseverance	20.8	62.4	54.5	54.5
Teacher's attention to the unique interests and abilities of students	33.3	25.0	0.0	0.0
Teacher's use of effective methods of teaching	25.0	4.2	27.3	27.3
Teacher's enthusiasm or perseverance	4.2	4.2	0.0	9.1

Key Findings: Study indicates a shift in perceptions of student success from teacher-driven to student-driven factors, with student enthusiasm and perseverance emerging as key contributors. This reflects a move away from fixed notions of intellectual ability towards valuing effort and persistence. The declining emphasis on teacher-driven factors, such as instructional methods and individualised attention, suggests a need to reassert the teacher's role in fostering student success. Gender differences reveal that male Mathematics teachers prioritise student perseverance, while female teachers increasingly recognise the importance of both teacher enthusiasm and student effort. These insights highlight the need to balance student agency with inclusive teaching practices to support all learners effectively.

4.1.5.2 Sources of Failure

The survey, which compares Baseline and Endline data, explores perceptions of Secondary Mathematics teachers regarding the sources of student failure in achieving intended goals or objectives. Teachers were asked to identify the most frequent cause of failure from a range of options, including factors related to the student's home background, intellectual ability, motivation, as well as various aspects of teacher effectiveness and engagement. This theme highlights the impact of both student and teacher-related factors in shaping student success, with a particular focus on diversity, inclusion, and gender.

Analysis: The survey revels significant changes in Mathematics teachers' perceptions of the most common sources of student failure. The most commonly mentioned factor across the Baseline and Endline was students' indifference or lack of perseverance, which increased slightly from 44% to 48.1%. It's interesting to note that the percentage of Mathematics teachers who were attributed to lacking intellectual capacity fell 15.4% to 0%. This indicates a shift away from rigid ideas of innate ability and toward valuing hard work and perseverance. No Mathematics teacher at either Baseline or Endline consistently blamed students' failure on their home backgrounds, demonstrating a common belief in the ability to overcome outside obstacles through successful teaching strategies.

Teacher-related factors (Table 4.10) showed notable changes. The attribution to teachers' failure to use effective teaching methods rose significantly, from 8.7% to 35.3%, suggesting a growing recognition of pedagogical practices' importance in addressing student challenges. In contrast, teacher failure to consider unique student interests and abilities saw a decline, from 23.2% at Baseline to 16.6% at Endline. At the same time, the percentage of Mathematics teachers attributing failure to teacher indifference or lack of perseverance dropped from 8.7% to 0%, indicating an increased acknowledgment of the critical role of teacher engagement and effort.

Table 4.10 *Teachers' Perceptions of the Sources of Student Failure in Mathematics (n=35)*

Source of Failure	Baseline (%)	Endline (%)
Student's home background	-	-
Students' lack of intellectual ability	15.4	-
Students' indifference or lack of perseverance	44	48.1
Teacher's failure to consider the unique interests and abilities of students	23.2	16.6
Teacher's failure to use effective methods of teaching	8.7	35.3
Teacher's indifference or lack of perseverance	8.7	-

Trend in Gender: Gender-specific findings (Table 4.11) provide additional insights. Among male Mathematics teachers, there was a decrease in attributing failure to students' lack of intellectual ability, from 12.5% to 0%, while recognition of teaching methods increased from 8.3% to 25%. There was dramatic increase in female Mathematics teachers attributing failure to use effective teaching methods, from 9.1% to 45.5%, while maintaining a consistent emphasis on students' lack of perseverance (54.5% at both Baseline and Endline). These trends reflect a growing consensus among both male and female Mathematics teachers on the importance of student effort and effective pedagogical strategies.

Table 4.11 *Gender Differences in Teachers' Perceptions of the Sources of Student Success in Mathematics (M=24; F=11)*

Statements	Baseline Male (%)	Endline Male (%)	Baseline Female (%)	Endline Female (%)
Student's home background	-	-	-	-
Students' lack of intellectual ability	12.5	-	18.2	-
Students' indifference or lack of perseverance	33.4	41.6	54.5	54.5
Teacher's failure to consider the unique interests and abilities of students	37.5	33.4	9.1	-
Teacher's failure to use effective methods of teaching	8.3	25.0	9.1	45.5
Teacher's indifference or lack of perseverance	8.3	-	9.1	-

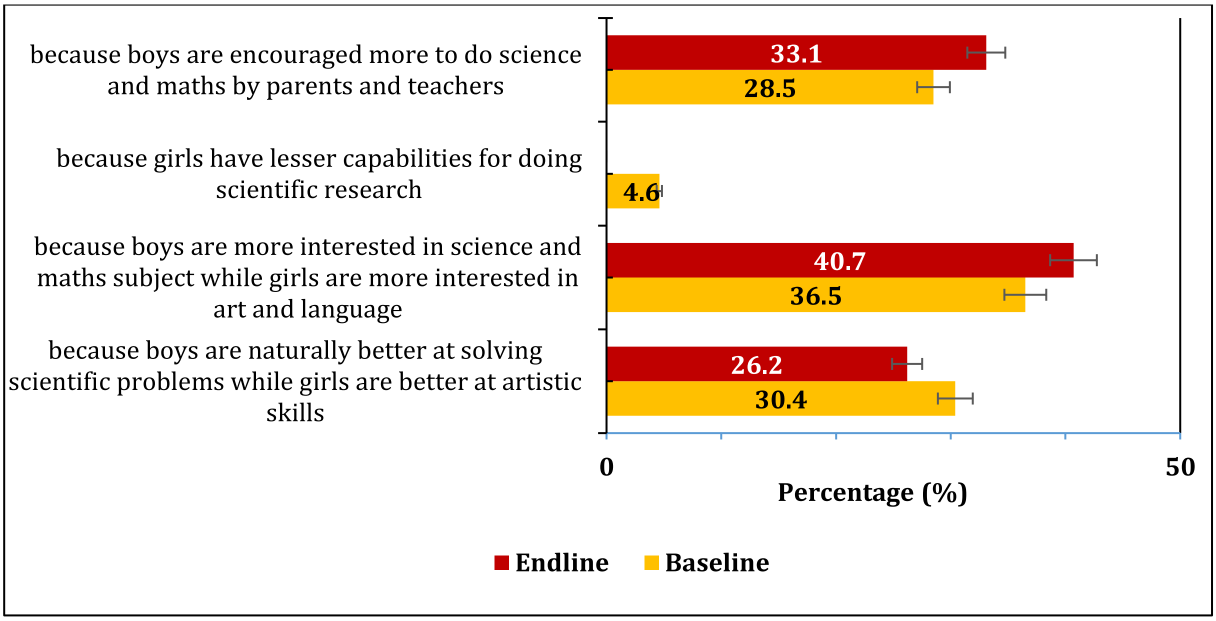
Key Findings: Overall, the findings emphasise a shift in focus from fixed student characteristics to dynamic factors like effort, perseverance, and teacher effectiveness. Mathematics teachers are placing increasing emphasis on inclusive practices and recognising the potential for all students to succeed with appropriate supports and practices. This evolving perspective highlights the need for a balanced approach that recognises both student agency and the critical role of effective teaching in promoting success.

4.1.6 Perceptions Towards all Genders Can Learn

Analysis: The survey data (Figure 4.2) reveals Mathematics teachers' perceptions of the gender disparity in students opting for engineering field, reflecting both persistent gender stereotypes and evolving views. When asked why boys make up a greater percentage of engineering graduates than girls, responses were divided among various factors. At Baseline, 30.4% of Mathematics teachers believed boys are naturally better at solving scientific problems compared to girls being better at artistic skills. By the Endline, this percentage declined slightly to 26.2%, suggesting a gradual shift away from biological determinism. Similarly, the attribution that girls have lesser capabilities for scientific research dropped from 4.6% to 0%, reflecting a significant reduction in overt bias about intellectual potential.

A consistent and slightly growing number of Mathematics teachers attributed the disparity to boys being more interested in science and math subjects (36.5% at Baseline to 40.7% at Endline). This suggests that some gendered assumptions about academic interests persist, although societal and cultural influences are increasingly recognized. The percentage of Mathematics teachers acknowledging the role of encouragement by parents and teachers rose from 28.5% at Baseline to 33.1% at Endline. This indicates a growing awareness of how external support and societal expectations influence students' academic and career choices.

Figure 4.2 *Teachers' Perceptions on Gender Disparities in Students Opting Engineering field (n=35)*



Trend in Gender: Gender-specific findings (Table 4.12) offer further insights. Male Mathematics teachers were more likely to believe boys are naturally better at scientific problem-solving and more interested in science and Mathematics, with 33.4% of male Mathematics attributing the disparity to natural aptitude of boys and girls at Baseline and 25% at Endline. Female Mathematics teachers, on the other hand, placed more emphasis on the role of encouragement, with 36.3% at Baseline and 45.4% at Endline attributing the gender gap in students opting for engineering filed to the support boys receive from parents and teachers. By the Endline, both male and female Mathematics teachers completely rejected the idea that girls have lesser scientific capabilities, underscoring a positive shift in perceptions.

Table 4.12 *Gender Differences in Teachers' Perceptions on Gender Disparities in Students Opting Engineering Field (n=35)*

Statements	BL_ Male (%)	EL_ Male (%)	BL_Female (%)	EL_Female (%)
Boys are naturally better at solving scientific problems while girls are better at artistic skills	33.4	25.0	27.3	2.7.3
Boys are more interested in science and maths subject while girls are more interested in art and language	45.8	54.2	27.3	27.3
Girls have lesser capabilities for doing scientific research	-	-	9.1	-
Boys are encouraged more to do science and Mathematics by parents and teachers	20.8	20.8	36.3	45.4

Note: BL-Baseline, EL-Endline

Key Findings: Overall, the findings highlight a gradual but notable shift in teachers' perspectives toward acknowledging the influence of societal and educational factors on academic outcomes. While some gendered perceptions of interest and ability persist, the increased recognition of the role of encouragement and the rejection of stereotypes about girls' capabilities point to a more inclusive and supportive view of learning potential. These evolving perceptions suggest an opportunity for targeted interventions to address gender biases and promote equal opportunities for students across all academic fields.

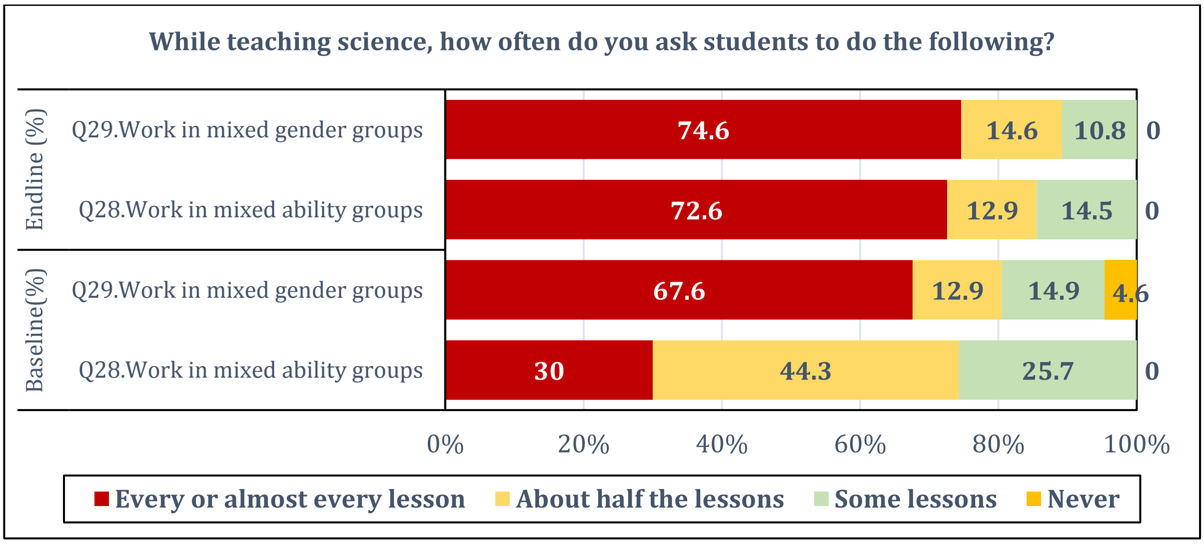
4.1.7 Value Diversity as a Resource

The survey (Figure 4.3) shows significant improvements in Mathematics teachers' practices of encouraging students to work in diverse groups. The use of mixed-ability and mixed-gender groupings increased significantly from Baseline to Endline, reflecting an increased commitment to inclusion and collaboration in classroom. Mathematics teachers gradually recognised the importance of such strategies in catering to diverse learning needs and promoting equity among students. Female Mathematics teachers made the most progress in adopting these practices, underscoring their growing commitment to inclusive education.

For mixed-ability groups, the percentage of teachers who used this strategy in "every or almost every lesson" increased dramatically from 30% at Baseline to 72.6% at Endline. At the same time, the percentage of Mathematics teachers using this method in "about half the lessons" fell from 44.3% to 12.9%. The percentage of Mathematics teachers using mixed-ability groupings in "some lessons" also fell from 25.7% to 14.9%, indicating a shift towards more consistent implementation of this approach.

For mixed-gender groups, the use in "every or almost every lesson" grew slightly, from 67.6% to 74.6%, while those employing this method "about half the lessons" increased from 12.9% to 14.6%. The percentage of Mathematics teachers using this strategy in "some lessons" decreased from 14.9% to 10.8%, and the percentage of Mathematics teachers who "never" used mixed-gender groups dropped to 0%, reflecting universal adoption by the Endline.

Figure 4.3 *Mathematics Teachers Perception on Using Mixed-Ability and Mixed-Gender Groupings (n=35)*



Trend in Gender: Among male Mathematics teachers, the percentage who consistently use diverse grouping increased from 52% to 56.3%, with a significant decrease among those who "rarely" use these methods, from 27.1% to 20.8%. Female Mathematics teachers showed exceptional progress, with the percentage of who "always" implemented different groupings increasing sharply, from 45.5-4% at the Baseline to 90.9% at the end (Table 4.13). At the same time, the proportion of female teachers who "rarely" or "never" use these practices decreased significantly, further highlighting their growing importance of inclusivity.

Table 4.13 *Trend in gender in Frequency of Using Mixed-Ability and Mixed-Gender Groupings (M=24; F=11)*

Data type	Every or almost every lesson (%)	About half the lessons (%)	Some lessons (%)	Never (%)
Baseline_Male	52.0	20.9	27.1	-
Endline_Male	56.3	22.9	20.8	-
Baseline_Female	45.4	36.3	13.7	4.6
Endline_Female	90.9	4.6	4.5	-

Key Findings: Overall, the findings demonstrate progress in promoting inclusive teaching practices aligned with the goals of believing that all children can learn, accepting responsibility to meet diverse needs, and valuing diversity as a resource. The increasing use of mixed-ability and mixed-gender groups underscore Mathematics teachers' commitment to promoting equity and collaboration in their classrooms. While male Mathematics teachers saw consistent improvements, female Mathematics teachers showed a particularly notable change, reflecting their increased focus on leveraging diversity to support student success. These findings highlight the positive impact of inclusive strategies on creating equitable learning environments and offer a foundation for further progress in addressing diverse student needs.

4.1.8 Summary

The findings of Mathematics Survey (Part I) indicate a positive trajectory in the use of teaching resources, lesson characteristics, student assessment practices, and perceptions of diversity and inclusion among Secondary Mathematics teachers. There has been a notable increase in resource utilisation, with improved access and integration of key materials, alongside gender-specific trends reflecting diverse adoption patterns.

The adoption of effective teaching practices has shown steady improvement, with more teachers incorporating student-centred strategies such as real-world problem-solving and peer interactions. Gender-based analysis suggests both male and female teachers are increasingly embracing these methodologies, though at varying rates.

Assessment practices have evolved towards greater consistency and frequency, reflecting a shift towards more structured and student-focused evaluation methods. Female teachers maintained a higher level of assessment integration, highlighting areas for targeted professional development among male teachers.

In terms of diversity and inclusion, while awareness has improved, variations in recognising specific challenges persist, indicating the need for sustained efforts to deepen teachers' understanding. Gender-specific findings suggest female teachers have made more significant progress in acknowledging diversity-related issues.

Teachers' perceptions of student success and failure have shifted towards a greater emphasis on student agency, with an increasing recognition of perseverance and effort as critical success factors. However, the declining attribution to teacher-driven factors suggests the need to reinforce the role of instructional practices in fostering achievement.

Finally, the study highlights progress in promoting inclusive classroom environments through the adoption of mixed-ability and mixed-gender groupings. While male teachers demonstrated steady progress, female teachers exhibited a more pronounced commitment to fostering inclusive practices.

Overall, the findings emphasise the importance of continued professional development and educational interventions to support Mathematics teachers in sustaining and expanding these positive trends.

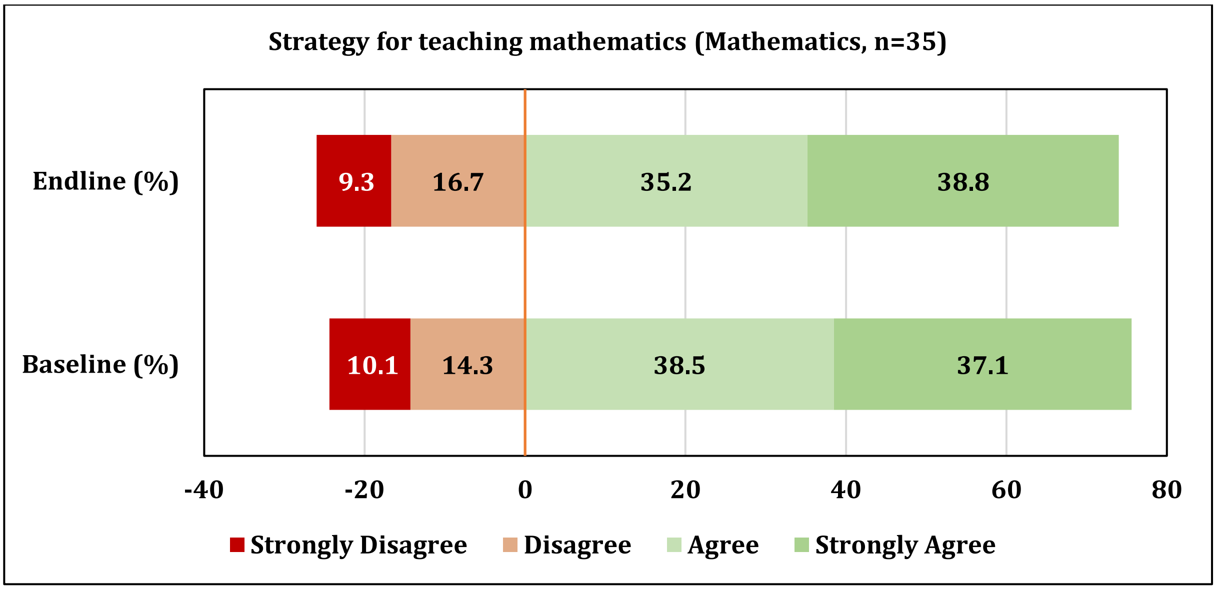
4.2 Baseline-Endline Mathematics Survey (Part II)

The Baseline-Endline Mathematics Survey Part 2 aims to assess various aspects of teaching and learning in Mathematics. The survey addresses key parameters such as teaching strategies, lesson characteristics, student learning assessment, and learner background. Key themes include the value of active learning, inclusive practices, and the acceptance of diverse learner needs. The survey also explores educators' attitudes towards growth versus fixed mindsets, gender, and diversity. Data will be analysed through summarisation and comparison across different demographic parameters, with a focus on recognising socio-economic, linguistic, and health needs, and valuing diversity as a resource. The results are expected to highlight the extent to which educators align with current best practices and inclusive pedagogies in Mathematics education.

4.2.1 Strategy for Teaching Mathematics

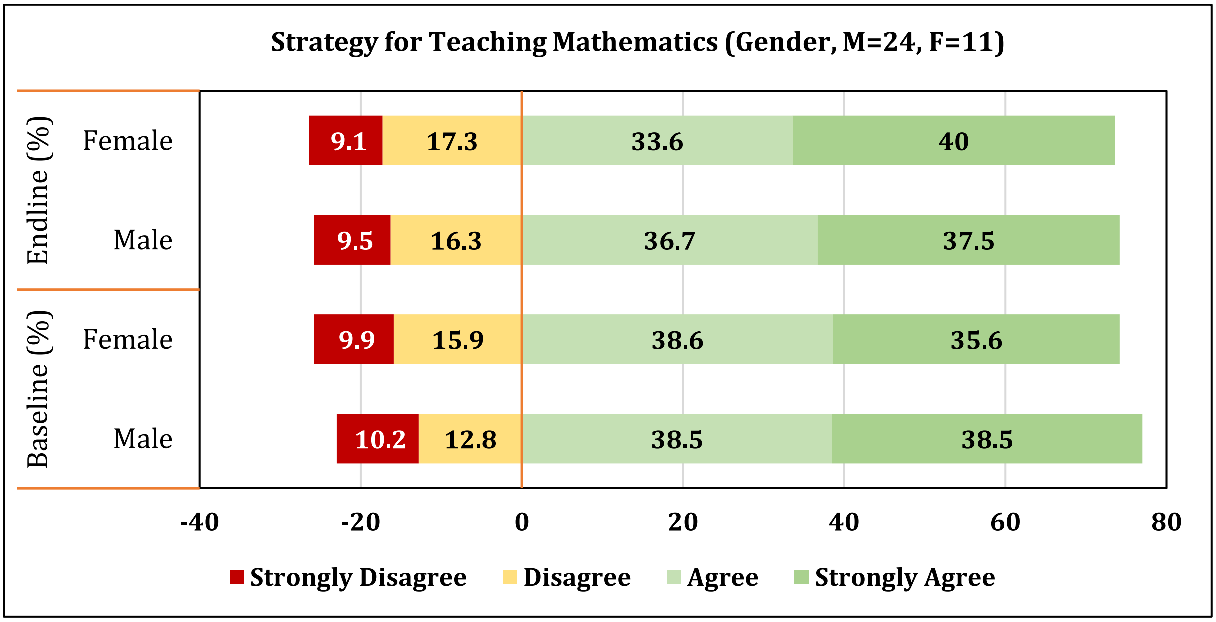
Analysis: The data (Figure 4.4) on teaching strategies suggests a shift towards more active learning and a greater emphasis on student engagement. From Baseline to Endline, there was a slight increase in the percentage of Mathematics teachers who strongly agreed with these approaches (from 37.1% to 38.8%) and a slight decrease in the percentage of Mathematics teachers who agreed (from 38.5% to 35.2%). This suggests a gradual alignment with contemporary educational practices, with an emphasis on student engagement, use of concrete materials, and valuing student contributions. However, there is a slight increase in the percentage of Mathematics teachers who disagree (from 14.3% to 16.7%), suggesting that some still follow more traditional approaches. This highlights the need for further integration of active learning principles.

Figure 4.4 *Overall Mathematics Teachers' Attitudes on the Strategy for Teaching Mathematics between Baseline and Endline.*



Trend in Gender: The gender responses (Figure 4.5) reveal some nuanced differences. Male Mathematics teachers strongly agreeing with these approaches saw a slight decrease from 38.5% at the Baseline to 37.5% at the Endline, along with a slight increase in disagreement percentages for both male and female Mathematics teachers. Female Mathematics teachers saw a larger increase in strong agreement (from 35.6% to 40.0%) and disagreement (from 15.9% to 17.3%). This suggests that female Mathematics teachers may be more open to modern teaching practices, particularly in areas such as student engagement and active learning strategies. Both genders appear to be increasingly aware of the importance of engaging students through methods such as group work, the use of concrete materials, and understanding student misconceptions.

Figure 4.5 *Gender-wise Mathematics Teachers' Attitudes on the Strategy for Teaching Mathematics between Baseline and Endline*



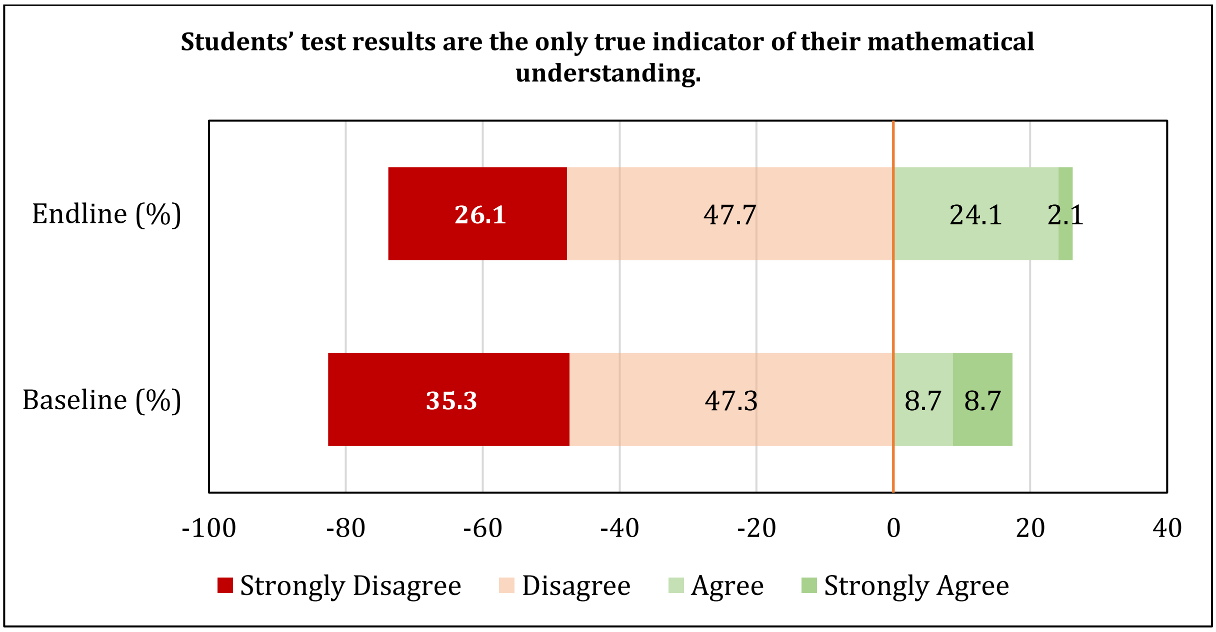
Key Findings: Overall, the trend reflects a shift toward active learning strategies, with more Mathematics teachers advocating methods that promote student engagement, collaboration, and the use of concrete materials for conceptual understanding. Despite these positive changes and the fact that a significant percentage of teachers agree with modern approaches, some are still reluctant to fully embrace them, as shown by the increased percentage of Mathematics teachers who disagree with them. The data also shows that female teachers are more likely than male Mathematics teachers to adopt modern teaching strategies, although both groups show growing support for engaging and interactive learning environments.

4.2.2 Assessment of Student Learning

The survey examines Mathematics teachers' perceptions of whether students' test scores are the only true indicator of their mathematical understanding.

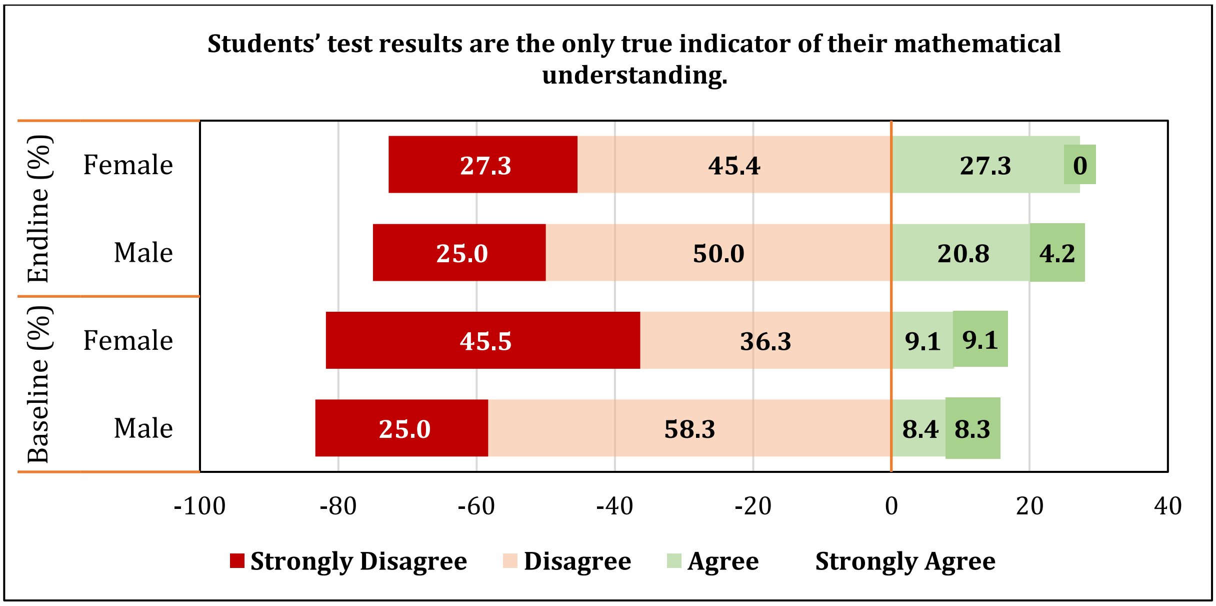
Analysis: The Analysis in Figure 4.6 indicates a shift in teachers' perceptions away from viewing test results as the sole measure of students' Mathematical understanding. The proportion of teachers who strongly disagree with the statement decreased from 35.3% at Baseline to 26.1% at Endline, while those who agree increased from 8.7% to 24.1%, showing a clear preference for more comprehensive assessment approaches. This finding suggests a growing recognition of alternative indicators of Mathematical understanding beyond test results.

Figure 4.6 *Overall Mathematics Teachers' Perception of Test Results as only True Indicator of Mathematical Understanding (n=35)*



Trend in Gender: The overall gender trend reveals that most Mathematics teachers continue to reject the notion that test results are the sole indicator of mathematical understanding. While initial disagreement was higher among female teachers (45.5%) compared to males (25%), this gap narrowed by the Endline, with female disagreement decreasing to 27.3% (Figure 4.7).

Figure 4.7 *Gender-wise Mathematics Teachers' Perception of Test Results as only True Indicator of Mathematical Understanding (Gender, M=24, F=11).*

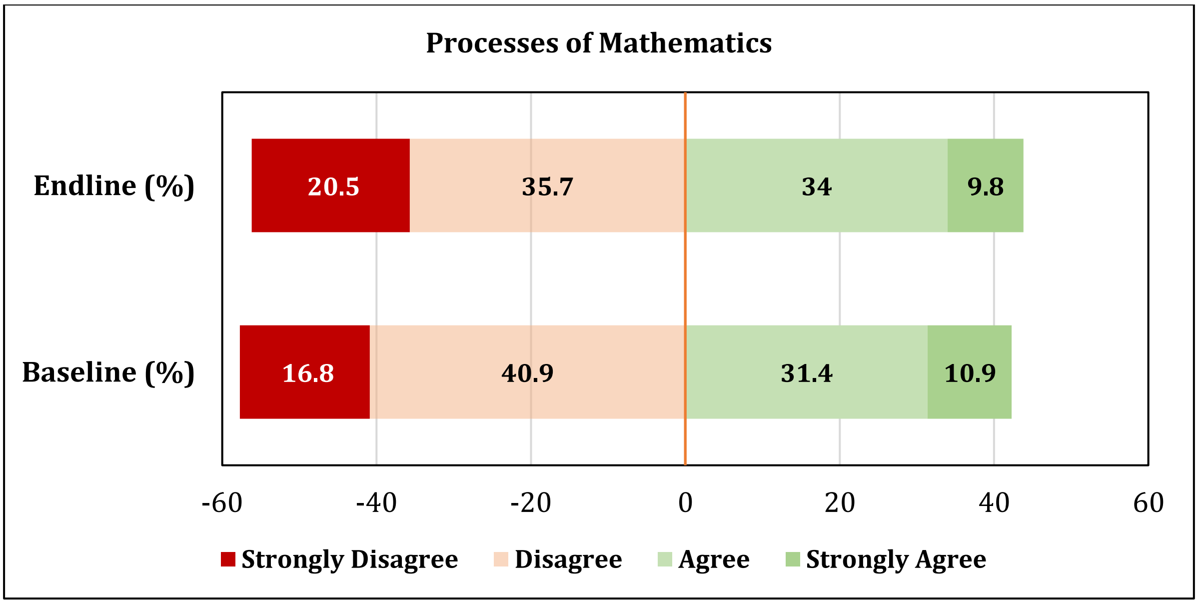


Key Findings: The Analysis in the findings indicates a shift in Mathematics teachers' perceptions, moving away from an exclusive reliance on test results to assess students' mathematical understanding. This suggests an increasing acceptance of alternative assessment methods beyond traditional test scores. Similarly, the gender-based trend reveals that female teachers initially demonstrated stronger disagreement (45.5%) compared to their male counterparts (25%). However, this gap narrowed at Endline, with female disagreement decreasing to 27.3%. These findings highlight a broader shift in educational perspectives, with Mathematics teachers increasingly recognising the value of diverse assessment strategies to more comprehensively evaluate students' mathematical abilities.

4.2.3 Process of Mathematics

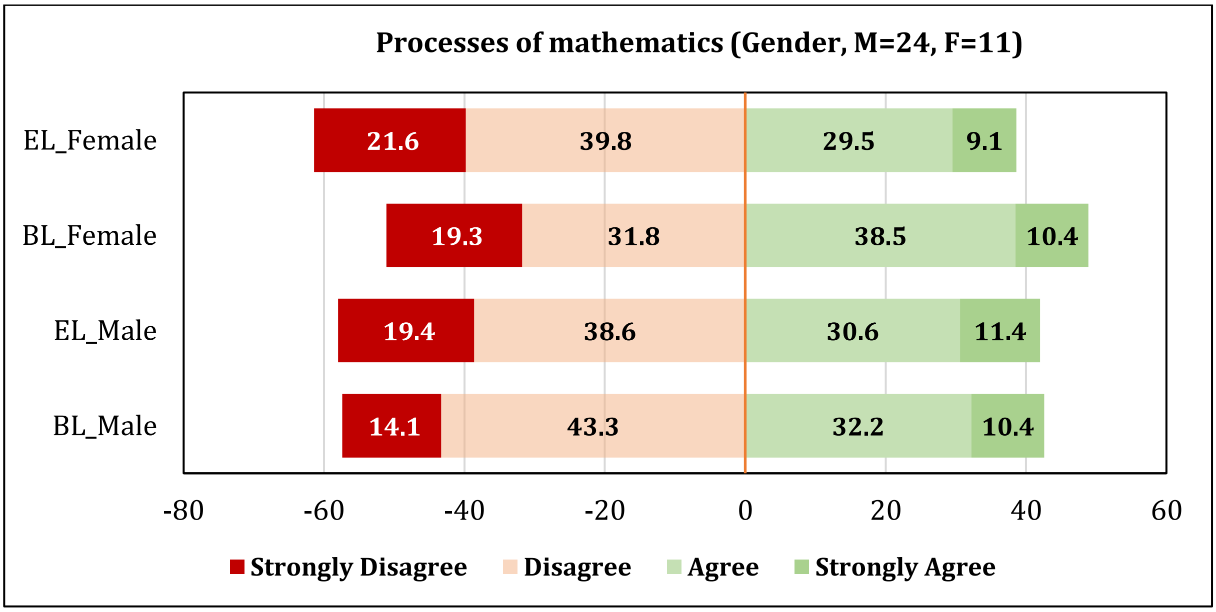
Analysis: The survey data on Mathematics teachers' beliefs reveals a notable increase in the acceptance of contemporary educational practices, such as valuing reasoning and acknowledging the evolving nature of Mathematics (Figure 4.8). This shift is evident in the growing rejection of traditional views, including the emphasis on rote memorization and the belief in solely right or wrong answers. The percentage of Mathematics teachers strongly disagreeing with these traditional views increased from 16.8 at Baseline to 20.5% at Endline. Moreover, the percentage of Mathematics teachers agreeing with progressive views rose from 31.4% to 34.0%, indicating a broader acceptance of modern beliefs, though the proportion of those strongly agreeing remained relatively stable.

Figure 4.8 *Overall attitudes of Mathematics teachers on the Nature of Science Between Baseline and Endline (n=35)*



Trend in Gender: Gender-wise analysis (Figure 4.9) shows male Mathematics teachers exhibited a more pronounced shift towards progressive beliefs, with a decrease in disagreement (from 43.2% to 38.6%) and a significant increase in strong disagreement with traditional views (from 14.1% to 19.4%). Female Mathematics teachers, while initially are more aligned with progressive views, demonstrated a slight increase in strong disagreement (from 19.3% to 21.6%) and a slight decrease in agreement (from 38.5% to 29.5%), suggesting a subtle shift towards stronger rejection of outdated views.

Figure 4.9 *Gender-wise Comparison of Teachers' Attitudes Towards the Process of Mathematics, with Gender Differences at Baseline and Endline*



Key Findings: Overall, these findings suggest that both male and female Mathematics teachers increasingly embraced modern pedagogical approaches, particularly regarding the dynamic and evolving nature of Mathematics. While the gender-based differences in attitude shifts were minimal, female Mathematics teachers appeared to consistently reject traditional practices more than their male counterparts. Despite these positive changes, some resistance to fully embracing contemporary views remains, indicating the need for continued efforts to promote reasoning, intuition, and flexibility in Mathematics education, especially among male Mathematics teachers.

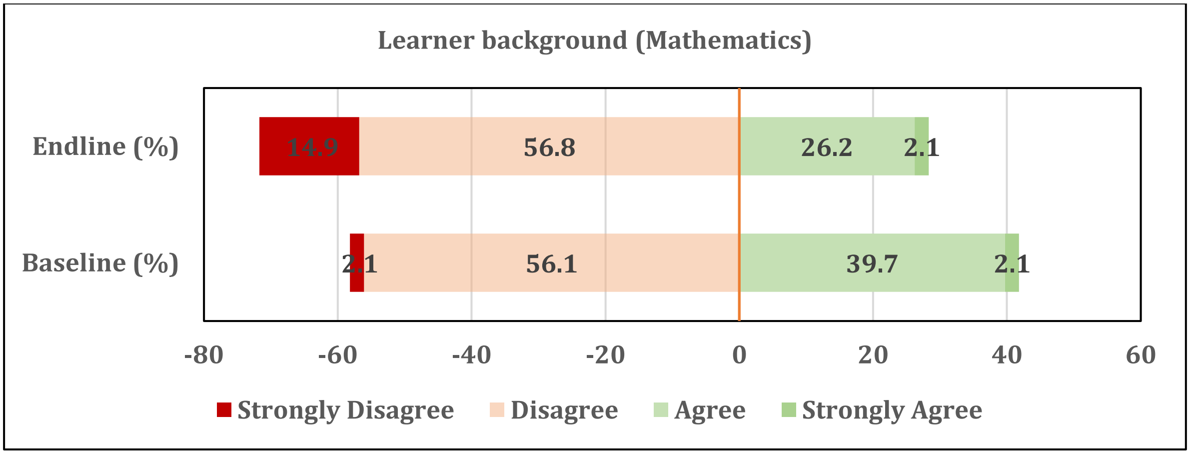
4.2.4 Learner Background

This section assesses the Mathematics teachers' perceptions of instructional approaches for students from low-income families, specifically regarding whether teacher-directed, whole-group instruction should be the primary method. The data compares trends from the Baseline and Endline studies, including gender-specific trends, to assess changes in teachers' views over time.

Analysis: At the Baseline, the proportion of Mathematics teachers who agreed or strongly agreed with the statement that teacher-directed, whole-group instruction should be the primary method was 42.8% (39.7% agreeing + 2.1% strongly agreeing). This suggests that a significant portion of teachers initially supported this method. However, by the Endline, the percentage of teachers who agreed or strongly agreed with the statement declined to 28.3% (26.2% agreeing + 2.1% strongly agreeing), indicating a noticeable decrease in support for teacher-directed instruction over time (Figure 4.10).

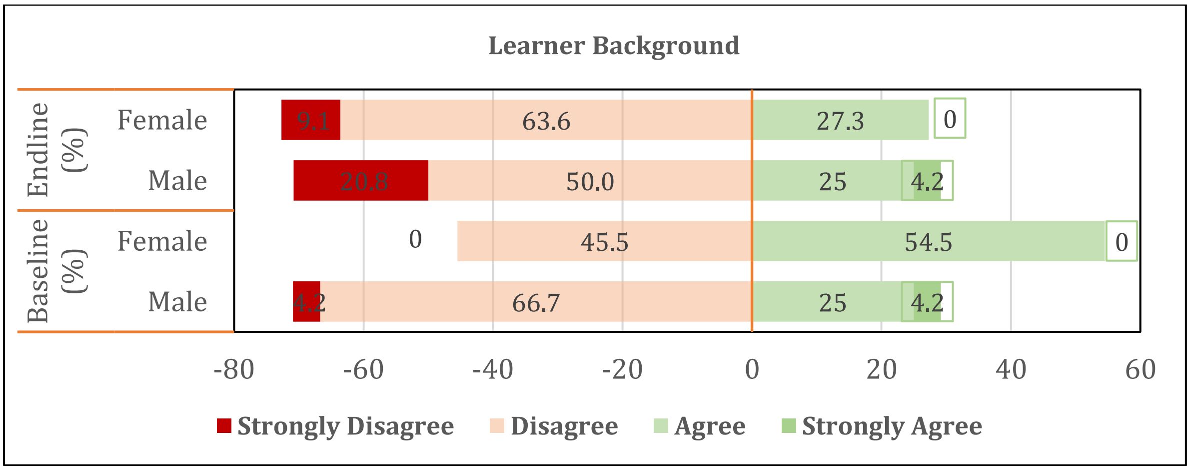
Conversely, the percentage of teachers who disagreed or strongly disagreed with the statement increased substantially, from 58.2% at Baseline (56.1% disagreeing + 2.1% strongly disagreeing) to 71.7% at Endline (56.8% disagreeing + 14.9% strongly disagreeing) (Table 4.10). This shift reflects a growing dissatisfaction with or critical stance towards teacher-directed, whole-group instruction. The marked increase in strong disagreement suggests that more teachers have come to recognise the limitations of this approach, particularly in diverse classrooms with students from low-income backgrounds.

Figure 4.10 *Mathematics Teachers' Attitudes Towards Student Background at Baseline and Endline (n=35)*



Trend in Gender: Gender-wise (Figure 4.11), distinct trends emerged among male and female Mathematics teachers. Among males, those strongly disagreeing increased significantly from 4.2% at Baseline to 20.8% at Endline, while disagreement decreased from 66.7% to 50%. Agreement and strong agreement remained stable at 25% and 4.2%, respectively. In contrast, female teachers experienced a drop in agreement from 54.5% to 27.3%, while disagreement rose from 45.5% to 63.6%. Notably, female teachers strongly disagreeing increased from 0% to 9.1%. These shifts suggest a growing recognition of the need to move beyond teacher-directed strategies for low-income students. Male teachers showed a stronger rejection of whole-group instruction, with a notable 16.6% increase in strong disagreement. Female teachers, however, exhibited a larger decrease in agreement (27.2%), reflecting changing attitudes. Despite these changes, some teachers continue to support teacher-directed methods, highlighting divergent views within the teaching community.

Figure 4. 11 *Gender-wise Mathematics Teachers' Attitudes Towards Student Background at Baseline and Endline (M=24; F=11)*



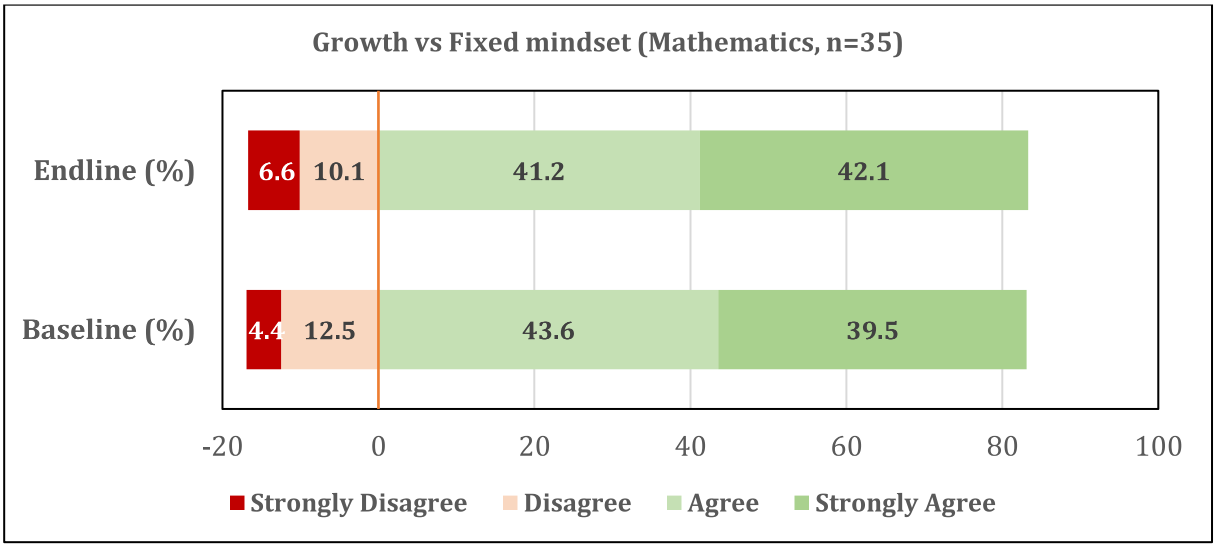
Key Findings: The findings reveal a significant shift in Mathematics teachers' perceptions of teacher-directed, whole-group instruction for low-income students. Overall, support for this method declined over time, with an increasing number of teachers expressing disagreement, indicating growing dissatisfaction with its effectiveness. Gender differences emerged, with male teachers showing a stronger rejection of teacher-directed instruction, marked by a notable rise in strong disagreement, while female teachers experienced a larger decrease in agreement and an increase in disagreement, reflecting evolving attitudes. Despite these trends, a subset of teachers continued to support teacher-directed methods, suggesting a diversity of perspectives within the teaching community regarding instructional approaches.

4.2.5 Growth vs Fixed-Mindset

This data assesses the Mathematics teachers' Growth vs. Fixed-mindset in relation to key beliefs about student success in Mathematics Education. The survey focused on statements such as the importance of effort versus natural ability, the potential to learn advanced science disciplines with full effort, and the role of hard work, confidence, and interest in excelling at Mathematics.

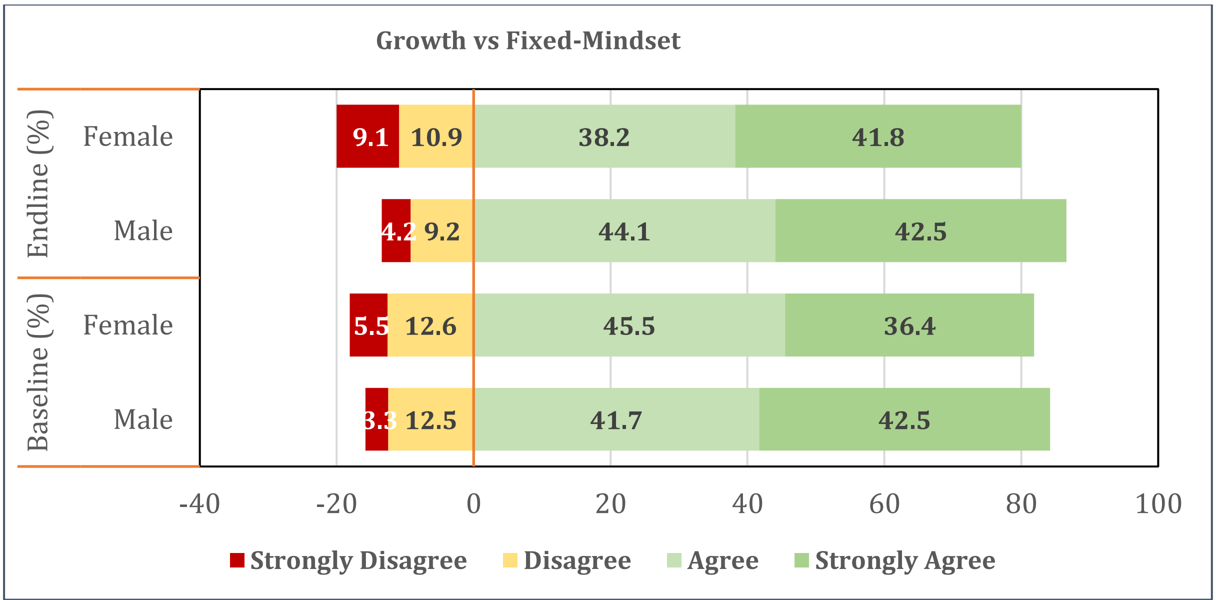
Analysis: An analysis of survey data (Figure 4.12) suggests a slight shift toward growth mindsets from Baseline to bottom line. Positive responses ("agree" and "strongly agree") remained predominant, with the percentage of Mathematics teachers who strongly agreed increasing from 39.56% at the Baseline to 42.1% at the Endline. At the same time, the percentage of Mathematics teachers who disagreed fell from 12.5% to 10.1%, indicating a decline in fixed mindset tendencies. However, a slight increase in the percentage of Mathematics teachers who strongly disagree (from 4.4% to 6.6%) suggests a small increase in fixed mindsets among them.

Figure 4.12 *Overall Mathematics Teachers' Perception Towards Growth and Mindset at Baseline and Endline*



Trend in Gender: Gender analysis (Figure 4.13) shows a consistent trend toward a stronger growth mindset among male Mathematics teachers. The percentage of male Mathematics teachers who agreed increased from 41.7% to 44.1%, while the percentage of those who strongly agreed remained constant at 42.5% from Baseline to Endline. In contrast, the percentage of female Mathematics teachers who agreed with the statement decreased from 45.5% to 38.2%, while those who strongly agreed with the statement increased from 36.4% to 41.8%. These mixed patterns among female Mathematics teachers require further investigation to understand potential challenges or barriers. Furthermore, the significant increase in the percentage of female Mathematics teachers who strongly disagree with this statement (from 5.5% to 9.1%) highlights the need for targeted interventions to address these concerns.

Figure 4.13 *Gender-wise Mathematics Teachers' Perception Towards Growth and Mindset at Baseline and Endline (M=24; F=11)*

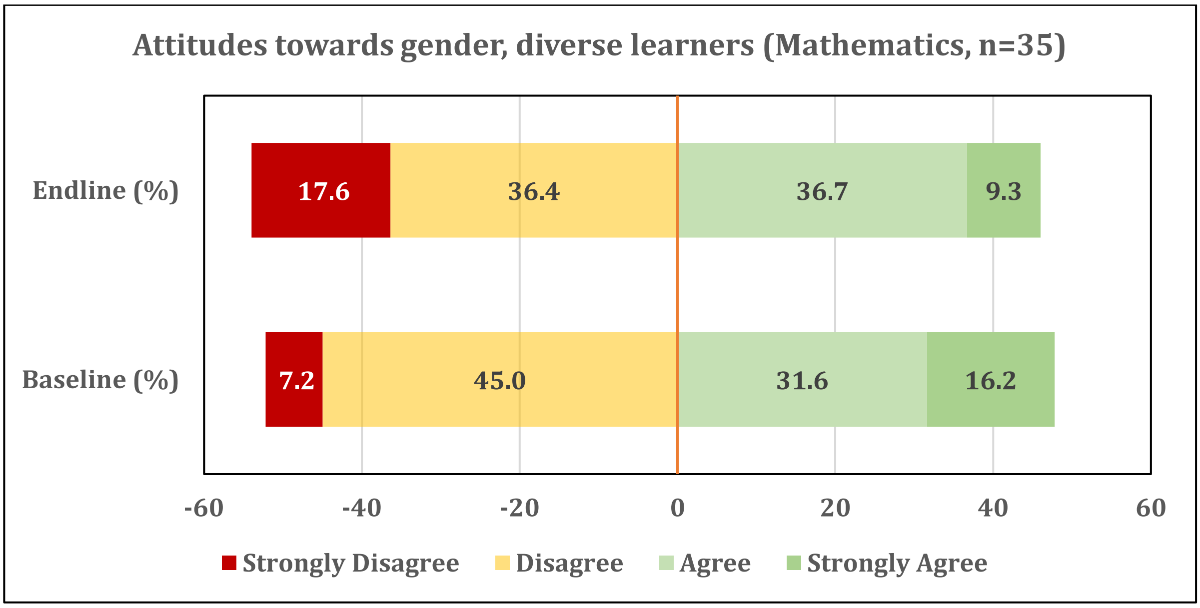


Key Findings: Overall, these findings suggest progress in promoting a growth mindset among Mathematics teachers, aligning with research parameters. However, the slight increase in fixed mindset tendencies, particularly among female Mathematics teachers, highlights the importance of ongoing support to cultivate and sustain growth mindset beliefs among all educators.

4.2.6 Attitudes Towards Gender, Diverse Learners

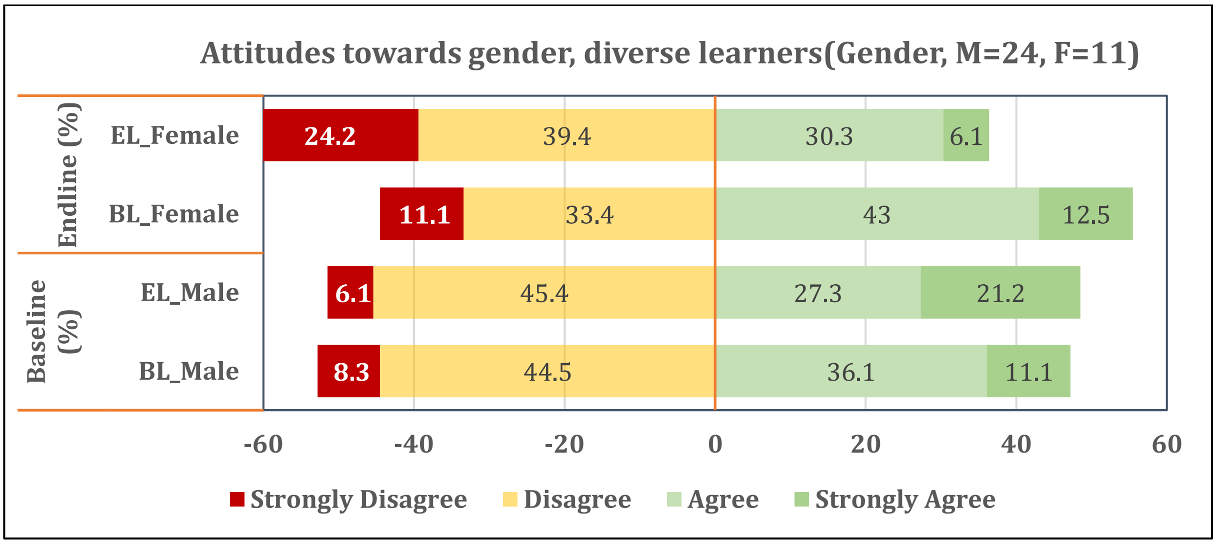
Analysis: The survey data (Figure 4.14) on Mathematics teachers' attitudes towards gender and diverse learners shows significant progress in rejecting exclusionary beliefs and embracing inclusion. The percentage of Mathematics teachers who strongly disagreed in response to exclusionary attitudes increased significantly from 7.2% at the Baseline to 15.2% at the Endline, reflecting a notable shift toward rejection of strongly held beliefs. Likewise, the percentage of Mathematics teachers who disagreed with inclusive practices fell from 45.0% to 36.4%, while those who agreed with inclusiveness increased from 31.6% to 36.7%. However, the percentage of teachers who strongly agreed with the statement decreased from 16.2% to 9.3%, indicating some reluctance to fully adopt inclusive practices

Figure 4.14 *Mathematics Teachers' Attitudes Towards Valuing Students' Diversity as a Resource in Teaching Mathematics.*



Trend in Gender: According to a gender analysis (Figure 4.15), male and female Mathematics teachers show different trends. Male Mathematics teachers demonstrated consistent progress in promoting inclusivity, as evidenced by increases in the percentage of Mathematics teachers who strongly agreed (from 11.1% to 12.5%) and agreed with the statement (from 36.1% at Baseline to 43% at the end). These results indicate that men are consistently and increasingly aligned with inclusive teaching practices. For female Mathematics teachers, however, a more complex pattern emerged. A stronger rejection of exclusionary beliefs was indicated by the sharp increase in percentage who strongly disagreed with the statement, from 6.1% to 24.2%. However, the percentage of female Mathematics teachers who strongly agreed fell precipitously from 21.2% to 6.1%, suggesting difficulty or reluctance to fully engage in inclusive practices.

Figure 4.15 *Gender-wise Mathematics Teachers' Attitudes Towards Valuing Students' Diversity as a Resource in Teaching Mathematics*

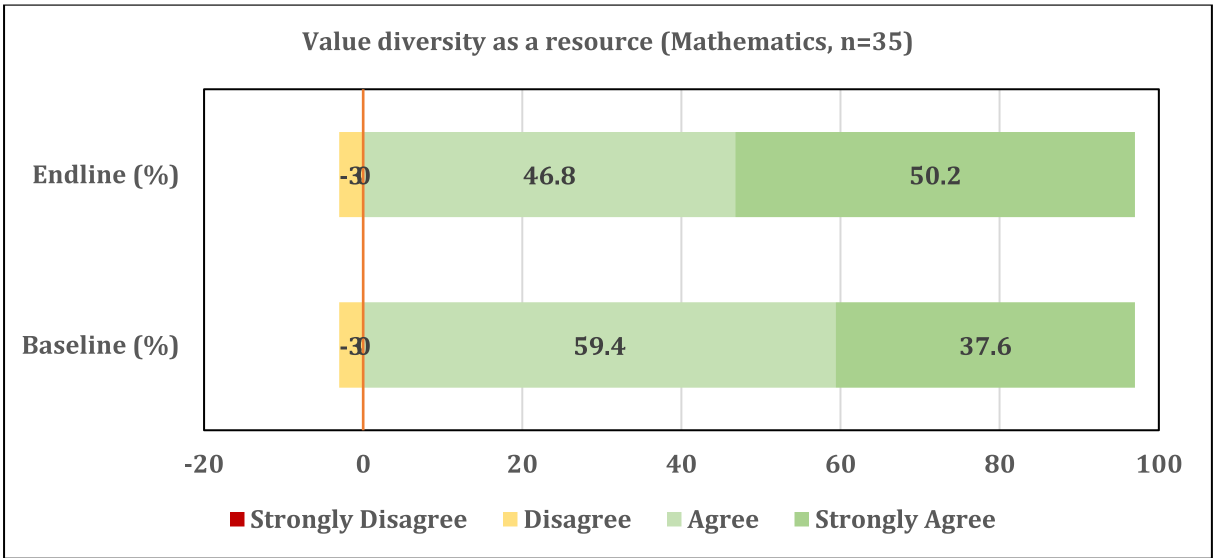


Key Findings: Overall, the findings show progress in promoting inclusivity and are consistent with research parameters. Nevertheless, the decrease in percentage of Mathematics teacher who strongly agreed with the statement, particularly among female teachers, highlights the need for targeted professional development and support. Addressing these gaps is critical to increasing teachers' confidence in effectively implementing inclusive policies and ensuring equitable educational opportunities for all students.

4.2.7 Value Diversity as a Resource

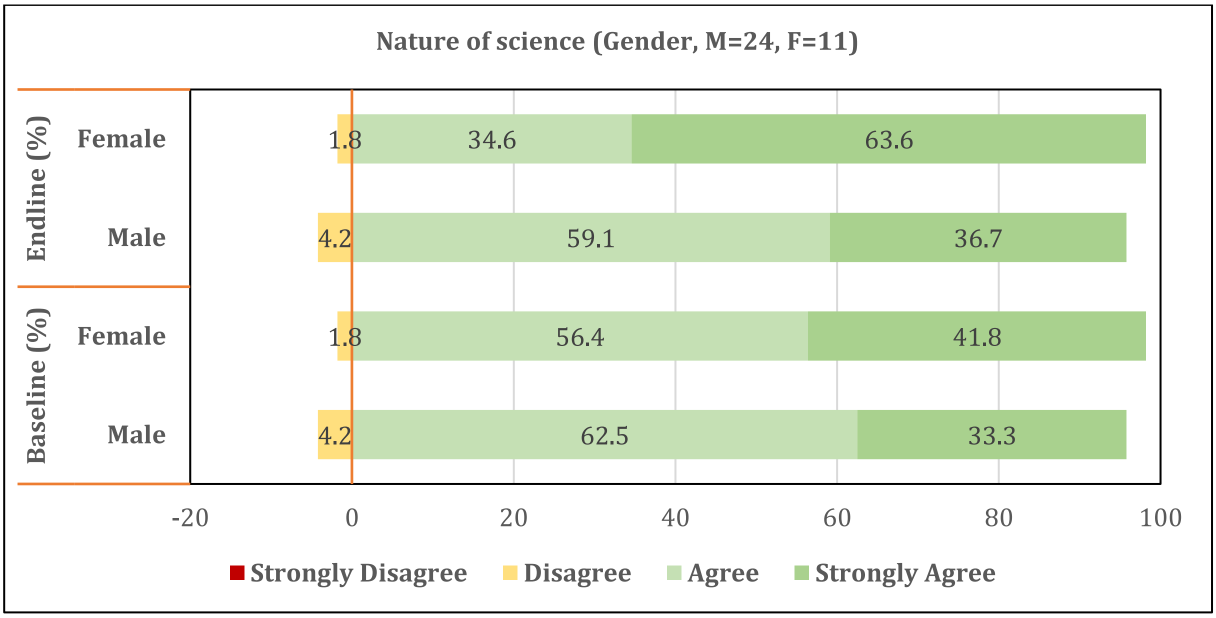
Analysis: Survey data (Figure 4.16) on Mathematics teachers' views on valuing diversity as a resource show encouraging progress from Baseline to Endline. Notably, the percentage of Mathematics teachers who strongly supported diversity as a resource increased significantly. The percentage of Mathematics teachers who strongly agreed with these statements increased from 37.6% at the Baseline to 50.2% at the Endline. While the percentage of who agreed fell from 59.46% to 46.8%, this data still suggests strong overall support for inclusive practices. Importantly, at neither point in time did Mathematics teachers disagree at all, suggesting widespread acceptance of the value of diversity as a resource in education.

Figure 4.16 *Teachers' Attitudes Towards Valuing Students' Diversity as a Resource.*



Trend in Gender: The gender-specific analysis shows clear patterns. The percentage of male Mathematics teachers who strongly agreed with the statement increased from 33.3% at the Baseline to 36.7% at the Endline, while the percentage of who agreed decreased slightly from 62.5% to 59.1% (Figure 4.17). This suggests a consistent endorsement of inclusivity with less pronounced movement compared to their female counterparts. In contrast, there was a more noticeable shift among female Mathematics teachers. The percentage of female Mathematics teachers who strongly agreed increased from 41.8% at the Baseline to 63.6% at the Endline, indicating a growing belief in the benefits of inclusion. However, the percentage of Mathematics teachers who agreed fell significantly from 56.4% to 34.6%, indicating that many teachers moved from moderate to strong agreement with inclusive teaching practices.

Figure 4.17 *Gender-wise Mathematics Teachers' Attitudes Towards Valuing Students' Diversity as a Resource.*



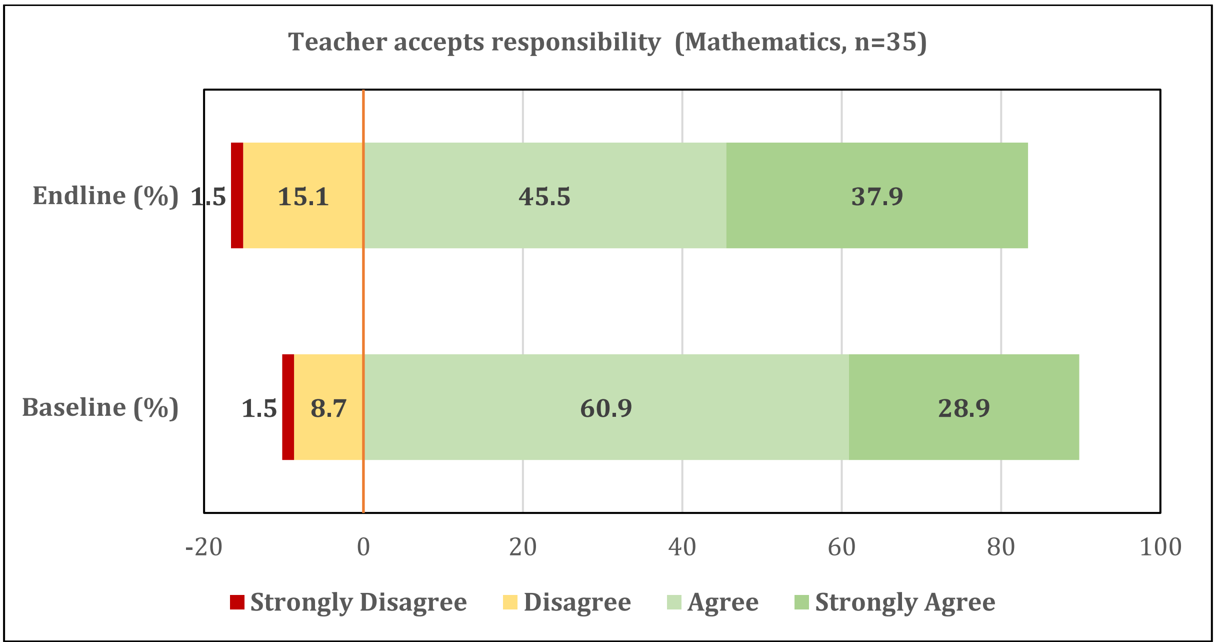
Key Findings: Overall, these findings demonstrate a positive trend in Mathematics teachers' attitudes towards valuing diversity as a resource, aligning with research parameter which emphasises the importance of diversity in teaching. The substantial increase in strong agreement across all statements highlights Mathematics teachers' growing belief in the social and academic benefits of inclusion and its positive impact on their own teaching practices. While both male and female Mathematics teachers are increasingly valuing diversity, the more pronounced shift among Mathematics female teachers necessitates continued professional development and support to ensure all teachers, regardless of gender, feel confident and equipped to effectively implement inclusive strategies.

Overall, these findings show a positive trend in Mathematics teachers' attitudes towards valuing diversity as a resource in the classroom. The significant increase in strong agreement across all statements underscores Mathematics teachers' growing belief in the social and academic benefits of inclusion and its positive impact on their own teaching practices. While both male and female Mathematics teachers are placing increasing emphasis on diversity, the more pronounced change among Mathematics teachers requires ongoing professional development and support to ensure that all teachers, regardless of gender, feel confident and equipped to implement inclusive strategies effectively.

4.2.8 Teacher Accepts Responsibility

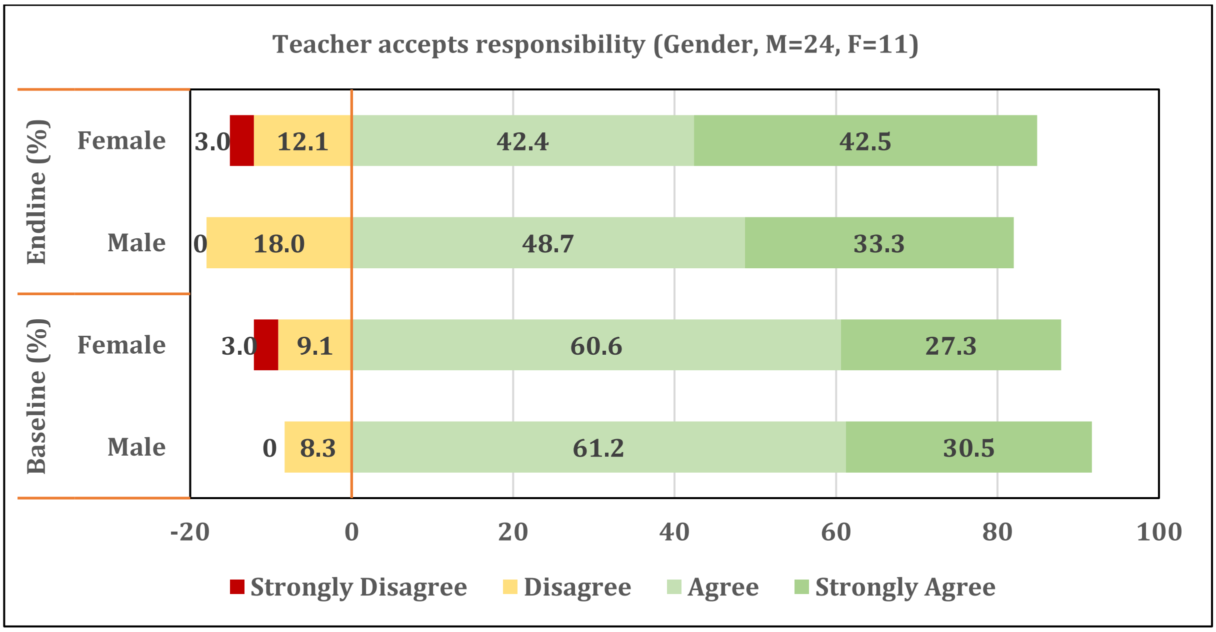
Analysis: The survey data (Figure 4.18) on Mathematics teachers' sense of responsibility for meeting learners' diverse needs through inclusive practices shows both progress and challenges from Baseline to Endline. Overall, the percentage of teachers who strongly agreed that they take responsibility for all students' learning increased from 28.9% at the Baseline to 37.9% at the Endline. This suggests that teachers are increasingly recognising their role in promoting inclusive learning environments. However, the percentage of teachers who simply agreed fell from 60.9% to 45.5%, while those who disagreed increased significantly from 8.7% to 15.1%. This shift suggests that while more teachers are recognising their responsibilities, some are also becoming aware of the challenges associated with adapting their instructional practices to meet the diverse needs of all students.

Figure 4.18 *Mathematics Teacher Responsibility Acceptance in Mathematics Teaching - Baseline and Endline Comparison (n=35)*



Trend in Gender: When examining gender differences (Figure 4.19), male Mathematics teachers demonstrated a more stable sense of responsibility. The percentage of male Mathematics who strongly agreed with the statement increased slightly from 30.5% at Baseline to 33.3% at Endline, while those who agreed decreased from 61.2% to 48.7%. This suggests that male Mathematics teachers maintain a relatively consistent level of confidence in their responsibility for student learning, albeit with some decline in moderate agreement. In contrast, there was a more noticeable shift among female Mathematics teachers. The percentage of female Mathematics teachers who strongly agreed with the statement increased from 27.3% at the Baseline to 42.5% at the Endline, indicating a greater sense of ownership of their students' learning. However, this increase in the percentage of female Mathematics teacher who strongly agreed with the statement was accompanied by a significant decrease in the percentage of who agreed, from 60.6% to 42.4%, possibly reflecting concerns or uncertainties about the practical application of inclusive practices indicates. Both male and female math teachers saw a slight increase in the percentage of who disagreed, although this increase was more pronounced for female teachers.

Figure 4.19 *Gender-wise Mathematics Teacher Responsibility Acceptance in Mathematics Teaching*



Key Findings: The overall findings highlight important trends in Mathematics teachers' evolving sense of responsibility for meeting the diverse needs of learners. The overall increase in strongly agree suggests growing acceptance of this responsibility, particularly among female Mathematics teachers. However, the rise in those who disagree, especially among females, underscores the challenges they face in effectively implementing inclusive teaching strategies. The data reflects a shift towards greater recognition of the complexities inherent of inclusive education. Although progress has been made, these results suggest that more targeted professional development and support is crucial to address the barriers teachers may encounter and ensure they have confidence in their ability to create inclusive classrooms for all students.

4.2.9 Summary

The findings from the Baseline-Endline Mathematics Survey (Part II) offer valuable insights into Mathematics teaching and learning, covering teaching strategies, student assessment, pedagogical beliefs, and attitudes towards diversity and inclusion. The analysis highlights key observations and demographic variations, offering a comprehensive understanding of Mathematics teachers' evolving perspectives.

Findings from the Baseline-Endline Mathematics Survey (Part II) indicate a gradual shift towards active learning approaches, with an increasing number of teachers supporting student engagement, the use of concrete materials, and valuing student contributions. This trend highlights a growing recognition of the benefits of active learning in fostering deeper understanding and participation. However, a segment of teachers continues to favour traditional methods, suggesting that additional efforts are required to further integrate active learning principles into teaching practices. Female teachers have shown a greater inclination towards adopting modern strategies compared to their male counterparts, reflecting a higher openness to contemporary pedagogical approaches. The survey also reveals a shift in assessment practices, with a growing preference for broader assessment methods rather than sole reliance on test scores. Initially, female teachers exhibited stronger opposition to test-based assessments than male teachers, but over time, this gap has diminished, indicating a collective transition towards more comprehensive evaluation techniques.

There is an increasing acceptance of contemporary educational beliefs, with teachers moving away from traditional notions such as rote memorisation and binary perspectives on problem-solving. Male teachers have demonstrated significant progress in embracing progressive beliefs, while female teachers have consistently aligned with modern pedagogical approaches. Despite these positive trends, some resistance to contemporary perspectives remains, underscoring the need for continued professional development and support. In terms of instructional strategies for students from low-income backgrounds, teachers are gradually moving away from teacher-directed, whole-group instruction in favour of student-centred methods that cater to diverse learning needs. Male teachers have shown a stronger rejection of traditional instruction, while female teachers have exhibited a notable decline in agreement with such methods. Encouragingly, a growth mindset is gaining traction among teachers, with more educators endorsing the value of effort and perseverance in Mathematics learning. However, a slight increase in fixed mindset tendencies, particularly among female teachers, points to the necessity of targeted interventions to sustain this positive shift.

Attitudes towards gender and diverse learners are also evolving, with teachers increasingly rejecting exclusionary beliefs and demonstrating a commitment to inclusivity. Male teachers have shown steady progress in supporting inclusivity, whereas female teachers' perspectives reveal a more complex pattern, highlighting challenges in fully implementing inclusive practices. Teachers' appreciation for diversity as a resource has grown significantly, with female teachers showing a pronounced shift in their beliefs. Despite this progress, continued professional development is essential to equip teachers with the confidence and skills needed to implement inclusive teaching strategies effectively. A stronger sense of responsibility for meeting learners' diverse needs is evident, though rising disagreement, particularly among female teachers, suggests challenges in translating inclusive principles into practice. Overall, findings suggest a positive trajectory towards modern pedagogical practices and inclusivity; however, targeted support and professional development remain crucial in addressing persistent challenges and ensuring sustainable progress.

Chapter 5: Teachers' Knowledge, Attitude and Practice (Qualitative)

This Chapter presents the thematic analysis of interviews derived from Biology, Chemistry, Physics, and Mathematics, organised around three overarching themes: Learners, Content, and Teaching and Learning. The Learners theme refers to the needs and backgrounds of students and how teachers make modifications in their strategies in order to build an inclusive and equitable learning environment for all their students. The Content theme probes the currency and accessibility of the content delivered in the Open Educational Resources (OER) modules. It also takes into account how relevant the contents are in accordance with the prior knowledge and life experiences of the students. The third theme Teaching and Learning concerns the nature of the teaching strategies employed within the classrooms and their general effectiveness at ensuring students do engage with teaching and learning.

This analysis explored how various elements of teaching and learning are interconnected, providing a deeper understanding of their collective impact. By focusing on these themes, the study aimed to contribute to a robust evidence base regarding their effects on the pedagogical content knowledge (PCK) of the teacher participants in the modules.

Within the three broad themes, there are 11 sub-themes as reflected below:

Learners

Promote Equity and Inclusion
Build on students' prior conceptions
Address misconceptions and areas of difficulties

Content

Use processes on Science and Mathematics
Facilitate higher order thinking
Plan to build students' competences to meet the goals of teaching STEM

Teaching and Learning

Use instructional strategies for active learning
Use of multiple representations
Create opportunities for multiple modes of expression
Use locally available materials
Link conceptual content to students' everyday life experiences and prior knowledge

The analysis was carried out around these 11 sub-themes. The detailed findings are presented in the following sections.

5.1 Learners

5.1.1 Promote Equity and Inclusion

Promoting inclusion and equity in the classroom is essential for creating an environment where all students, regardless of their background or ability, feel valued and have equal opportunities to succeed. By recognising and addressing diverse learning needs, teachers can tailor their approaches to ensure every student has access to the support and resources they need. This commitment to inclusion fosters a sense of belonging and empowers students to engage fully in their learning, ultimately leading to better outcomes for all.

The Baseline data showed that teachers were already aware of students' diverse backgrounds, learning abilities, and socio-economic conditions, and adapted their teaching methods to ensure inclusivity. For instance, in Biology, one teacher highlighted the need for "different means and different ways" to engage students with varying learning styles (BLBM5005). BLBM5037 noted the differences in learning speeds, with some students being faster learners while others needed more support. In Chemistry, BLCF5055 emphasised tailoring lessons for different ability levels to support low-achieving students. In Mathematics, BLMM5139 stressed the importance of treating all students equally while offering extra support to those from low-income families, who often lacked parental guidance. In terms of language, most of the students come from a background where English is not commonly used at home for communication. This lack of exposure to English outside the classroom limits their ability to engage in complex discussions, read academic texts fluently, and respond to questions with the depth of understanding expected in the classroom. However, only one teacher (BLBM5008) mentioned being aware of it and addressing this limitation using Dzongkha to make concepts clear.

By the Endline, all the teachers had expanded their use of pedagogical strategies to further promote equity and inclusion. Specifically, ELBM5005, ELCM5069, and ELCM5070 described using differentiated instruction, backward design, and Universal Design for Learning (UDL), which allowed students to engage with the material through writing, art, or speaking, catering to different learning styles. Teachers also recognised the challenges faced by students from less-educated families and highlighted efforts to support them, ensuring no student was left behind due to limited parental guidance or socio-economic background (ELMF5131, ELPM5088, ELCM5064, ELBF5027). Additionally, some teachers took proactive steps to support students' learning. For instance, ELCM5070 introduced a flipped classroom approach, providing printed resources and videos to ensure all students had access to learning materials, regardless of their technology access at home. In terms of language, the data showed that most teachers were aware of this limitation and worked towards addressing it. For example, some teachers (ELBM5008, ELCF5055, ELPM5077) used Dzongkha to ensure all students understood complex concepts. These approach reflects a deeper commitment to addressing socio-economic disparities.

However, the socio-economic divide remained a concern, particularly regarding access to the internet and digital tools. BLPM5088 observed that students from affluent families performed better due to their easier access to technology. In response, teachers implemented peer learning, pairing students with different levels of technological access, and allowing them to complete tasks within the school setting to help bridge the gap (ELPM5104, ELCM5070). This collaborative approach fostered a more inclusive learning environment. Emotional and psychological support also remained crucial. ELPM5077 shared how teachers worked with Special Educational Needs (SEN) students, providing extra time and using local dialects to support their learning. Similarly, ELMM5149 emphasised offering individual attention to low-achieving students.

Summary: Teachers at the Baseline were aware of their students' diverse backgrounds, but their efforts to ensure inclusivity primarily focused on addressing varying learning speeds, ability levels, and to a small extent on language barriers. By the Endline, they had broadened their approach, incorporating strategies like differentiated instruction and Universal Design for Learning (UDL) to further promote equity. While progress was made, access to technology remained a challenge, prompting teachers to implement peer learning and allow in-school task completion. Emotional and psychological support remained crucial, with teachers providing extra time and individualised attention to SEN and low-achieving students.

5.1.2 Build on Students' Prior Conceptions

Building on students' prior conceptions is a key strategy in fostering deeper understanding and promoting long-term retention of new concepts. By connecting new knowledge to what students already know, teachers can create a more cohesive learning experience and help students make meaningful connections.

At the Baseline, teachers recognised the importance of connecting new concepts to existing knowledge but used mostly informal, reactive methods. For example, in Biology, BLBM5037 noted, "I always check their previous knowledge, at the same time I also show them videos to make the concept clear," using assessment and visual aids, but without a structured strategy. Similarly, in Chemistry, BLCM5064 and BLCM5073 revisited foundational topics such as atomic structure and chemical bonding reactively, typically during or after lessons. In Physics, BLPM5077 relied on questioning to assess prior knowledge, but this was mainly used for review rather than preparation.

By the Endline, teachers adopted more structured and proactive methods. They began using pre-tests or "warm-up" sessions at the start of lessons to assess and activate prior knowledge. For example, in Chemistry, ELCF5040 introduced a "warm-up" session to assess students' understanding before diving into new material, and in Physics, ELPM5103 used pre-tests and experiments to link existing knowledge with new concepts. Mathematics teachers used hands-on methods, such as graph plotting (ELMF5151) and theoretical exercises (ELMM5149), to bridge gaps between prior and new content. The use of real-world examples became more prominent across subjects, particularly in Physics and Chemistry. For instance, ELPF5093 connected energy concepts to daily life, such as firewood for cooking, and ELCF5044 used cooking gas to explain methane. These connections helped students engage more deeply with the material and reinforced their understanding.

While the implementation of the OER modules led to positive changes in how teachers integrated prior knowledge into their lessons, some areas showed less improvement. For example, the use of questioning remained largely passive, with teachers still relying on students' responses without actively using this feedback to adjust lessons. In Physics, one teacher noted, “I try to get views from this mixed group of students, and if there are no volunteers, I just pinpoint" (ELPM5079), indicating that student engagement was not always dynamic. Additionally, despite attempts to link new content to real-world examples, some students continued to struggle with abstract concepts (ELPF5093). In Chemistry, one teacher admitted, "These topics are introduced at once without enough context, so students tend to lump them together" (ELBF5027), showing that the challenges in connecting prior knowledge to new material persisted in some subjects.

Summary: At the Baseline, teachers acknowledged the importance of connecting new concepts to prior knowledge but mainly used informal methods, like checking prior knowledge during lessons or using videos. By the Endline, they adopted more structured strategies, such as pre-tests, "warm-up" sessions, and real-world examples to activate prior knowledge and link abstract concepts to everyday experiences. Despite some challenges, including limited student engagement and difficulties in contextualising new content, there was a clear improvement in how teachers integrated prior knowledge into their lessons as a result of implemntation of OER modules.

5.1.3 Address Misconceptions and Areas of Difficulties

Addressing misconceptions and areas of difficulty is crucial for ensuring that students develop a clear and accurate understanding of key concepts. Identifying these challenges early allows teachers to provide targeted support and clarify misunderstandings before they become obstacles to further learning.

At Baseline, teachers across subjects primarily relied on videos, animations, and diagrams to simplify complex concepts and address common misconceptions. For example, in Biology, teachers like BLBM5005 highlighted the use of "video and picture modelling" to present ideas, while BLBM5008 mentioned simplifying complex concepts using videos and animations. Similarly, in Chemistry, BLCF5055 emphasised using video clips and group discussions to address the misconception that "cation will go to the anode and anion will move to the cathode" during the teaching of electrolysis. Physics teachers also used multimedia, with BLPM5079 stating, "I use more videos and simulations to overcome challenges" related to abstract concepts like nuclear Physics. While these strategies helped, they were more of a reactive approach to student learning difficulties, focusing on simplifying abstract ideas and addressing misconceptions after they had been introduced.

By the Endline, there was a noticeable shift toward more interactive and contextualised teaching approaches. Teachers moved beyond merely using multimedia tools to focus on conceptual understanding and real-life applications. For example, in Biology, ELBM5005 observed that students had misconceptions about DNA and chromosomes, stating, "The confusion occurs because students hear terms like 'genes,' 'DNA,' and 'chromosomes' in similar contexts, making it hard to distinguish between them." To address this, teachers employed visual aids and hands-on activities to make these concepts clearer. Similarly, in Chemistry, teachers like ELCM5064 used simulations to help students understand the concept of electron clouds by stating, "I show them the electron clouds... how it is not definitive that the electrons will revolve around it." In Physics, teachers like ELPM5103 integrated more real-life analogies to make abstract topics relatable, with one teacher noting, "I simplify complex concepts with analogies, like using a friendly wrestling match to explain Newton's third law." This approach helped students relate abstract concepts to familiar experiences. Similarly, Mathematics teachers emphasised understanding the why behind formulae rather than just memorisation. For instance, ELMF5146 explained, "I make sure to explain why each formula works and how it can be used in real life."

While the move toward more interactive, context-driven teaching has had positive outcomes, some students across subjects still had misconceptions. In Chemistry, students still struggled with understanding the concept of atomic structure and the probabilistic nature of electrons (ELCM5064). In Mathematics, ELMF5126 pointed out, “Students have misconceptions in ratio and fraction, thinking they are the same,” suggesting that these foundational concepts still require more targeted attention. In Physics, ELPM5103 observed that some students were still unable to fully grasp the concepts of magnetism or Newton’s laws, even with simulations and analogies. The statement by ELPM5103, “Even with different methods, some students still can’t get the concept” indicated that the switch from passive learning to active learning may not always lead to better understanding, especially when students face foundational learning gaps.

Summary: At the Baseline, teachers used videos, animations, and diagrams to simplify complex ideas and correct misconceptions. These methods, while helpful, were reactive and focused on clarifying misunderstandings after they occurred. By the Endline, teachers shifted to more interactive, contextualised approaches, using hands-on activities, real-life analogies, and simulations to enhance conceptual understanding. However, the persistent misconceptions and challenges suggest that some students may require even more tailored interventions, especially in areas where abstract concepts are difficult to visualise or relate to real-life experiences.

5.2 Content

5.2.1 Use Processes on Science and Mathematics

The use of processes in STEM is essential for helping students develop critical thinking and problem-solving skills. By emphasising processes, teachers can help students not only grasp content but also apply their learning in real-world contexts.

At Baseline, teachers primarily relied on methods which are mostly oriented towards traditional practices, such as lectures, diagrams, YouTube videos, and simple experiments. In Biology, teachers often used student-created diagrams or external resources like YouTube to explain abstract concepts (BLBM5008, BLBF5027, BLBF5029). In Chemistry, group activities and experiments were common, but theoretical explanations and concept notes were still heavily relied upon (BLCF5055). Physics teaching focused on explaining theories and conducting basic experiments (BLPM5077), while Mathematics emphasised problem-solving, and direct application of mathematical concepts often through real-life examples or games (BLMF5126, BLMF5146, BLMM5149, BLMF5154). However, the overall approach remained teacher-directed and procedural, with an emphasis on memorisation, repetitive practice, and standard formulae, particularly in Mathematics. Some teachers noted the challenges of conducting experiments in Mathematics (BLMF5131) and suggested changes to the curriculum to make certain topics more practical (BLCF5040).

By the Endline, there was a noticeable shift towards more hands-on, inquiry-based, and student-centred learning. In Biology, teachers actively engaged students through role play and model-making to explore complex topics (ELBM5005). In Chemistry, the focus shifted to interactive, hands-on activities, with teachers ensuring all students participated in practical experiments (ELCF5040, ELCM5064). Physics teachers also reported greater student involvement through experimentation and technology (ELPM5104) while emphasising the real-world relevance of the concepts taught (ELPF5093). However, Mathematics still relied on traditional methods, despite some increase in the use of games and more varied teaching strategies (ELMF5146). Challenges such as limited resources for experiments and a continued emphasis on repetitive practice and exam-focused learning persisted, (ELMM5149, ELMF5151) preventing a full embrace of the inquiry-driven approaches promoted by the OER modules.

Summary: The implementation of the OER modules led to a shift towards more active, inquiry-based, and student-centred teaching, particularly in Science subjects. At the Baseline, teachers relied on traditional methods like lectures, diagrams, and simple experiments, with a focus on memorisation and procedural learning, especially in Mathematics. By the Endline, there was increased student engagement through hands-on activities, role play, and real-world applications in Science subjects. However, Mathematics continued to rely on traditional methods, with challenges such as limited resources for experiments and a focus on repetitive practice, hindering full adoption of inquiry-based approaches. There is a need to make a concerted effort to highlight the students centred approaches being used in the OERS in Mathematics.

5.2.2 Facilitate Higher Order Thinking

Facilitating higher-order thinking (HOT)is essential for helping students move beyond rote memorisation and engage with content at a deeper level. By encouraging critical thinking, teachers can support students to apply their knowledge to solve complex problems, make connections to real-life, and generate new ideas.

At Baseline, the focus across subjects was on foundational knowledge acquisition, with teachers largely using traditional methods like real-life examples, videos, and simple hands-on activities to engage students. For instance, teachers cited using YouTube videos to explain complex concepts (BLBM5005, BLCF5055, BLPM5115) and connecting the lesson to real-life examples (BLBF5027), drawing (BLCF5044), experiments (BLCF5070, BLCF5066, BLPM5104, BLMM5149), use of demonstrations and simulations to explain abstract concepts (BLPM5079, BLPF5093, BLPM5103), and hands-on activities to solve problems (BLMF5126, BLCM5069, BLCF5070). While these strategies promoted some level of engagement, they largely focused on foundational knowledge and understanding, with less emphasis on critical thinking or student-driven inquiry.

By the Endline, there was a shift in both the teaching methods and the level of student engagement. Teachers increasingly employed interactive tools, simulations, and collaborative learning strategies designed to encourage deeper thinking. For example, Biology teachers used interactive simulations to explore cell structures (ELBM5005) and engaged students in project-based learning (ELBF5027). Chemistry teachers adopted inquiry-based approaches, incorporating cooperative learning methods like the jigsaw strategy, where students worked together to explore complex topics and share their findings (ELCF5073). Physics teachers embraced project-based learning, asking students to analyse energy usage in household appliances and explore real-world issues like global warming (ELPM5077, ELPM5088). Additionally, formative assessments gained prominence, with teachers offering opportunities for students to revisit content, retake tests, and revise their understanding through peer discussions and visual representations (ELCF5040, ELCF5044). The shift towards higher-order thinking was evident in the increased use of open-ended questions that challenged students to justify their responses and apply concepts to unfamiliar situations (ELBM5008, ELPM5104). Tools like gamification (ELCM5064) and real-world applications (ELMF5151) further supported a move towards active, student-centred learning environments.

However, traditional methods remained prevalent. Teachers continued to use videos and simulations to clarify complex concepts, while hands-on experiments remained central to lessons (BLCF5070, ELCF5070, BLPF5093, ELPF5093). Formative assessments, including quizzes and peer discussions, were still essential tools for measuring student understanding, especially in Chemistry and Mathematics (BLMM5149, ELCF5040). Despite the emphasis on inquiry and critical thinking, these foundational methods persisted throughout the study.

Summary: There is a marked improvement in the way teachers helped to enhance students' HOT. The use of interactive strategies and teaching methods encouraged critical thinking and problem solving, significantly enhancing students' HOT. Science teachers increasingly incorporated inquiry-based and real-world applications, while formative assessments became more common, encouraging students to revisit and refine their understanding. However, traditional methods like videos, hands-on experiments, and quizzes continued to play an essential role, reflecting a balance between new approaches and established practices. A full transition to these new methods will require time and ongoing effort. To make a complete shift to newer practices and approaches will require time and ongoing effort.

5.2.3 Plan to Build Students' Competencies to Meet the Goals of Teaching STEM

Building students' competencies is essential for achieving STEM teaching goals, ensuring they can grasp complex concepts and apply them effectively. A well-structured plan bridges the gap between theory and practice, empowering students to succeed both academically and in real-world contexts.

At the Baseline, teachers across STEM subjects prioritised content delivery through textbooks, direct explanations, and general classroom activities. For example, a Biology teacher emphasised building a foundational understanding using basic resources, stating, "We can use the YouTube video and... make them understand" (BLBM5008). In Chemistry, the focus was similarly on transmitting textbook content, as pointed out by BLCM5064, "We are just teaching the syllabus". In Physics and Mathematics, the focus was largely on problem-solving skills, with less emphasis on connecting concepts to real-life situations. A Physics teacher (BLPM5088) noted, "If they are able to do well in Mathematics... they will be able to solve the numerical questions", while a Mathematics teacher (BLMF5131) highlighted the importance of mastering concepts but did not explicitly link them to real-world contexts.

Post-implementation, there is a visible change towards building students' competencies to meet the goals of STEM teaching. Biology teachers, for example, began to employ hands-on activities and linking the lesson to current events, such as gene therapy or CRISPR technology, promoting conceptual understanding and critical thinking. Another teacher (ELBF5027) stated, "Relate biological concepts to current events... to spark interest". Chemistry teaching also evolved, with a stronger emphasis on practical activities that enhanced problem-solving skills and connected Chemistry to real-life industries (ELCM5055). Physics teachers incorporated more demonstrations and experiments, allowing students to engage actively with the material and fostering deeper understanding: "I think the student is able to explain theories... and create motors on their own" (ELPM5079). In Mathematics, teachers began linking mathematical concepts to real-world situations, helping students see the relevance of the subject in everyday life. As one teacher (ELMF5153) noted, "Students really enjoyed the topic... maths concepts could be found in nature".

Despite these positive changes, some challenges remained in Mathematics and Physics. The complexity of concepts sometimes hindered immediate comprehension, with teachers having to repeatedly explain procedures. According to ELMF5154, "We need to explain the concepts time and again". Additionally, in some instances, the lesson planning remained somewhat brief, without a full elaboration of every detail or question, which may limit the scope of student engagement. For instance, ELMM5149 said, "We plan lessons in short... and deliver based on the reminder".

Summary: At Baseline, STEM teachers focused primarily on content delivery through textbooks, direct explanations, and basic activities, with limited connection to real-world applications. By the Endline, there was a clear shift towards enhancing students' competencies through hands-on activities, real-world connections, and problem-solving skills. Teachers began linking concepts to current events and practical applications, promoting deeper understanding and critical thinking. However, challenges remained in Mathematics and Physics, where the complexity of concepts sometimes hindered full comprehension, and lesson planning remained brief, limiting student engagement.

5.3 Teaching and Learning

5.3.1 Use Instructional Strategies for Active Learning

Using instructional strategies for active learning is essential for achieving effective teaching outcomes, as it encourages students to engage with content more deeply and apply their knowledge in meaningful ways. It helps to bridge the gap between passive learning and real-world application, fostering critical thinking, problem-solving, and collaboration.

At the Baseline, teachers relied on a variety of strategies to ensure active, student-centred learning, with a strong focus on collaborative methods. Group and pair work, often utilising mixed-ability grouping and peer tutoring, were common practices to encourage participation and inclusivity. Teachers also adopted inquiry-based and problem-based learning approaches, using experiments, field trips, and real-life applications to engage students. One teacher noted, "I use pre-set questions and most of the time open-ended questions related to that particular topic" (BLBM5005), while another emphasised an inductive, student-centred approach: "I use the inductive process with more questions, and from their responses, together we develop the concept" (BLPM5088). Technology, such as PowerPoint presentations, smart TVs, and video lessons, were integrated to supplement learning. Despite these interactive strategies, teachers focused primarily on foundational knowledge and understanding, using clear instructions and peer learning to make lessons meaningful and engaging.

By the Endline, there was a clear progress in the use of instructional strategies, with an even stronger emphasis on active, student-centred learning. Group and project work remained dominant, but teachers took steps to ensure that every student actively participated. As one teacher explained, "I use group work and project work" (ELBF5019), and another added, "For group work, I ensure every student gets a role, like making observation tables or calculations, so all participate" (ELPM5088). Mixed-ability grouping continued to be employed, with one teacher highlighting, "I mix students of higher ability with those of lower ability in group activities. This fosters peer learning" (ELCM5070). Teachers also placed greater emphasis on inquiry-based and problem-based learning, using real-world examples to contextualise abstract concepts. A teacher demonstrated an experiment on translocation, saying, "I demonstrated how to remove the outer layer of the stem, then monitored students' work outside" (ELBF5029). Another connected Newton's laws to local examples: "While teaching Newton's law, I begin with local examples such as the amount of force to be applied on the car to push it on different surfaces" (ELPF5093). Technology use was enhanced, with teachers incorporating PowerPoint, smart TVs, and internet browsing to facilitate interactive learning: "I get them to discuss in groups and browse the internet for further exploration" (ELCM5040). Clear instructions and open-ended questions continued to be used to promote critical thinking and discussion. For example, ELBM5005 noted, "I use open-ended questions related to the topic to encourage discussion and critical thinking."

Summary: The implementation phase significantly enhanced active, student-centred learning by refining teaching strategies. Collaborative learning remained central, but teachers increasingly integrated structured inquiry-based and problem-based approaches to boost engagement. Real-life applications became more prominent, helping students connect abstract concepts to their daily experiences. The use of technology, further enriched lessons, fostering interactivity. Overall, the implementation phase created a more dynamic and engaging learning environment, promoting deeper understanding and increased student participation.

5.3.2 Use of Multiple Representations

The use of multiple representations in teaching involves presenting information through various forms, such as visual aids, diagrams, graphs, models, and verbal explanations. These approaches cater to diverse learning styles, enhancing students' comprehension and fostering deeper engagement with the content. It helps students connect abstract concepts to concrete experiences, promoting a more thorough understanding.

The Baseline data highlights the diverse ways in which teachers used multiple representations and resources to enhance conceptual understanding and make learning more interactive. Teachers frequently employed a combination of visual, practical, and digital tools to convey abstract ideas. For instance, in Biology, teachers like BLBF5027 used microscopes and hands-on experiments, stating, “For Class 9 I have been doing experiments on the plant cell and animal cell. Animal cell we usually use RBCS permanent slides that we have in the laboratory.” Chemistry teachers mixed experiments, videos, and online platforms such as Khan Academy and PhET simulations (BLCM5069, BLCM5064), alongside real-life materials like carbonated drinks (BLCM5040) and common household items (BLCF5066). In Physics, BLPM5079 utilised a smart TV for showing videos and simulations, and BLPM5103 integrated projectors and PowerPoint slides with practical lab experiments. Mathematics teachers like BLMF5146 creatively used real-world items, such as carton boxes for teaching polynomials, and allowed students to create their own models, saying, “When I was talking about polynomial ties, I used a carton box to make them.” Another incorporated field trips, with a teacher stating, "I take students to shops to explore discounts" (BLMF5151). These examples demonstrate teachers' efforts to link abstract concepts to tangible, real-life experiences, fostering engagement and deeper understanding.

The Endline data reflected a more diverse and systematic approach to assessment in teaching, with the implementation of Open Educational Resources (OERs) enhancing the use of multiple representations. Teachers increasingly incorporated various forms of formative and summative assessments to assess student comprehension and engagement. For instance, ELBM5005 utilised group activities, self-exploration, and video clips to reinforce learning, allowing students to present in various formats such as infographics. Similarly, ELBM5008 emphasised hands-on activities like "testing their blood" for blood group identification, actively involving students in practical learning experiences. Other teachers, such as ELCF5044, used group assessments, peer reviews, and presentations to foster collaboration and engage students in deeper learning, stating, "I prefer group assessments because it allows students to work together... even the low achievers can learn from the high achievers in their group." Additionally, many teachers now blend traditional assessments with digital tools as ELCM5069 mentioned using "Group and individual feedback," while ELPM5103 incorporated interactive quizzes and problem-solving scenarios, like creating a functioning DC motor. There is also evidence of increased use of real-world applications, such as ELPM5104, where students were asked to explain concepts in their own words and relate them to practical examples. These practices indicate that the integration of OERs has positively impacted teaching methods, encouraging a more student-centred approach that combines multiple representations, interactive assessments, and practical engagement with the content.

The broader trend is toward more interactive, varied, and reflective forms of assessment that cater to diverse learning styles. Teachers are using a mix of digital tools, group-based work, hands-on experiments, and real-life applications to enrich their lessons. For example, ELMF5146 used "interactive quizzes like Kahoot!" and "project-based learning," while ELMF5131 leveraged tools like GeoGebra to enable students to "come in front and draw the lines," making abstract concepts more tangible. These shifts suggest a clear positive impact from the OER implementation, as teachers embrace varied methods to both assess and engage students more effectively. However, there remains some reliance on traditional tests and summative assessments, indicating a balanced but evolving approach toward student evaluation.

Summary: The analysis of Baseline and Endline data shows a marked shift towards more diverse and interactive assessment strategies following the implementation of Open Educational Resources (OERs). While teachers in both phases used multiple representations, the Endline data indicates a more systematic integration of various forms of assessments, such as group work, peer reviews, hands-on activities, and digital tools like quizzes and simulations. Teachers increasingly linked real-world applications and practical learning experiences to reinforce concepts, demonstrating a positive impact of OERs in creating more engaging and student-centered learning environments. However, traditional assessments still remain a part of the approach, highlighting a balanced evolution in teaching practices.

5.3.3 Create Opportunities for Multiple Modes of Expression

Multiple modes of expression in the classroom are crucial for fostering an inclusive and dynamic learning environment. By encouraging students to express their understanding through different ways to express ideas encourages creativity, critical thinking, and confidence, helping students communicate more effectively both inside and outside the classroom.

At the Baseline, teachers employed a range of strategies to assess and promote student learning through multiple modes of expression. These included group and individual presentations, model building, reflective writing, hands-on experiments, and quizzes to foster engagement. For example, one teacher shared, “I ask questions on the previous topic before starting the new session and sometimes we do class tests” (BLBF5027). Teachers also made use of creative approaches like "students testing Charles's law at home with balloons and hot/cold water, taking snapshots, and sharing them in the class Telegram group" (BLCM5069). Tools such as Kahoot and collaborative group assessments, as mentioned by BLMF5146 and BLCF5044, further encouraged active participation and inclusivity in the classroom. Regular testing, formative assessments such as chapter-end tests (BLCM5064), and project-based activities (e.g., model-making, infographics) were also central to tracking student progress and encouraging hands-on, collaborative learning. Teachers frequently used questioning to keep students engaged, as one Biology teacher noted, “Most of the time I ensure that they participate in the class by asking questions. I keep them on their toes” (BLBF5029), a method echoed across disciplines.

By the Endline, teachers expanded their use of strategies to create more varied opportunities for students to express their understanding. A wider array of assessments and activities, including group activities, self-exploration, and infographics, became central to the teaching process. For example, one teacher said, “I use group activities, self-exploration, and infographics to present ideas” (ELBM5005), while another emphasised, “I give students class activities, quizzes, and presentations” (ELPM5077). There was also an increased focus on practical applications, such as “testing blood groups for practical exposure” (ELBM5008) and using tools like GeoGebra for real-time, conceptual learning (ELBF5131). In addition, group work became more intentionally organised to ensure inclusivity and active participation, as reflected in the teacher's comment: “Group assessments allow low achievers to learn from high achievers while distributing work to ensure everyone participates” (ELCF5044). The data also indicated a shift towards a more problem-solving-oriented learning environment, with a focus on resilience and trial-and-error learning. For instance, in Physics, one teacher noted, "Every time the group made a mistake and their DC motor did not work, I kept on letting them think of the next step, how they could make the DC motor work, and in that process, students did not give up" (ELPM5103). This emphasis on learning from mistakes reflected the impact of OERs, which may have fostered more exploratory and inquiry-based approaches to learning. In Chemistry, practical assessments, including lab work and student presentations, remained key methods for evaluating both understanding and communication (ELCM5040). Additionally, in Mathematics, teachers encouraged greater student autonomy, allowing them to choose their preferred problem-solving strategies: “I ask them to solve the question using the strategy that they feel comfortable with” (ELMF5131). Project-based learning remained prominent across subjects, with real-world connections, such as students creating budgets based on personal income and expenses (ELMF5146), reinforcing the practical application of academic concepts.

Summary: At the Baseline, teachers employed a variety of strategies to engage students and assess their learning, such as group presentations, hands-on experiments, quizzes, model building, questioning and chapter tests. By the Endline, there was an expansion in teaching methods, with a greater emphasis on group activities, self-exploration, and practical applications. Group work became more intentionally structured to promote inclusivity, and a focus on problem-solving and trial-and-error learning was reinforced. Overall, a shift toward more student-centred, inquiry-based learning characterised the Endline approach.

5.3.4 Use Locally Available Materials

The use of locally available materials in teaching and learning provides a practical and resourceful approach, particularly in settings where specialised resources may be scarce. By incorporating these materials, teachers can create engaging, hands-on experiences that are not only cost-effective but also encourage creativity and resourcefulness among both students and educators. This approach fosters a deeper, more meaningful connection to the content being taught, making learning more relevant and accessible.

The Baseline data showed that classroom teaching involved a small-scale but creative use of locally available materials, with some teachers integrating these resources in innovative ways. For example, BLBM5008 collaborated with the public health centre, saying, "I collaborated with PHCC, the public healthcare center, and discussed with the health worker to use their resources," while BLBF5029 took students outdoors, noting, "I take students out into the environment when we talk about the ecosystem and all." Teachers also used accessible materials such as salt, chart paper, and household items in practical experiments, as BLCM5064 explained: "Doing simple Chemistry experiments using local materials, trying to align the concepts with practical." However, most teachers still relied on laboratory resources or online simulations to supplement their teaching.

By the Endline, teachers continued to creatively incorporate locally available materials, though still in a limited way. For instance, ELPM5103 shared, "I design DC motors using locally available materials," and ELMF5146 said, "I take simple things, like card boxes to explain polynomials." Teachers also used the natural environment to enhance learning, with ELBF5029 noting, "I take students out of the classroom to observe ecosystems," and BLBF5019 saying, "observing the physical features of organisms and their habitats." Some teachers drew on local materials like "water, buckets, and salt to teach colligative properties" (ELCM5069) and used improvised teaching aids like “chart paper” (ELCF5073). Collaborations with external resources were also evident, with ELBM5008 saying, "I worked with health workers at a public health centre," and ELCM5064 mentioning, "seeking assistance from a nearby college for Science experiments."

Despite these creative efforts, many teachers reported challenges in integrating local materials and relied on school laboratory equipment or digital tools as substitutes, with ELPM5088 stating, "We don't have adequate computer labs, so I provide printed hand notes and encourage students to browse the materials during free time." Teachers also adopted collaborative strategies, such as "sharing resources with colleagues" (ELMM5139), to address resource limitations.

Summary: The analysis of Baseline and Endline data highlights a developing recognition of the potential of locally available materials in enhancing learning. Teachers demonstrated creativity and commitment by incorporating community resources, natural environments, and everyday materials to create relevant and interactive learning experiences. However, the use of local resources remained limited, with many teachers still relying on laboratory equipment or digital tools. These efforts reflect a growing awareness of the value of local materials, but they also emphasise the need for greater support and resources to fully exploit these opportunities and make learning more contextualised and impactful.

5.3.5 Link Conceptual Content to Students’ Everyday Life Experiences and Prior Knowledge

Linking conceptual content to students’ everyday life experiences and prior knowledge is an essential teaching strategy that enhances learning by making abstract concepts more relatable and meaningful. This approach helps bridge the gap between theoretical knowledge and the real world, allowing students to see the relevance of what they are learning in their own lives. By connecting new ideas to familiar experiences, teachers can tap into students' existing knowledge and make complex topics easier to understand.

At the Baseline, teachers made noticeable effort to connect conceptual content with students' life experiences and prior knowledge, particularly toward the end of the lesson.

While comprehensive evidence was limited, there were several creative and engaging examples of real-life contexts in teaching. For instance, BLBM5005 connected plant structure to engineering design concepts, and BLBF5029 enhanced the learning of ecosystems by taking students outdoors. Similarly, BLCF5044 used everyday examples to explain Physics, such as relating bike tire maintenance to the concepts of pressure and volume. Chemistry and Biology lessons also connected to real-life experiences, such as BLCM5064's explanation of fluoride in toothpaste and BLBF5019's focus on hygiene to prevent diseases. Teachers also drew on cultural and community knowledge: BLCF5040 explained the logic of adding salt early in cooking, and BLPM5079 related the distribution of water in villages to fluid mechanics. Mathematics was linked to practical situations like budgeting during Mathematics festivals (BLMF5146), and games were used to explain probability (BLMM5139). Some teachers, like BLMF5153, made efforts to show the utility of abstract topics: "I taught them the utility of this particular topic. They asked why we were learning this and what they would miss if they didn't study it." These examples reflected an emerging recognition that making lessons relevant to students' lives could enhance engagement and understanding.

By the Endline, teachers increasingly reported efforts to connect conceptual content with students' everyday life experiences, particularly in the conclusion of lessons. The strategies varied, but many teachers shared effective ways to make abstract concepts more relatable. For example, one teacher explained the idea of a mole by comparing it to more familiar counting units: "I related the idea of a mole to more relatable examples like counting: a dozen is 12, a pair is two, and a mole is 6 × 10^23 particles" (ELCM5069). Another teacher used the everyday experience of a straw in water to explain refraction: "I asked students to consider how a straw seemed to bend when it was inserted into water" (ELPM5088). Teachers also drew from local environments, with one teacher noting, "To explain the concept of ecosystems, I brought the students out to the environment to make observations" (ELBF5029). Everyday objects were used to explain abstract concepts, such as "washing soda used in soap to introduce the practical application of chemicals" (ELCF5066) and "commercial Mathematics applied to business planning" (ELMF5146). These examples illustrated an increased recognition of the importance of contextualising learning, bridging theory and practice to create more relevant and engaging lessons. However, the data also suggested that there were still opportunities to further systematise the integration of real-world contexts to enrich students' understanding and interest in the subjects.

Summary: At the Baseline, teachers made efforts to link conceptual content to students' real-life experiences, but these were somewhat sporadic and not always systematically applied. By the Endline, there was a more consistent and intentional effort to integrate everyday examples, with teachers using a wider range of real-life contexts, such as local environments and cultural knowledge, to deepen student engagement. This shift highlights a growing recognition of the value of contextualising learning to make abstract concepts more accessible and relevant, though further opportunities remain for broader integration.

5.4 Chapter Summary

The analysis of Baseline and Endline interviews revealed significant changes across the three broad themes of ***Learners, Content***, and ***Teaching and Learning,*** following the implementation of OERs.

Learners: There was a notable shift towards more inclusive and responsive teaching practices. Initially, teachers were aware of their students' diverse backgrounds, focusing on addressing differences in learning speeds and ability levels. By the Endline, however, their approach expanded to incorporate differentiated instruction and Universal Design for Learning, aiming to better support all learners, including those with Special Educational Needs and low achievers. Despite challenges like limited access to technology, teachers employed peer learning and provided additional support to help these students succeed. Teachers also made strides in linking new content to students' prior knowledge. While early strategies were informal, by the Endline, more structured approaches like pre-tests, "warm-up" sessions, and real-world examples were used to activate prior knowledge, helping students relate new concepts to their everyday experiences. These efforts were particularly successful in Science, although Mathematics remained more reliant on traditional teaching methods, with resource limitations slowing the adoption of interactive strategies. Addressing misconceptions also improved, with a shift from reactive methods like use of videos and diagrams to more proactive strategies, such as simulations, hands-on activities, and real-life analogies, though some misconceptions persisted, particularly in abstract subjects.

Content: This theme reflected changes in how teachers planned and delivered lessons. Teachers at the Baseline were primarily focused on content delivery through textbooks and basic activities, with limited real-world application. By the Endline, however, there was a clear shift towards linking concepts to real-life situations and practical applications. Teachers increasingly used hands-on activities and problem-solving tasks, particularly in Science, to promote deeper understanding. However, challenges remained in subjects like Mathematics and Physics, where the complexity of concepts sometimes hindered full comprehension. Despite these difficulties, teachers made efforts to improve students' competencies by linking learning to current events and real-world contexts. There was also an increased emphasis on higher-order thinking, with more interactive teaching methods being used to foster critical thinking and problem-solving. Though traditional approaches like quizzes and experiments remained part of the teaching practice, the balance was shifting towards methods that encouraged deeper engagement and understanding.

Teaching and Learning: In this theme the implementation of OERs played a crucial role in transforming teaching methods. Teachers moved towards more active, student-centered learning approaches, using inquiry-based methods and promoting collaboration among students. The integration of technology further enhanced the interactivity of lessons, providing opportunities for real-time feedback and more engaging learning experiences. Assessment practices became more varied, with an increased use of group work, peer reviews, and digital tools, alongside traditional assessments. These changes were particularly noticeable in Science, where hands-on activities and real-world applications became more central to the teaching approach. The use of locally available materials also became more prevalent, as teachers began to incorporate community resources and environmental contexts into lessons. This shift helped make learning more relevant and relatable to students, although it was not fully realised in all classrooms. Overall, the changes in teaching and learning practices reflected a growing focus on creating dynamic, inclusive, and engaging learning environments, although challenges remained in fully integrating these approaches across all subjects, particularly in Mathematics.

In conclusion, the implementation of OERs led to a more inclusive, interactive, and real-world connected approach to teaching and learning. While there was substantial progress in supporting learners and improving content delivery, full integration of these changes, particularly in Mathematics, required ongoing effort and additional resources. The shift towards a more student-centered, competency-focused learning environment marked a significant step forward, although challenges like resource constraints and varying levels of engagement continued to pose obstacles.

Chapter 6: Conclusion and Recommendations

6.1 Introduction

This Chapter presents the conclusions drawn from the findings of both the Baseline and Endline quantitative surveys and qualitative interviews, conducted following the implementation of Open Educational Resources (OERs) modules as interventions to secondary school teachers of Science (Biology, Chemistry, and Physics) and Mathematics in Bhutan. Insights from these Baseline and Endline study provide a comprehensive understanding of the shifts in teachers' knowledge, attitudes, and practices, as well as the overall conducive learning environment. The chapter presents the key findings and offers targeted recommendations aimed at sustaining and advancing these developments, particularly in fostering inclusive, student-centred, and evidence-based teaching practices. The recommendations are for key stakeholders, including the Ministry of Education and Skills Development (MoESD) and the Colleges of Education of the Royal University of Bhutan (RUB), with the goal of further enhancing the impact of these interventions.

6.2 Key Findings

6.2.1 Shifts in STEM Teaching and Learning

The findings indicated a positive shift in the knowledge, attitudes, and practices (KAP) of Science and Mathematics teachers following the implementation of OERs modules. Teachers showed an increased commitment to student-centred pedagogies, with a greater emphasis on inclusivity and diversity in their classrooms. Notably, there was a reduction in traditional gender stereotypes in STEM fields, with teachers demonstrating a stronger commitment to promoting gender equity. Female teachers, in particular, exhibited a more pronounced shift towards inclusive teaching practices and a greater appreciation of diversity as a classroom resource. Despite these positive changes, challenges persist, particularly with respect to gender biases, such as the tendency for boys to receive more encouragement from their parents and teachers to pursue science-related subjects.

6.2.2 Gender Dynamics in Pedagogical Change

Gender-based differences were observed in the adoption of inclusive teaching practices. Female teachers were generally more proactive in creating diverse group settings and adopting inclusive pedagogies. Study revealed that female teachers were more likely to embrace a growth mindset, prioritise diversity, and feel responsible for meeting the needs of diverse learners. In contrast, male teachers, while showing positive shifts, tended to favour teacher-directed methods more than their female counterparts. This gender difference underscores the importance of targeted professional development to ensure both male and female teachers are equipped with the tools to promote inclusivity in the classroom.

6.2.3 Shifts in Assessment Practices

Teachers increasingly recognised the need to cater to the diverse needs of students, adopting strategies such as differentiated instruction, Universal Design for Learning (UDL), and formative assessments. The growing awareness of the value of diversity as a resource in the classroom suggests a move away from a one-size-fits-all approach towards more tailored practices. These shifts align with contemporary educational standards and highlight the positive influence of OERs on teaching and learning in Bhutan. Teachers also made significant changes in assessment practices, shifting towards diverse assessment methods such as peer reviews, group work, and digital tools. Female teachers, in particular, were more open to these approaches. However, many teachers, particularly male teachers, remained uncertain about the reliability and fairness of alternative assessments, underscoring the need for further training to enhance teachers' confidence and competence in implementing non-traditional assessment methods.

6.2.4 Barriers and Challenges

Despite the positive changes, several barriers remain. Limited access to technology and teaching resources continues to be a significant obstacle, particularly in resource-intensive subjects like Mathematics and Physics. Furthermore, while teachers recognised the importance of diversity and inclusion, challenges persist in fully implementing these practices, especially when addressing the needs of students with Special Educational Needs (SEN) or low academic performance. Additionally, the full integration of contemporary pedagogical practices in Mathematics remains a work in progress, with traditional methods still prevalent. The gender-based differences in teaching practices also present a challenge. Female teachers have shown a more pronounced shift in areas such as growth mindset and diversity, while male teachers may require more targeted support to ensure they are equipped to foster inclusive classrooms. Moreover, persistent biases related to gender roles in STEM education highlight the need for continued efforts to challenge traditional gender stereotypes and ensure equal opportunities for all students.

Finally, while teachers increasingly recognised the importance of emotional and psychological support for students, particularly those with SEN or low academic performance, the provision of such support remains insufficient. There is a need for greater investment in resources for counselling, peer support, and individualised attention to ensure all students receive the support they need to succeed.

6.3 Recommendations

Based on the findings from this study, the following recommendations are proposed to address the identified challenges and further enhance the teaching and learning practices in Bhutanese secondary schools:

6.3.1 Increase Access to Technology and Resources

The study highlights the ongoing challenges related to limited access to technology and teaching resources. To fully implement interactive and inquiry-based teaching methods, it is essential to invest in digital tools, lab equipment, and locally available materials. These resources will help teachers create more engaging and effective learning environments, particularly in resource-intensive subjects. The Ministry of Education and Skills Development should prioritise the provision of these resources to ensure that teachers have the tools they need to implement contemporary pedagogical strategies effectively.

6.3.2 Provide Ongoing Professional Development

The findings underscore the importance of professional development for teachers, particularly in areas such as differentiated instruction, UDL, interactive methods, inquiry-based learning, design thinking, and formative assessments. These professional development opportunities will help teachers refine their practices, better support diverse learners, and enhance student engagement, critical thinking, and problem-solving skills. Colleges of Education of the Royal University of Bhutan should emphasise more on these topics into their teacher training programmes to ensure that new and existing teachers are equipped with the knowledge and skills necessary to promote inclusive and student-centred teaching practices.

6.3.3 Strengthen Real-World Connections in Mathematics

While Science teaching has benefitted from linking content to real-life situations, Mathematics teaching still relies heavily on traditional methods. To make Mathematics more engaging and accessible to students, teachers should be supported in integrating real-world applications and problem-solving into their lessons. This will help students see the relevance of Mathematics to their everyday lives and improve their understanding of abstract concepts. The MoESD should provide resources and professional development to help Mathematics teachers incorporate these strategies into their teaching practices.

6.3.4 Increase Support for Emotional and Psychological Well-Being

The study highlights the importance of emotional and psychological support for students, particularly those with SEN or low academic performance. Schools should continue to prioritise the emotional well-being of students by providing more resources for counselling, peer support, and individualised attention. This will ensure that all learners, especially those facing challenges, feel supported in their learning journey and can reach their full potential.

6.4 Summary

In conclusion, the implementation of OERs in Bhutanese secondary schools has led to significant positive changes in teaching practices, with teachers increasingly adopting inclusive, student-centred pedagogies that promote diversity and engagement. However, challenges remain, particularly in terms of resource limitations, gender biases, and the full integration of contemporary pedagogical strategies. The recommendations put forward in this chapter aim to address these challenges and further enhance the quality of education in Bhutan. By increasing access to resources, providing targeted professional development, fostering real-world connections in Mathematics, and supporting the emotional well-being of students, Bhutan can continue to make strides towards an inclusive, engaging, and effective education system for all learners.

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